THE BEST OF BOB PEASE

What's All This Homepage Stuff, Anyhow?

Once upon a time I couldn't even spell "Web Freak", and now I am one. But several people agreed, that in response to the popular demand, RAP should put out a "Web Page" with several kinds of useful information on it.

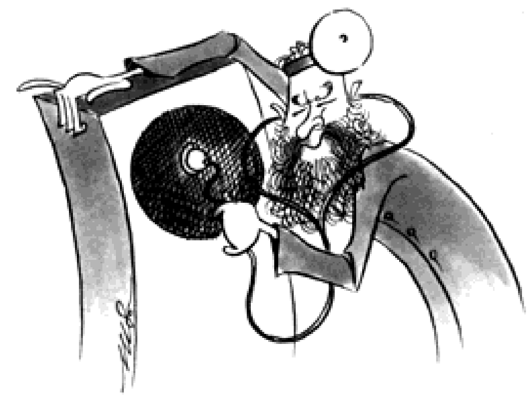
You guys all know that there is an awful lot of garbage on the Great World Wide Web. I am trying to NOT contribute to that. I'll put on ONE set of information for people who have not been receiving Electronic Design: Some of my RECENT COLUMNS. Already we have over twenty, and I'll try to keep adding more. These will mostly be in straight ASCII, with no hokey graphics. If there are small drawings, we'll expand them to make them legible when you print them out.

- Remembering Bob Pease

Topic:	**Driving High-Power LEDs Without Getting Burned - Part 2**	**Topic:**	**Driving High-Power LEDs Without Getting Burned - Part 1**
Your Hosts:	Bob Pease & Dr. Howard Johnson	**Your Hosts:**	Bob Pease & Dr. Howard Johnson
Guests:	Patrick Durand - Future Lighting Solutions Pat Goodman - Philips Lumileds Lighting Co. Chris Richardson - National	**Guests:**	Patrick Durand - Future Lighting Solution Pat Goodman - Philips Lumileds Lighting Co. Chris Richardson - National

Tune In Today!

Tune In Today!



Circuit to provide rail-to-rail output, even with a (light) load

Complete Circuit for Cold Toe Detector...

Solutions to March 31 Electronic Design Puzzles

The origin of the WOM - the "Write Only Memory"

As decribed in my December 8 2004 ED column, "What's all this Merit Badge Stuff Anyhow", here is RAP's Merit Badge Workbook.

Vacuum-tubes Op-Amps!

View Our Archived Online Seminars

- The Use, Mis-use, and Abuse of Amplifiers (12/5/02)

NoiseMaker and Level-Shifter and Preamp Circuits, to use with "Ripple-Rejection Stuff"!

The San Francisco Chronicle had a good write up on Analog Designers

Trekking in the Annapurna Sanctuary.

Hikers and adventurers may enjoy reading about my trek around the Annapurna Circuit, in Nepal, in November of 1997.

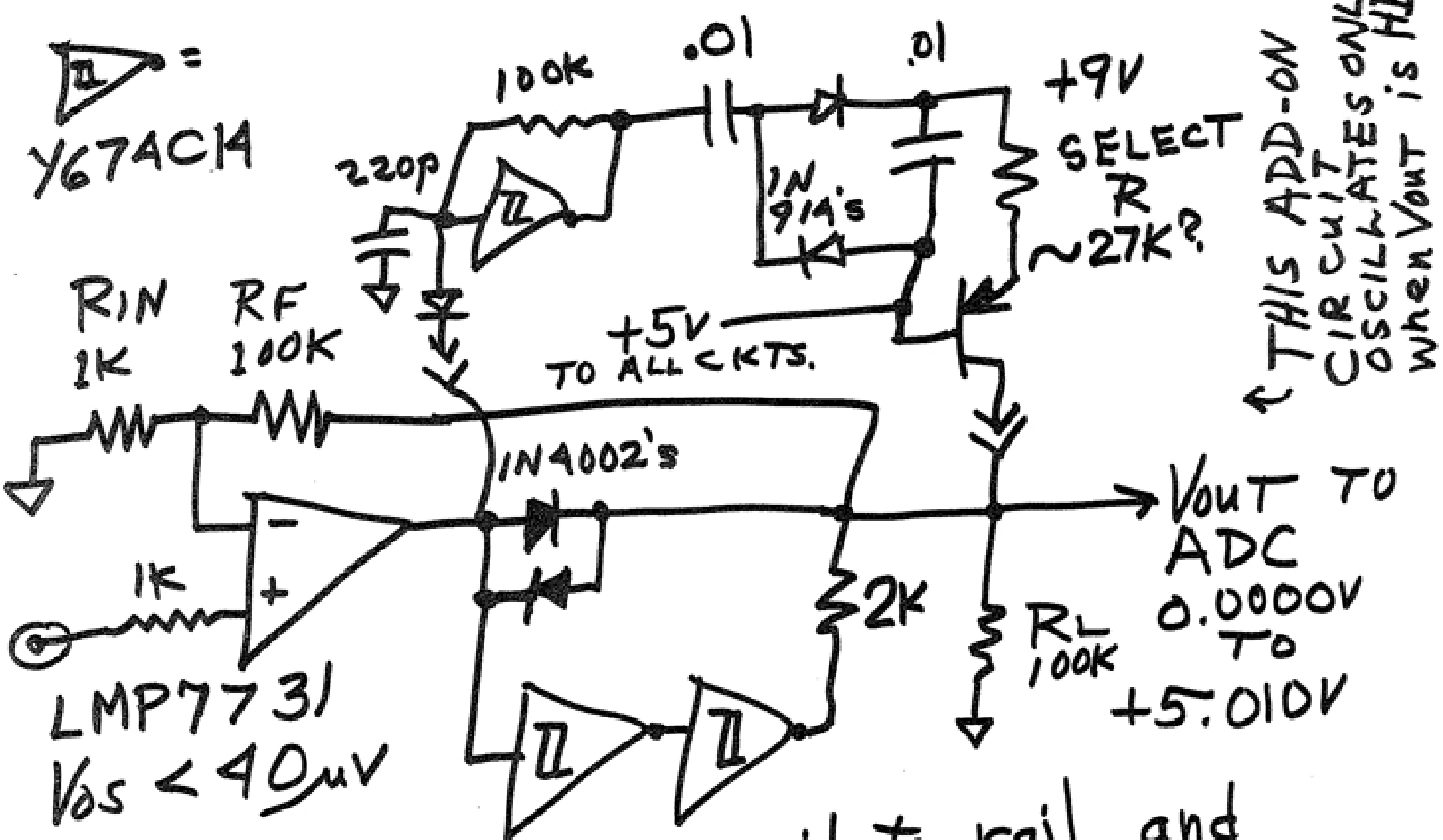
Also, we'll try to have some Miscellaneous stuff:

- Anybody who has to do some REAL Analog Troubleshooting, and wants to buy my books, we'll make it easy. Just click on BOOK.
- Check here for a listing of ED columns
- If you want to see a horrible photograph, we may occasionally have one. Click on HORRIBLE.
- We will refer you to the Electronic Design Website. Just click on ELECTRONIC DESIGN.
- We will have LISTS.
- And if you have any comments on what ought to be in this Website, holler. Holler to robert.a.pease@nsc.com. Send nasty comments. I'll read your comments.
- AND we will also put in some good technical material, even for guys who have read all my columns in E. D. These will be based on some of the old technical notes I have written over the last 35 years. With comments. I bet you'll find something interesting.

All for now.
Best regards./ R. A. Pease / Engineer / NSC

THE BEST OF BOB PEASE

- What's All This Neatness Stuff, Anyhow?
- What's All This Splicing Stuff, Anyhow?
- What's All This Teflon Stuff, Anyhow?
- What's All This Femtoampere Stuff, Anyhow?
- What's All This Cost-Accounting Stuff, Anyhow?
- What's All This Mentoring Stuff, Anyhow?
- What's All This "SMWISICDSI" Stuff, Anyhow?
- What's All This Multiplication Stuff, Anyhow?
- What's All This Box Stuff, Anyhow?
- What's All This Copper-Clad Stuff, Anyhow?
- What's All This Reflex Response Stuff, Anyhow?
- What's All This Dead Car Stuff, Anyhow?
- What's All This Applications Engineering Stuff, Anyhow?
- What's All This Muntzing Stuff, Anyhow?
- What's All This Ground Noise Stuff, Anyhow?
- What's All This Quality Stuff, Anyhow?
- What's All This Smog Stuff, Anyhow
- What's All This Measurement Stuff, Anyhow?
- What's All This Common-Centroid Stuff, Anyhow?
- How To Make Your Own Matched Transistors
- What's All This VBE Stuff, Anyhow?
- What's All This Widlar Stuff, Anyhow?
- What's All This Fuzzy Logic Stuff, Anyhow? (Part II)



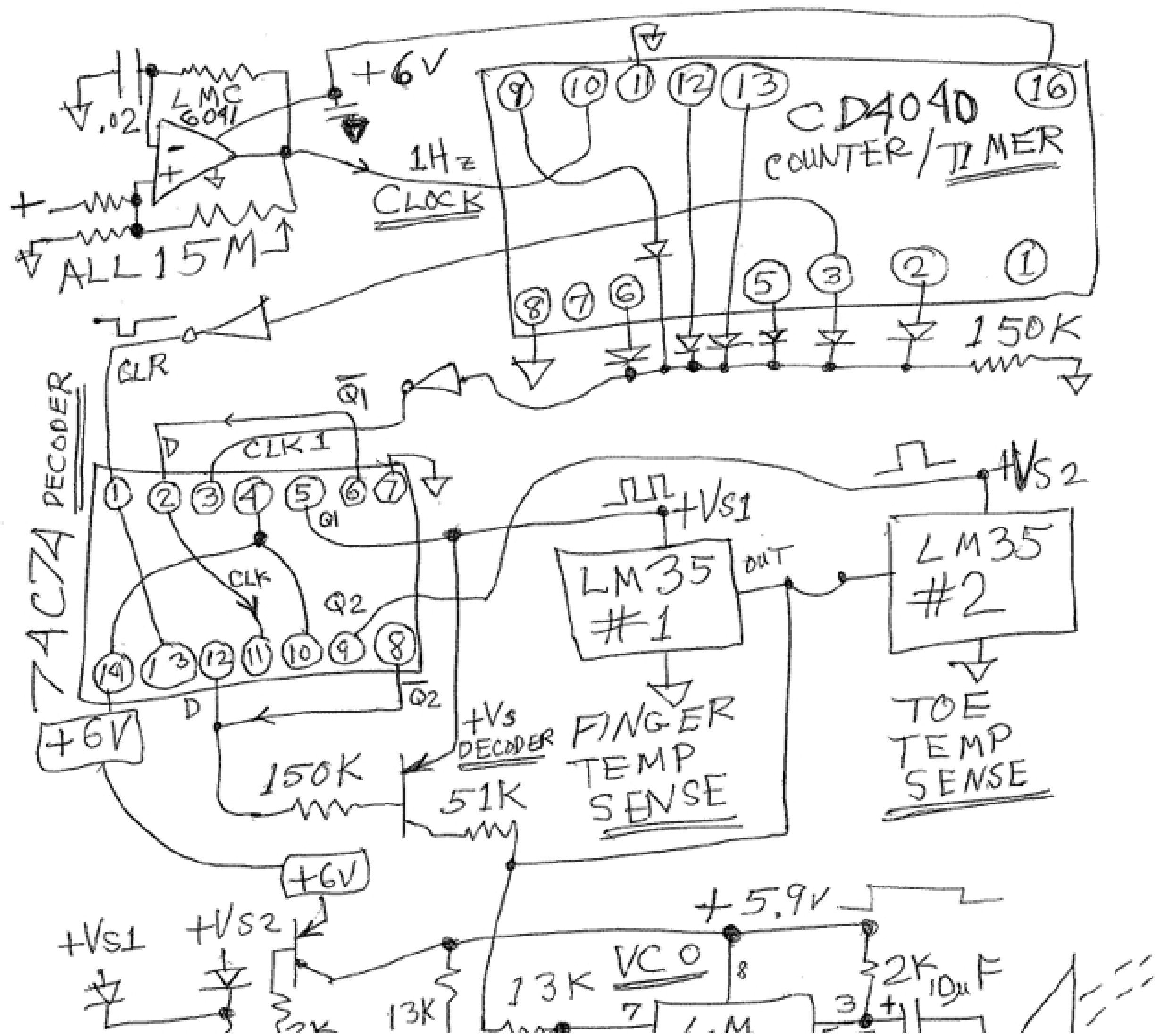
The output can swing rail-to-rail and even a bit higher while driving a light load.

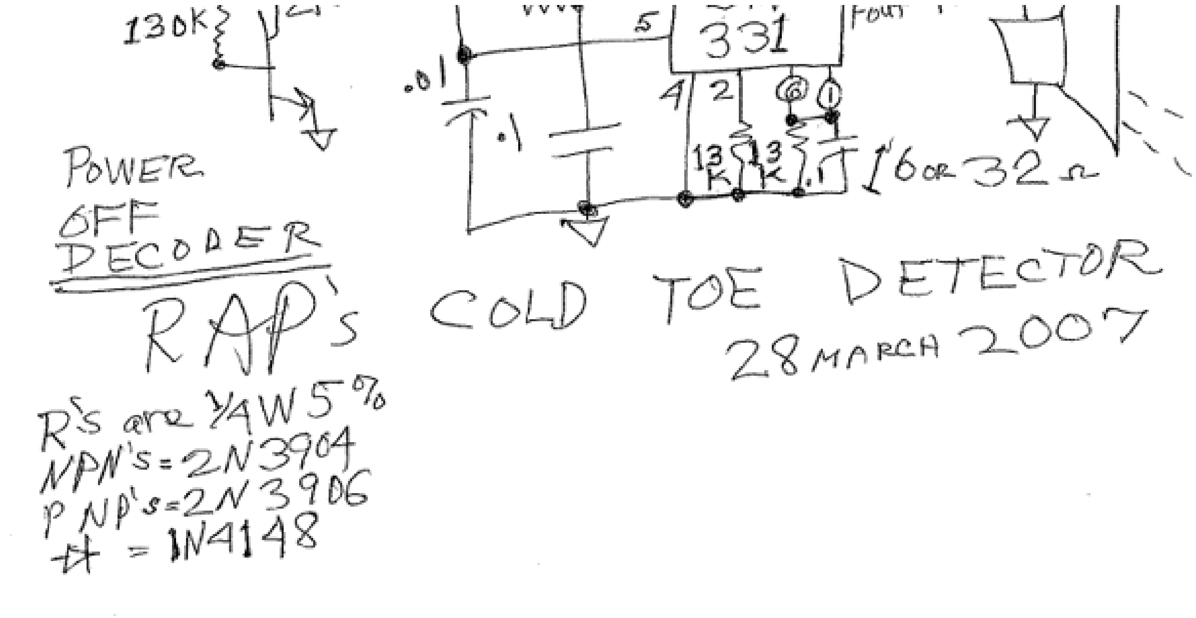
RAP 5xii2007

THE BEST OF BOB PEASE

Complete Circuit for Cold Toe Detector...

Link to Electronic Design Article




130K
.01
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6 OR 32 Ω
POWER OFF DECODER
RAP's COLD TOE DETECTOR
28 MARCH 2007
R's are 1/4 W 5%
NPN's = 2N3904
PNP's = 2N3906
= 1N4148

THE BEST OF BOB PEASE

Solutions to Mental Math Puzzles, Electronic Design, 31 March 2006

1. How can a train ascend a 1-mile radius hemisphere, without exceeding a 4% grade? The train track must spiral up the hill as far as it can, at a 4% gradient. About 25 miles or so, up to point "X". And how far is that, exactly? Where is this "point X"?

Let's look at this from the standpoint of starting down the hill. The track will go STRAIGHT DOWN the hill as fast as it can - but it starts out on the level, and gradually starts getting steeper, as it descends further along the Great Circle. How far down can it go? It can go down to a point where the gradient reaches 4.0%, and then it has to curve over to one side, and start spiralling. That defines Point X, in terms of its (r) and (Z) coordinates. (It does not tell us about the angle, theta.)

How can we describe this point X? It's a point where the slope (the tangent) is at 4 degrees. There, the radius (from the center of the hemisphere) is still exactly 1 mile, and the vertical elevation above the plain is exactly - 1 mile x cosine of (arctan 4%). About 0.999200958 mile. And, this is about 4.21894 feet closer to the plain, than the top of the hill. In other words, you only descend 4.21894 feet of elevation, before it has hit the 4% gradient. That's the view from the top. And this point is barely 211.2 feet from the top, before it has to curve.

Now, starting from the bottom, every mile you ascend and travel, at a 4% grade, the horizontal distance is - cos (arctan4%). So when you travel one horizontal mile, the vertical ascent is 0.040000 mile, and the amount of track needed is - 1/cos (arctan 4%) - or about 1.00079968 miles

When you need to spiral up to ascend a vertical distance that is exactly 1 mile x cos (arctan 4%) - the amount of track needed is exactly 25.0000000 miles, to get UP to Point X. The value of cos (arctan 4%) cancels out, in both parts of the math - - - so you never have to know the exact value of this quantity.

What is the distance from point X to the top of the mountain? Well, it is quite close to (4% of 1 mile), or 0.04 x 5280, or 211.2 feet. That is 4% of a mile. But the angle, in radians, is NOT 0.0400, but 0.039978687. That is the arctan of 0.0400. If you go in a straight line that would be (211.0734 feet) But since we are travelling along an arc with a true radius of 5280' - - the actual mileage from point X to the top, along the arc, is very close to 211.0875 feet.

The TOTAL is quite close to 1 mile x [(1/.04) + (.04)], or 25.04000 miles, or 132,211.20 feet. That is a very good estimate. Actually you don't need 132,211.20'; 132,211.087 feet will be enough, so 25.0400 miles would be over by about 1.35 inches. But since this isn't even 1 ppm over, it won't cost Egbert too much.

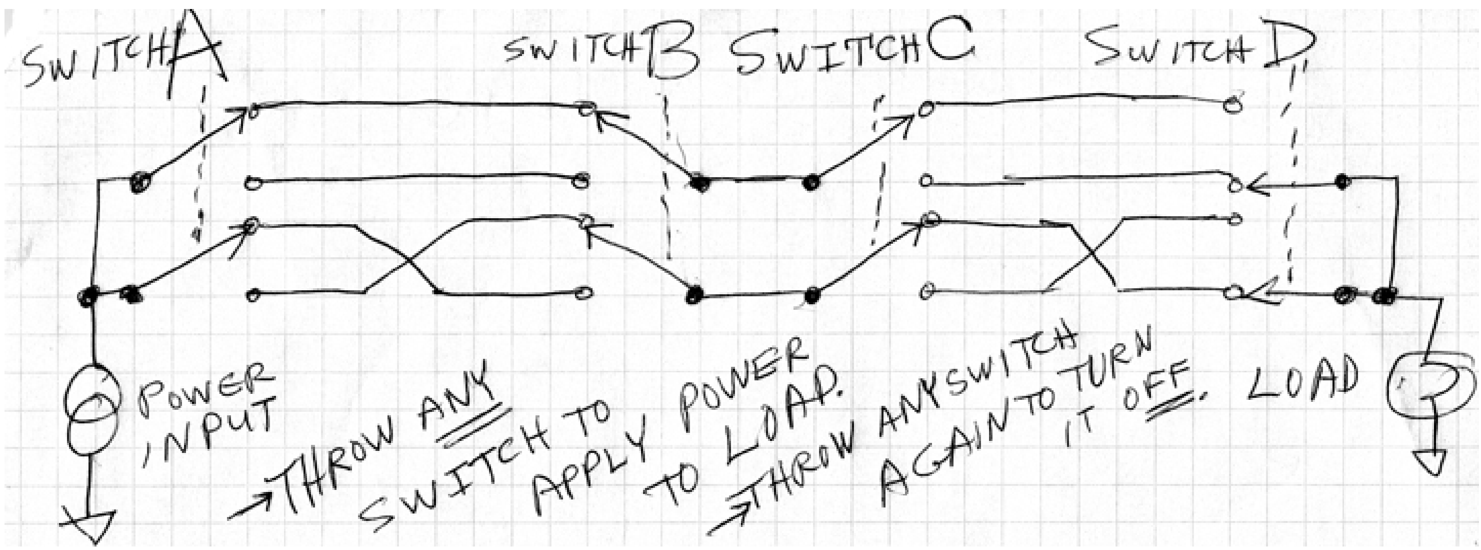
Nobody buys rail with an accuracy better than 1 PPM. To do that, you would need a very tightly controlled temperature-controlled rail-yard.

Problem 1.b. If you start on the exact west side of the mountain, heading north, from what angle do you approach the summit? In other words, at what angle is "point X"? I have no idea. My best guess is: About (XX) degrees. But that is a very crude guess. I'll allow you guys who can program computers to compute trivia like this, tell me what the answer is. I'll post the best answer that 2 people can agree on.

Problem 2. When Egbert has travelled 2.000 miles, he is already very close to the goal. In fact, this hypotenuse is 2.00249844 miles, so he is only 0.00249844 miles from the goal, or 13.19176 feet. The other fellow has 528 feet to go. Egbert continues at 2 mph, and will arrive in 4.4972 seconds. His brother must go 528 feet in this time, or 528 feet/4.4972 sec, or 117.41 ft/sec, or 80.05 mph. It is OK to round this off to 80 mph. Or 80.1 mph... so he won't be late.

When you are doing this in your head, it is OK to simplify a bit, that the hypotenuse is 2 miles + 1/400 mile. Thus the ratio of the distance Egbert has to go, versus the distance his brother has to go, is 1/400 versus 1/10, or 1:40, so the solution must be 40 x 2 mph. This answer is within 1%...

Problem 3: For the problem with 4 doors, at each of the 4 switch locations, install a DPDT switch, and connect as show in this diagram:



Richard Hensel writes: Bob,
I loved your mental math problems.However problem number 3 is quite simple to solve if you know anything about house wiring. For any number of control points to control a single light where n > 2, you need 2 single pole double throw switches and n - 2"crossovers".A "crossover switch" has 4 terminals, 2 on each side, call them (a) and (b) on the left side and (c) and (d) on the

right. In one position (a) connects to (d), and (b) connects to (c); in the other (a) connects to (c) and (b) connects to (d). This actually came up in a physics class I had in high school about 40 years ago.There were 4 doors to the lab; each door had a switch that controlled the lights, how were they wired?The prof actually put the question on a test.
You can buy them at Home Depot. They are often called "4-Way" switches. Schematically they look kind of like this:

```
Pos. 1:        Pos. 2:

(a)O  O(c)     (a)O - O(c)
    \/
    /\
(b)O  O(d)     (b)O - O(d)
```

The contact bar would connect diagonal contacts or adjacent contacts.

In the following diagram, the load is energized; throw any switch and de-energize; throw any switch again and load is re-energized

```
               0-------0  0-------0 - 0----------0
Source -------/         \/                        ----load
                        /\                       /
               0-------0  0-------0 - 0----------0
```

As you can see, you can add as many of the crossover switches as needed, and only 2 travelers are required between each switch. Handy 'cause romex has 2 wires + ground.

The physics prof didn't know how it worked either; I had worked for an electrician during the summer and found out about it.

Richard Hensel,
Non Impediti Ratione Cogitationis
Lexington, Ohio

*** Hello, Richard,
Well, that is a great solution. I did not know about "crossover" switches. Of course, one can take a DPDT switch and wire it to act as a "crossover", but many hardware stores do not sell DPDT switches, to mount on your wall. YOUR elegant solution uses about 1/2 as much wire as mine does! And YOUR solution can obviously be extended to n = 5 or more. Thanks for writing! / rap

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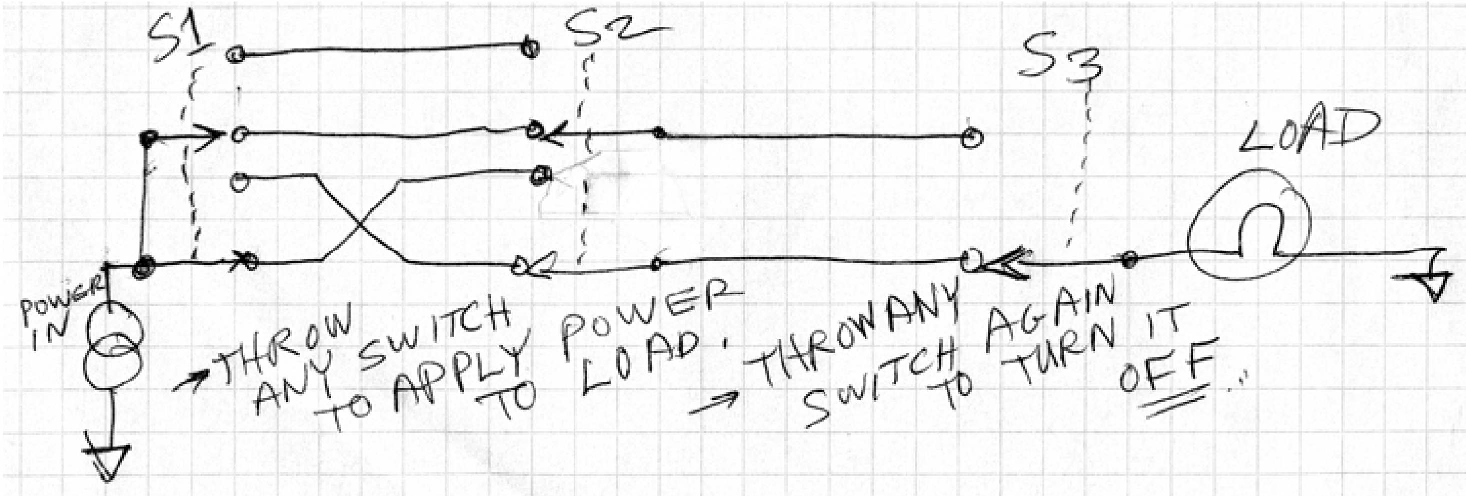
For the version with 3 doors, install the 3 DPDT switches as shown (Actually, you only need 2 DPDT's and one SPDT):



Note, it's true that a room that's 100 feet square, would need about 1000 feet of heavy-gauge wire. And the I x R drop of several amperes through 300 feet of wire is NOT small or trivial. Using light-gauge wire to drive a relay would begin to make sense.

And, if the number of switches goes past 4, using SPST switches which drive light wires, which drive exclusive OR gates, which drive a relay, would become effective. Okay?

Problem 4: One good way to find the square root of 156 is to recognize that 12.5 (squared) is 156.25. Now, 156 compared to 156.25 is 0.16% low. So the square root of 156 must be slightly less than 12.5. About 0.08% less than 12.5. That will be very close to 12.490.

One good way to get VERY close to the square root of (N) is to divide (N) by a number which is close to (sqrt N) - let's call it (n). You then get a result: N / (n) = n'. Then the square root of N is very close to (n + n')/2. This is because (A + b) x (A - b) = A (squared) - b(squared). If b/A = .001, then (n + n')/2 = (sqrt N) with a precision of 1/2 ppm. If b/A = .000001, then (n + n')/2 is equal to the square root of N with an accuracy better than 1 part per TRILLION.

In this case if we divide 12.4900 into 156, the quotient is about 12.48999200. This is easy to do in your head, as it's just a bunch of chained additions, multiplications, and subtractions at the 4-digit level. So the square root of 156 must be VERY close to (n + n')/2 = 12.48999600. Well within 1 ppm. Actually, about 0.003 ppm.

If you then want to divide THIS into 156, you can pin down that the solution is closer to 12.48999599680.

Some calculators will tell you that the (sqrt) 156.0000 is 12.489995995, but this is an example of an incorrect round-off. It's 12.489995997 (if you round off to just 11 places) or 12.48999599680 or 12.489995996797.

THIS solution is down below 1 part per TRILLION. Even for space travel, we don't need accuracy better than that.

So this is just to remind you that if you need a square root, you don't need a calculator that can do square roots. You can get accuracy well below 1 ppm with just a calculator that can just do DIVISION, and the right techniques. Or, you could use a stick to write in the sand. Or, you could do it in your head....

Problem 5. When you drop an object (such as a plumb bob with a point) about 16 feet, it will fall to the ground in about 1.00 second.

The radius of the earth is ABOUT 4000 miles, or ~ 21,000,000 feet, or ~ 250 million inches. The velocity of the ground, at the foot of the ladder, is about 2 pi x 250,000,000 inches per (86400 seconds) (i.e. - one day).

The velocity at the top of the ladder is 2 pi x 250,000,192 inches per (86400 seconds). The relative speed is that the object atop the ladder is moving faster, by 2 pi x 192 , inches per 86400 seconds. We do NOT have to know the actual radius of the earth - or the speed - we just need to know that the top of the ladder is moving faster by 2 pi x 192/86400, in terms of inches per second.

Now, you don't actually have to crunch those numbers, with a slide rule or calculator. Because there are about 7 factors of 2 in each of the numerator and the denominator. After you cancel out all the common factors, the final answer is about (pi) / 225, or 1/72, or 13.96 milli-inches. Say, 14. That's well within 1% or 0.1%, actually.

THUS: If you drop an object, which is moving EAST, FASTER than the ground, then in the time the object falls 1 second, the object moves FARTHER EAST, farther than the ground. It will hit the ground in a place that is offset about 14 milli-inches east of the point it touched, when it was LOWERED to the ground. (In that one second, both places will have moved about 17,900 inches...) (This is a resolution of about 1 part per 10 billion, comparing the RELATIVE speed to the ABSOLUTE speed.)

If the height of the ladder is 16 x (M) feet, then the distance will be 14 mils x (M) exp 3/2. So if (M) = 4, and the ladder is 64 feet high, the offset distance would be a definitely noticeable distance of 112 milli-inches. Of course, you would have to avoid all winds, and you would have to have a release mechanism that imparts negligible speed to the falling object. And the step-ladder can't wiggle. OK, drop it down a well.....

This effect is not EXACTLY the same as a Coriolis force, because all forces are oriented directly toward the center of the earth. All MOTION is referred to the plane that is moving "EAST" at about 17,000 inches per second. If you do this much more than 1.0 seconds, you would find the rotation is annoying...

This just goes to show, that when you drop something, it does not just fall DOWN. It falls in a sort of elliptical orbit, around the center of the earth (in the absence of wind or friction or any other influence). So, NO, when you drop something, it does not just fall "down". It falls in some kind of orbit. And, if you measure closely, you can tell the difference. Thanks to "Goldie", Maurice Goldwater, from 40 year ago.

Best regards! Comments invited. / rap

I believe we got an answer to Problem 1b. Israel Schleicher, by e-mail, and Ermi Roos of Miami Florida sent in simple and elegant solutions that the train circles a little more than 6 times, and both agree that the train approaches the Summit from an angle of 32.7347 degrees north of west. If you argue that you have a solution that is different from 32.7 degrees north of west, you are probably wrong.

Details to follow. / rap

THE BEST OF BOB PEASE

The origin of the WOM - the "Write Only Memory"

An engineer at Signetics, frustrated by the long and useless sequence of approvals for data sheets (during which no actual checking occurred), once made up a spec for a "Write Only Memory" (a "WOM") and sent it along with a batch of other data sheets to be approved. After all, if you are selling "Read Only Memories", why not have a "Write Only Memory"? It's perfectly logical - - which is why the managers saw nothing wrong with the data sheet.

The WOM data sheet went through the approval chain, just fine, and wound up in Signetics' new products catalog. This came to the attention of the managers at Signetics, only after customers began asking for price and delivery. Signetics shortly printed up new "corrected" databooks, without any WOMs, and asked for the "erroneous" ones to be returned. But customers soon got word of why they asked for returns, and hid them properly.

About 1974, Signetics bought a two-page, full-color spread in the April issue of ELECTRONICS Magazine, and published the WOM data sheet, as a (rather expensive) April Fool's Joke. This version of the WOM data sheet shows the various features of Signetics' Model 25120 "fully-encoded, 9046 x N Random Access, Write Only Memory". This advertisement has been saved, and greatly prized by engineers, for many years. We recently found a copy of this data sheet, in very good shape except for where it had been punched for a 3-ring binder. See the next pages.

This was not the end of the WOM. Signetics also brought out a promotional pamphlet, " Be Famous!! Have a WOM named after you." Unfortunately, not many of these survive. If anybody can loan us a good photocopy, we would love to add it to these pages.

At many companies, managers are accused of not having any sense of humor. But in this case, the Signetics guys did it right! Even if it did cost them a lot of money!! And our managers here at National approved my posting of this Data Sheet on my web site - to show that we have a good sense of humor, too!

Further, as we pointed out in a recent web-cast, XILINX makes FPGA's such as the XC4V LX15-10 SF363 - - which can be used in conjunction with our 3-Giga-samples-per-second ADC's, at such high data rates, that they are faster than most WOMs. The FPGA's can then give you back your data at a slower, controlled rate - - whereas WOMs never give you your bits back!

Download datasheet (pdf 2.4MB)

/ rap / Robert A. Pease, Staff Scientist, NSC.

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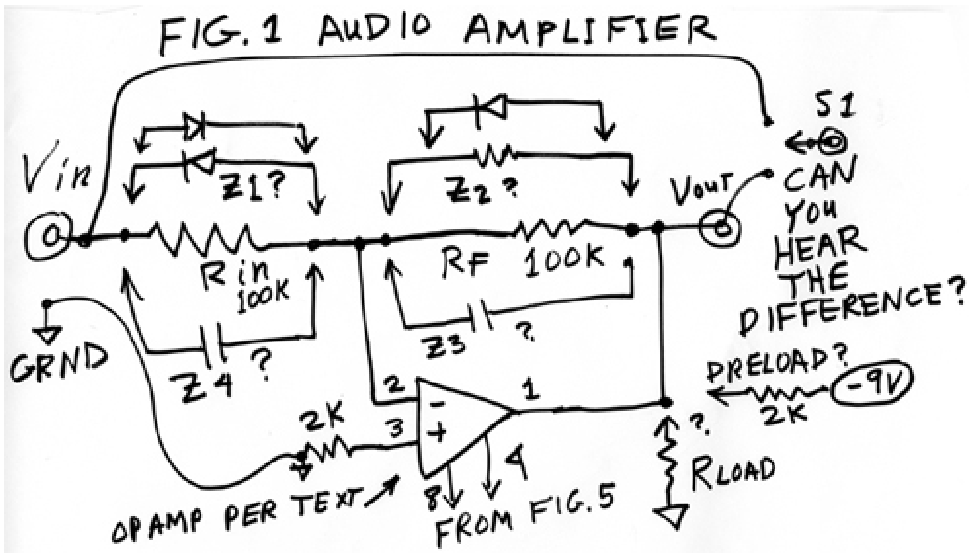
THE BEST OF BOB PEASE

Merit Badge Stuff

Hello to Friends -

Audio Amplifiers.

HERE is a very basic circuit which can be modified in dozens of ways, to make useful effects, by adding very simple components. A simple op-amp may be useful to make INTERESTING GAINS - interesting sounds and noises. None of these signals is big enough to shock or bite you, nor burn you.



Parts needed: A couple Dual Operational Amplifiers (op-amps) such as LF412, LF353, or TL082. Preferably in mini-dip packages. AND, an LM358N. And several sockets for them. Mini-Dip sockets are fine. You'll probably need two 9-volt batteries, and sockets for those batteries, and switches to turn off the batteries when not in use. You'll need a few resistors (1 or 5 or 10%) such as 20k, 50k, or 100k ohms, and a couple 1-turn potentiometers (usually called "pots"), such as 50k (but 100k or 200k could be used.) You'll also want a few RCA phono plugs, to connect to your existing amplifier jacks, inputs and outputs.

You need to connect the output to a conventional audio amplifier and speaker, such as a "stereo amplifier" or "hi-fi amplifier", plugging into the "AUX" or Auxiliary input, or to any input, such as the "tape" input, but preferably not the "Phono input" - that is often too sensitive. When you are ready to start, turn the volume down, most of the way.

You can use the same batteries and switches for all various circuits, but you might use new sockets for each circuit, and move the amplifiers around.

Apply a volt or so of input signal to Vin. THIS could be from a sine wave generator, triangle, or square wave, or radio, or tape deck or CD player.

The input resistor, Rin, is chosen as about 100k. The feedback resistor is Rf.

If Rf = Rin, the gain will be about 1, so you might not be able to distinguish between Vin and Vout, using S1. (S1 need not be a real switch. You can use any clip-lead to connect to one signal or another, or an alligator clip to just clip onto various signal leads.)

What if you start adding components? Cf? Small, Big?

What if you add a load resistor? It might not make much difference because operational amplifiers are good at tolerating resistive loads as low as 2 kilohms. Adding a load heavier than that (lower ohms)might cause distortion and waste battery power.

What if you add a resistor across Rf? This will cut the gain a lot, if Rf gets low enough. You might have to turn up the gain.

What if you add a resistor across Rin? This will increase the gain a lot, if the total conductance of Rin gets low enough. You might have to turn DOWN the gain, after the output.

What if you add 1 or 2 DIODEs at Z1? If the signal is small enough, not much change occurs, but with a bigger signal (~ 2 volts) the diodes at Z1 can have a big effect - this is called DISTORTION.

Another kind of DISTORTION is called clipping. You can fool around by adding diodes at Z3 and/or Z2. If you put in BOTH diodes, the clipping will be significant. No matter how big you make Vin, the output doesn't get much bigger. Set aside the diodes for a while.

If you add a capacitor at CF (Z3), and bigger and bigger ones, the high-frequency sounds will be rolled off. This is called a Filter. It passes low-frequency signals, but rolls off the fast ones, a LOT.

If you add a capacitor at Z1, it will cause a high-pass filter. The gain for high frequencies will be increased. Be careful as a large capacitor might cause very loud noise and even oscillation! (a constant loud noise and tone, even if there is no incoming signal.)

What if you add BOTH an input capacitance across Rin and a similar feedback capacitor across Rf? Do the effects cancel?

One of the reasons these operational amplifiers are popular is that their gain depends on the RATIO of feedback and input resistors or capacitors. The actual resistor or capacitor is not important, just the ratio. Not all audio circuits use Operational Amplifiers, but some do.

DISTORTION. Turn off power and use a small knife and pry the TL082 out of its socket. Ease an LM358 into that socket. Check carefully to see where its pins are located, for pins 4 and 8. Apply power. See Fig. 5. Apply signals. The LM358 is usually considered a LOUSY (that's a technical term) high-distortion amplifier. If you put in a sine or triangle wave, the distortion will be obvious.

Now if you connect a 2-kilohm resistor from the output to the - 9-V supply, (you can do this with your fingers - nothing will bite!) - the distortion will go away. If you connect it from the output to the + 9V supply, the distortion will also go away. The LM358 is one of a very few amplifiers that will distort like that. It's very efficient, and low-power, and inexpensive, but it does not have low distortion for audio signals unless you put an extra "pre-load" on its output.

Part TWO: Filters

There are many kinds of filters. They change the Frequency Response. They add or cut, the Treble (high frequencies) or the Bass (low Frequencies).

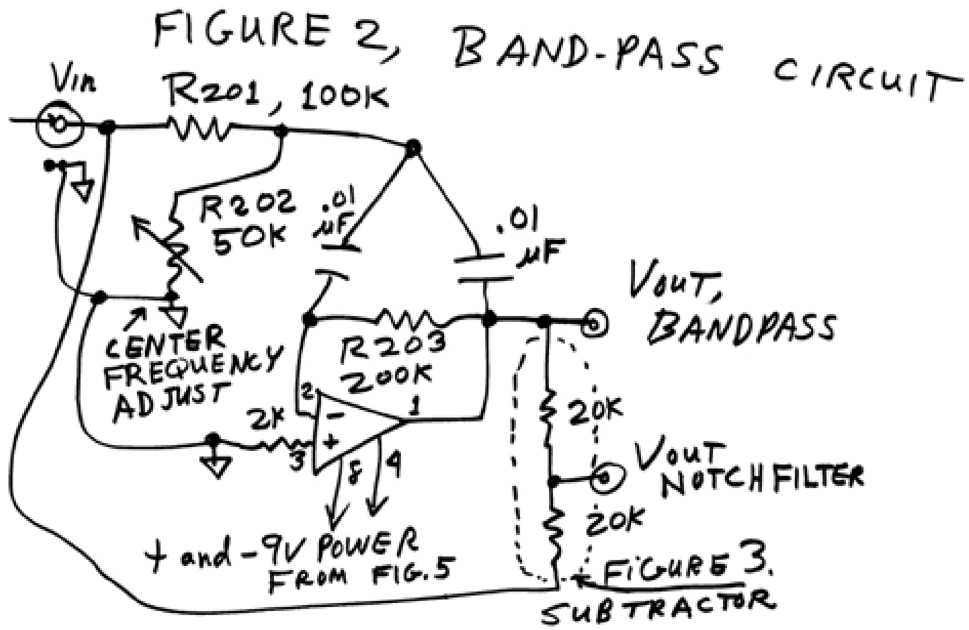


Figure 2. shows a basic BAND-pass filter. It passes signals in the MIDDLE of the signal bandwidth. Also, this is an ADJUSTABLE filter. You can fool around with it, and see what interesting effects you hear. Adjust the 1-turn pot at R202. THIS makes it easy to adjust the center frequency and the Quality (Q) of the circuit. The gain is always 1, due to the ratio of R203/(2 x R201). The bandwidth is always 1/(3.14 x R203 x C), or about 160 Hz. That's a pretty narrow bandpass! (Considering that audio frequencies usually go down past 100 Hz and go up above 10,000 Hz!) This is a very versatile bandpass circuit because trimming R202 does not change the bandwidth, but does change the center frequency. You can trim R202 and move the center frequency around, for interesting effects.

*** If there is any adult who can help you understand the shapes of the signals, that might be nice. If you know an electrical engineer, engineer, or electronics technician - or even a science major, they might help you interpret what you are hearing.

*** If you can find an engineer or technician who can loan you an oscilloscope, for a few hours, that might help you understand what you are looking at. Do fast wiggly signals sound high-pitched? Do slow wobbly signal sound "low-pitched"? This is likely to make sense if you think about it.

If you compare Vin versus Vout on the 2 inputs of a scope, you can see the phase shifts between the input and the output. Or if you can borrow a dual-trace scope, you can see the input and the output at the same time. An engineer, technician, or scientist can help you interpret what you are looking at.

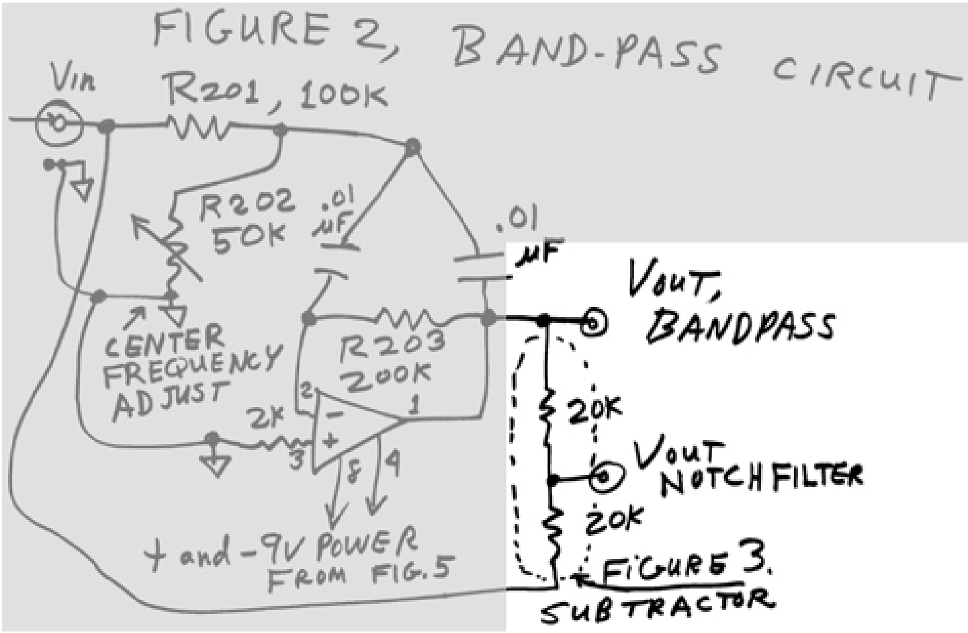


Figure 3. If we add the BAND-pass filter to a subtractor,this this can be a BAND-reject filter, often called a NOTCH filter, as it rejects mid-frequencies. Play it by ear, as you adjust the R202. Which settings sound the most interesting?

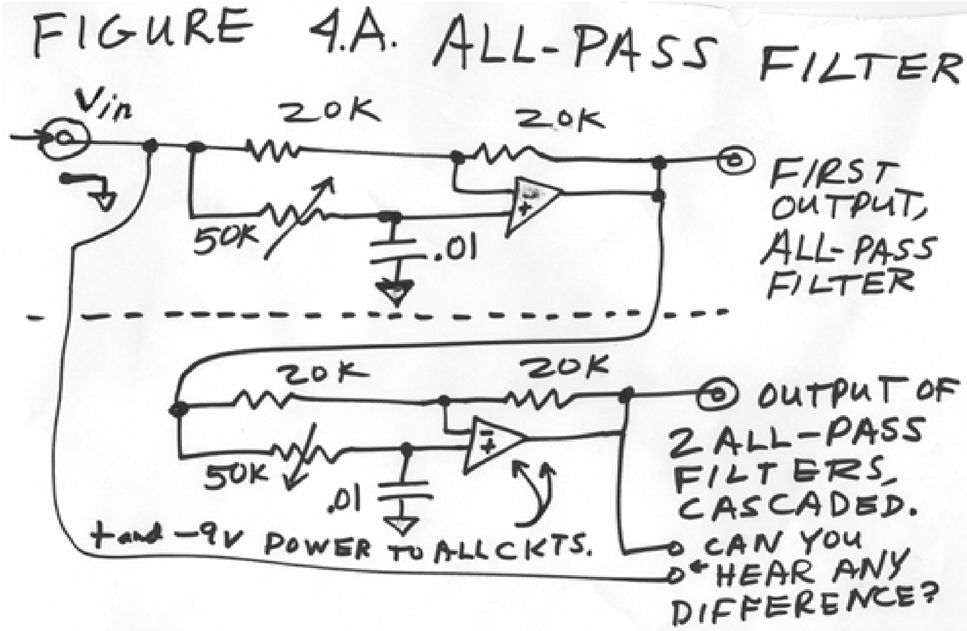


Figure 4A. shows an ALL-PASS filter. It passes low frequencies, high frequencies, and mid frequencies, but it screws up the phase response. When you put the signal through 2 in series - does it sound weird? Try different pot settings.

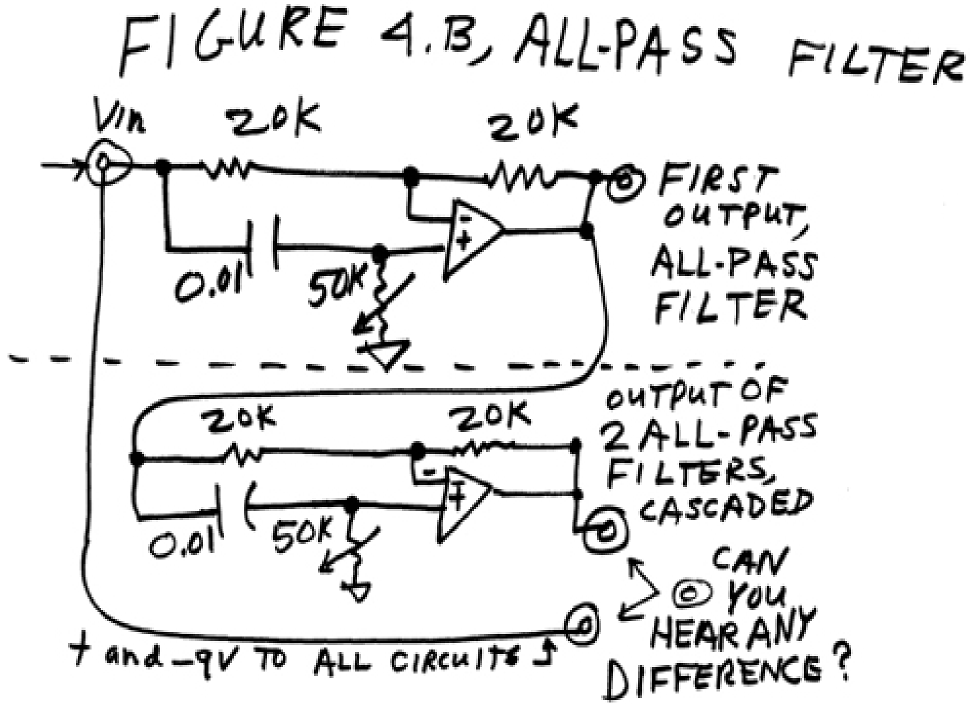


Figure 4B shows a similar ALL-pass filter. It likewise passes all frequencies, but with a leading phase response, different from the circuit of 4A. Can you hear a difference?

Sometimes people make a cascade of several all-pass filters in series, one after the other adding their phase shift. Have you got several pots? I gotta see if I can hear all those effects.

If this is for a YOUNG student, he/she should request MORE advice from a parent, or older friend, or engineer or technician. Older students may need less supervision. They may be able to explain why things sound "weird"!

NOTE to the student. Please make NOTES on each circuit, each experiment. Mostly so you can go back to where you were, if you find something interesting.

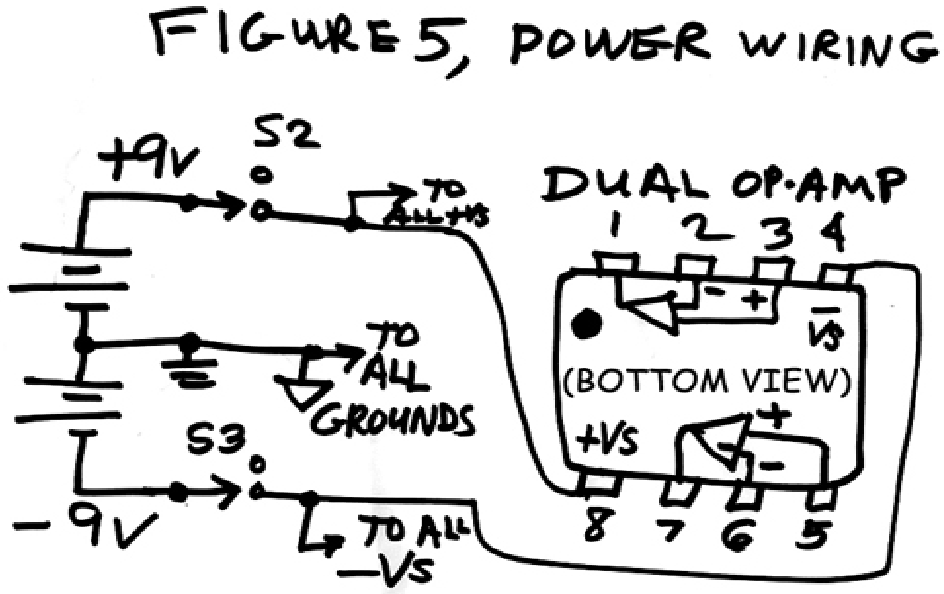


Figure 5. just shows how to connect the + and - 9 volt power to all circuits. Be sure you don't put in the amplifier backwards, or it will probably be damaged, and would hurt the batteries.

Soldering:
Can you use solder to connect the components? Yeah, but younger students will need a LOT of supervision. Soldering is an art best learned by experiments, with a wise advisor. Have good rules for soldering, for making sure the solder iron is not going to touch any combustible materials, nor fall on the floor, nor burn your hand. Make sure it is un-plugged before you leave the area. And it should rest on a big metal pan, when it is in use.

Construction ideas: If you have a soldering iron, you can build these circuits on a "breadboard" - or on a copper ground plane. If you have clip leads or a "solderless breadboard", you can use that, as these circuits are not critical about big or small signals, or high impedances. When you think you have finished a circuit, check to make sure you have made it right, before you turn on the power. Make sure the power supplies do not get shorted out, as the batteries can be ruined quickly by that.

Best wishes! Have fun!
Robert A. Pease, Electronics Engineer
December 2004
Posted ~ January 2005.

THE BEST OF BOB PEASE

Vacuum-Tubes Operational Amplifiers

Here are some of the vacuum-tube operational amplifiers that form our heritage:

1. Loebe Julie's 1941 vacuum-tube operational amplifier with differential inputs.
2. 1942 M-IX Gun Director Operational Amplifier (which needed 5 precision regulated power supplies). **(printer version)**
3. 1950-era operational amplifier for Nike Missiles.
4. Data sheet, Philbrick K2-W. (page 1, page 2) **(printer version: page1, page2)**
5. Expanded Schematic Diagram, Philbrick K2-W. **(printer version)**
6. Data sheet, Philbrick K2-XA. (page 1, page 2) **(printer version: page1, page2)**

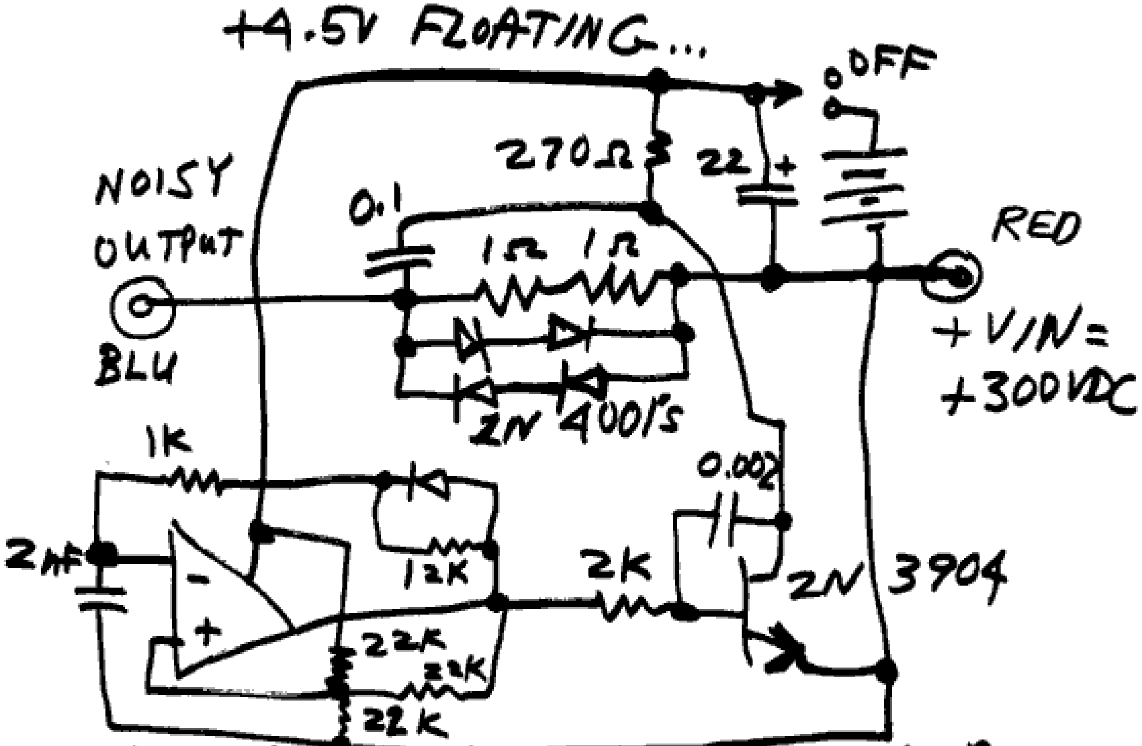
THE BEST OF BOB PEASE

What's All This Ripple Rejection Stuff, Anyhow?

These are the Schematic Diagrams of the 3 circuits I employed, NoiseMaker and Level-Shifter and Preamp Circuits, to use with "Ripple-Rejection Stuff" columns, to evaluate the low-noise, low-ripple circuits in Electronic Design:

- "What's All This Ripple Rejection Stuff, Anyway?" Part 1 (Jan 2002)
- "What's All This Ripple Rejection Stuff, Anyway?" Part 2 (Nov 2002)
- "What's All This Ripple Rejection Stuff, Anyway?" Part 3 (Dec 2002)

Diagram 1
Diagram 2
Diagram 3



LMC 6681, 26KHz OSCILLATOR

FIGURE c., NOISE-MAKER

Top

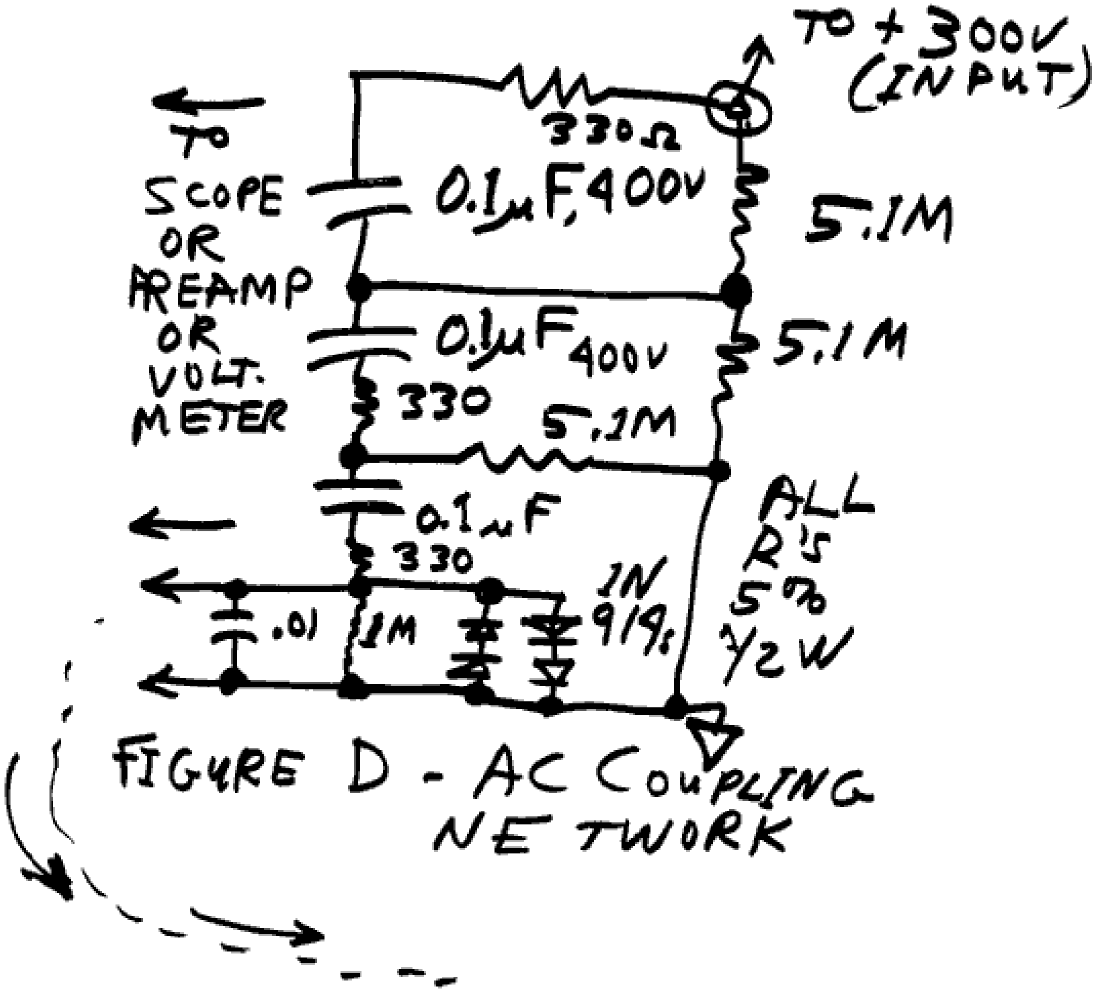


FIGURE D - AC COUPLING NETWORK

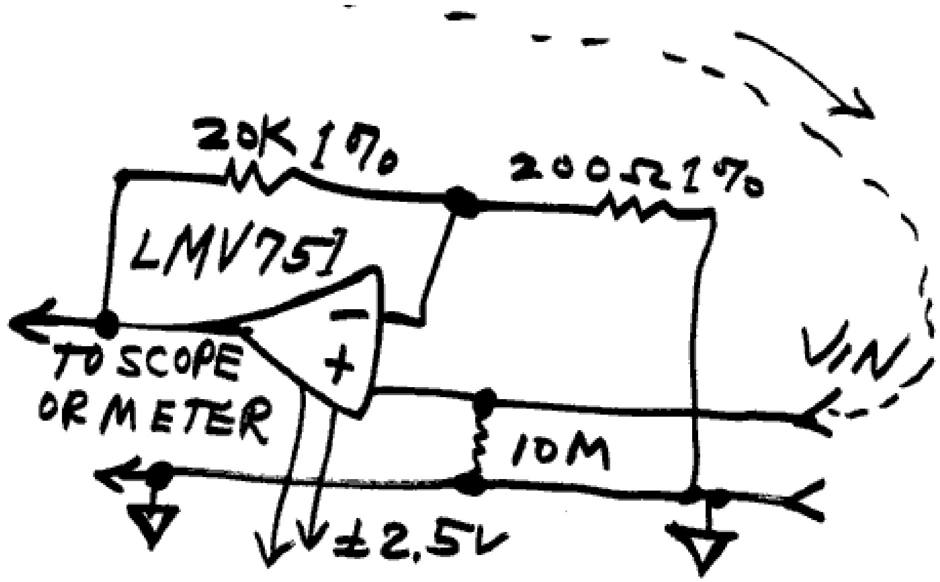
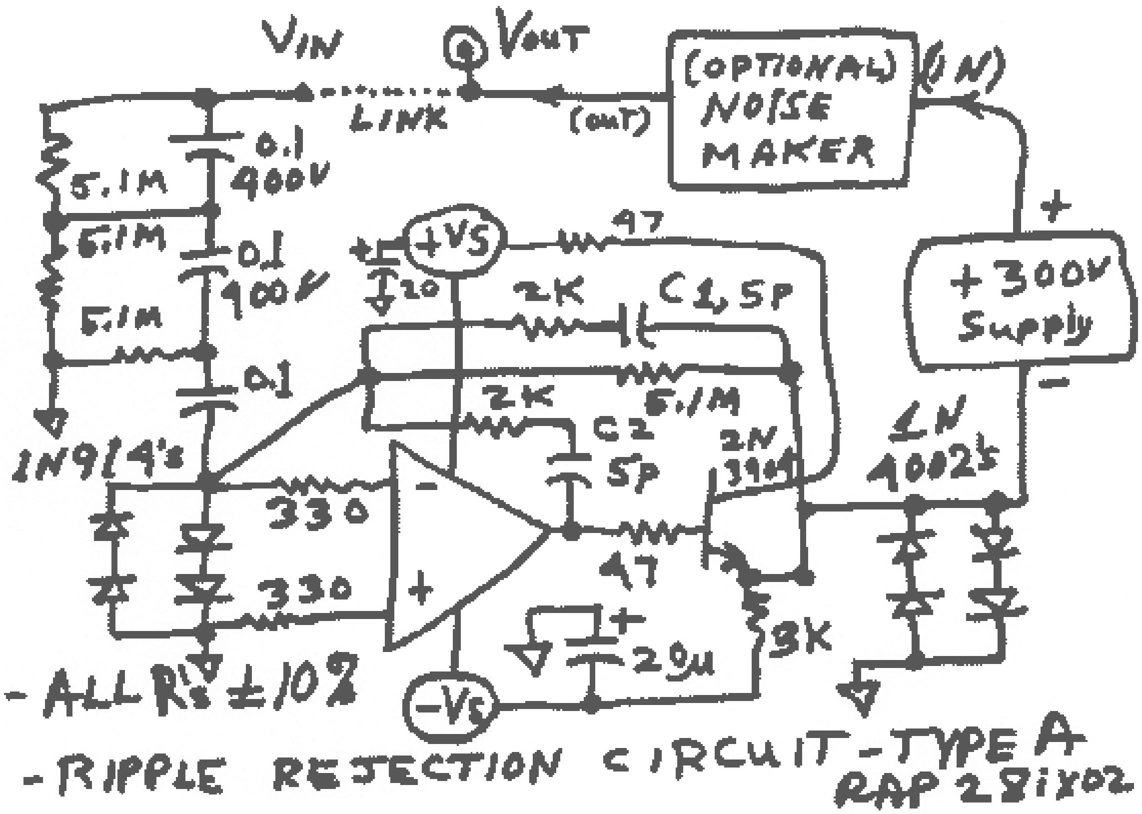


Figure E, LOW-NOISE PREAMP
G = 100

(ALL POWER SUPPLIES WELL-BYPASSED)

Top



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THE BEST OF BOB PEASE

What's All this Trekking Stuff, Anyhow? - Maxi-Report

This is my Maxi-Report on our successful Trek around the Annapurna Circuit, in Nepal, in November of 1997. It has gone out to some people by snail mail, and to others by e-mail. This is a long report, about 26 pages, and if you print it out, it may be easier to handle than just reading it on-screen. Some topics are covered in more detail than you would ever want to know, and you can ignore or skim or skip over those. I hope some of the info, detail, etc., tells you as much as you want to know about our Trek that was so pleasant, in Nepal. It is not my intention to show that I can go to strange places. Rather, it's to show that any good hiker would really enjoy a trek like this. / R. A. Pease, February 1998.

The following links continue the adventure to Nepal.

1. Opening
2. Equipment & Photography
3. The Head Cook - Buddi
4. GPS STUFF
5. More information about Trekking
6. Peter Owens' Staff
7. Diary - Nepal, November Stroll, 1997
8. Conclusion
9. Nepal Photograph Gallery
10. MAXI-Report about our October 2000 Trek to the Everest Area - Part 1
11. MAXI-Report on Trek to the Everest Area - Part 2
12. Midi-Report on Climbing Mt. Fuji in Japan
13. Invitation to our next trek in Nepal
14. A Bicycle Trek - June 2002 - around The Annapurna Circuit
15. A Bicycle Trek - June 2002 - Day by Day
16. Trekking in the Annapurna Sanctuary, November 2005
17. Winter Backpacking in NH - to Crag Cabin on Mt. Adams

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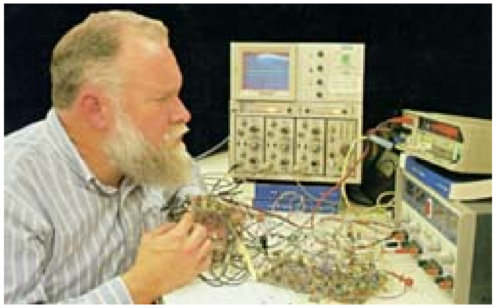

Robert A. Pease, *National Semiconductor*

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THE BEST OF BOB PEASE

Horrible Pictures

- Bob Pease - Czar of Band-Gap References
- Robert Widlar - Creator of the IC Op Amp
- Sheep - At Work
- Hiking - Away from the Office
- Archeology?
- Abominable Snowman?
- Too fuzzy?
- - The following pictures were taken at Pashupatinath in Kathmandu, Nepal:
  - Nancy and Bob and friends
  - Friends, close up
  - More friends
  - More friends

THE BEST OF BOB PEASE

- RAP's List of Good Websites
- RAP's Check List for Business Travel
- RAP's Check List for Backpacking Trips and Summer Mountaineering

THE BEST OF BOB PEASE

THE BEST OF BOB PEASE

What's All This Neatness Stuff, Anyhow?

Once upon a time, there was a rapidly converging conflict: My boss thought my office was getting messier and messier, and he wanted me to make it neater. Now, this was just a year or so after my desk had won a $500 prize for being the "Ugliest Desk in Northern California." So I guess he thought he was justified in pressuring me to clean up my act. He solved that problem by making it one of my goals to get my office to an acceptable (whatever that meant) level of neatness. Well, we never found out what that meant. Every time he would ask me how I was coming on the neatness campaign, I would tell him all of the other things I was doing to help our customers.

What if I came in on a Saturday with good intentions of neatening up some of my office, and the phone rang. Should I tell the customer, "No, I won't help you, I have more important things to do"?

So every year he would mark me down points in my review for not fulfilling my goals. He finally got so discouraged that he left the company. The poor guy. He just wasn't devious enough! He could have waited until the next earthquake and told one of the guys to knock over a couple of my piles of papers. Then he could then explain that I had to get it at least to a reasonable level of *safety*. But he never figured that out, and I didn't tell him until after he left.

Some people keep their desk neat because that's what feels good to them. I find that neatness is not a priority compared to a number of other things, such as answering the phone when a guy needs help, or volunteering advice when a customer has a problem. Some people find it easy to keep a neat desk because they throw out things that make it look messy. I just don't operate that way.

One time I was working on a Saturday after being at National just a few months. My desk was already stack up pretty high. Another guy was at his desk, which had just a few dozen things on it. He was picking them up, one by one, studying them, and then throwing most of them in the wastebasket. I commented, "You sure do keep your desk neat." He said, "Yeah, if I find something I don't need, I throw it out." I said, "Doesn't your wife ever get nervous?" He replied, "It's my third wife ..." No, I don't operate that way.

One day, an engineer stepped gingerly into the entry way of my office and asked, "Bob, do you have a Siliconix catalog?" I replied, "Sean ... you're standing on it." He looked down and, indeed, he was. He was impressed. But I knew right where it was, because I had recently tossed it over by the doorway so I could then put it in the bookcase by the door. Sean just happened to walk in before I put it in the bookcase.

More recently, I inherited a couple of filing cabinets and a huge 7 ft. x 3 ft. x 7 ft. cabinet from a Fairchild laboratory.

Our secretary explained that I would have to junk it unless I could find a use for it. I said, "Well, I could always put it in my office." She looked at this huge ark and said, aghast, "No, you couldn't do *that*."

I thought about it. I got a yardstick, and I figured out that, with an inch to spare, I *could* do that. My technician and I spent nearly all morning reassembling that cabinet and easing it into the corner of my office. I put about 1/3 of a million cubic inches of my paperwork into that, and into the other file cabinets, and improved the appearance of my office so much that our senior secretary admitted that I qualified for an "Enviros Award." In the past, the various departments would vie to achieve cleaner clean rooms and higher-yield fab lines by having better cleanliness. A whole department of 20 or 30 people would work real hard to cut down the number of *particles* in their area and win an Enviros Award. But I got my Enviros Award single-handedly. I hate to guess how many particles I straightened up.

Right now, my office seems to be in the getting-messier-again phase. When I have to review a mask set, with precision down to the last tenth of a micron, I get my head in the right mood to do that. And when I'm done, in sheer rebellion I guess, I abandon the neatness for a while. I save what seems to me to be of value. Often that includes documents and papers and notes that other people would think aren't very valuable - until they come to see me years later, hoping I might have the information they need. Often I do. Go ahead, call me *retentive*. See if I care.

Now that the NBS has changed its name to the "NIST" or "National Institute of Standards and Technology," I have figured out the next way to enhance the neatness of my office. I'm going to buy a big dresser with 6 big drawers and a mirror and everything. I'm going to put it right at the entrance of my office, and put our ultra-precision resistors and capacitors in those dresser drawers. And I'm going to call it "The National Bureau of Standards."

Comments invited! / RAP
Robert A. Pease / Engineer

Originally published in Electronic Design,
October 25, 1990.

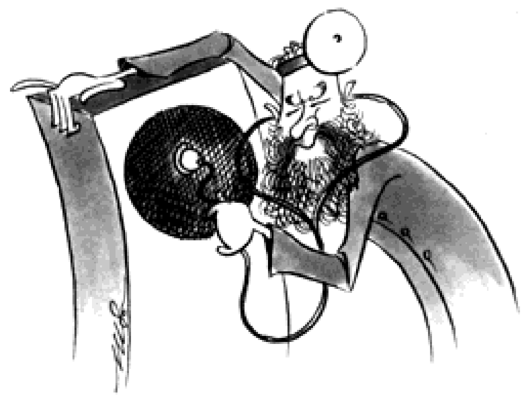
RAP Update: *This was the fourth column I wrote, the fourth to be published. And suddenly I began to get some Fan Mail. A lot of people said they had desks that were pretty close behind mine in sheer messiness. My desk still is a Federal Disaster Area. I tried to put a recent picture of my desk in this web page, but it isn't even recognizable as a desk. Is it?*

THE BEST OF BOB PEASE

What's All This Splicing Stuff, Anyhow?

Several months ago, a reader wrote in to one of the local newspapers: "If I want to move my speakers a few feet further from my amplifiers, can I splice in a few more feet of speaker cable, or should I buy all new cable? My brother-in-law claims that splicing would hamper the sound." The resident expert at the paper stated that the brother-in-law was wise, as the spliced wire would give inferior audio results.

I promptly wrote in to the resident expert, asking him on what basis he could say this. Was he claiming that *he* could *hear* the difference? I demanded that he show us readers how the spliced wire could possibly make any difference. I challenged him to listen to any music, under any audio conditions, and I would swap in various pieces of speaker wire (enclosed in boxes, on a double-blind basis) that had 0 or 1 or 2 or 6 or 12 splices. How, short of clairvoyance, could he tell which wire had the splices, using ordinary audio-frequency signals? Of course, if you used an impedance analyzer with a bandwidth of several gigahertz, you could "see" some of the splices. But, for good high-fidelity audio, there's no way you could discern this, especially as a splice may make the wire's impedance lower or higher or unchanged.



The expert, with his "golden ears" and all, never wrote back. So, I sent my criticism to one of the local skeptics' groups called "BASIS," the Bay Area Skeptics Information Sheet.

They edited it lightly, and in their newsletter, they printed my complaint, which amounted to this: If a person claims to talk to the dead, or summon spirits, or show extrasensory perception, then we must apply some skepticism so as not to encourage gullible persons to invest their money in these hoaxes.

But if a person who is endorsed as the "high-fidelity expert" says that you can hear the difference between spliced and unspliced wires, then we, as technical people, have an obligation to express our doubts and our skepticism. Why should a hi-fi salesman be able to sell a bright-eyed yuppie a $50 hank of speaker wire, (or $100 or $200 or $400 or more, which is where the really high-end speaker wire is priced these days - believe it or not) just because an "expert" says it's *better* to buy new wires rather than splice on a few extra feet? Obviously, ethics in technical electronics and science is involved here.

Many hi-fi experts, with their "golden ears," claim that they can hear differences in sophisticated speakers, expensive amplifiers, or just fancy wires, that I can't possibly discern or detect. It might take many thousands of dollars to just buy the equipment and duplicate the experiment. And, their ears might be correct - much more discerning than mine, more than I could imagine. But, when the "expert" talks about wire and splices, then I find myself compelled to comment and raise doubts. There are some experiments that even I can propose and that I could conduct, that would be decisive, if the "expert" did not duck the challenge.

Now, there are many persons who have *golden* ears and will claim that they can easily distinguish between *good, better,* and *best-quality* speaker cables. However, when these persons are invited to a double-blind test, they usually have a strong tendency to demur. Some people like to call this *the shyness factor*. Other people liken this to the tendency of cockroaches to scuttle into a dark corner when the lights are turned on.

I was only slightly concerned about how to conduct the test, because to do a fair test, you might have to change back and forth from, say, speaker wire #1 to speaker wire #2 or #6. If you do that with screwdrivers and pliers, it might take a long time to make the changes; a critical listener's judgment might be affected by long delays, and it would be unfair to ask for good judgment under those conditions. But if I proposed to use a number of selector switches, the man with the "golden ears" might argue that the switch's impedance would be worse than the splices, so a switch would be suspect! No, you can't use switches when you want to do an A-B comparison!

But in the last few weeks, the hi-fi review column of this "expert" was discussing how he compares different speakers: He said to change from one set of speakers to another, he uses switches! I just hope the switches don't cloud his judgment, as if they were (God forbid) *splices.*

Comments invited! / RAP
Robert A. Pease / Engineer

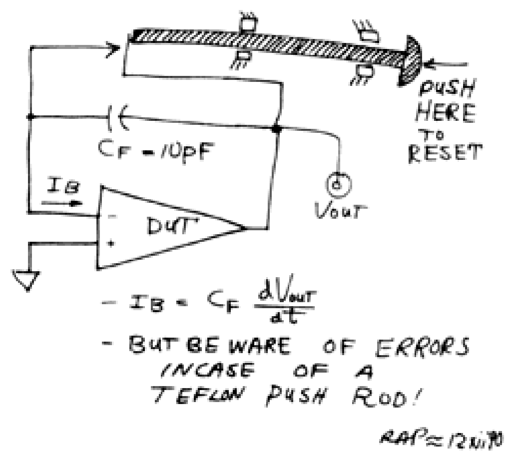
Originally published in Electronic Design,
December 27, 1990.

RAP Update: *This was my ninth column, and I got a LOT of fan mail on this, dozens and dozens of letters. People sent me all sorts of advertising pages for outrageous claims on speaker cables. Some of this material went into my 1994 column on Hoaxes, and some of the ideas were brought into the recent one on Speaker Cables. Now that Tom Nousaine has established that nobody can tell any difference between speaker cables, the conceit of this fellow, Harry Somerfield, that he could hear the difference between spliced and un-spliced cables, is seen to be just hilarious - as it was at the time. I sent Harry Somerfield a challenge, to tell how many splices were in the wires in each of 10 sealed boxes. Are you surprised that he didn't ever reply?*

THE BEST OF BOB PEASE

What's All This Teflon Stuff, Anyhow?

Once upon a time, a long time ago, a friend of mine, Arnie Liberman, designed a really good operational amplifier with a very low bias current - less than 0.1 pA. Now, when you want to measure and test a current as small as that, you don't just measure the I x R drop across a resistor, because even with a 100,000-MOhm resistor, it's hard to get resolution or accuracy. (0.1 picoamperes x 100 kMOhm = just 10 mV). So Arnie set up a test with an integrator. If this amplifier had an output drift rate (or ramp rate) of 5 mV/s with a feedback capacitor of 10 pF, that would prove that the amplifier's input current was 5 milli x 10 pico, or 50 femtoamperes.



But you can't just run an integrator without resetting it occasionally. And Arnie knew you could not easily find a relay that would short out the feedback capacitor without introducing lots of leakage and a bad jump when you turned off the drive to the relay's coil. So he made up a "relay" by applying a lever to a long push-rod which reached into the sealed box where the test was going on. The push-rod would close the contacts and short out the capacitor. Then when you backed off on the push-rod, the integrator would integrate the current, and all you have to do is measure the output's dV/dt to tell if the input current was within spec. And this worked fine, even at the level of small femtoamperes.

It worked fine in 1971 ... it worked okay in 1972 ... it worked in 1973. But after you started the test, you had to wait many seconds for the output dV/dt to stabilize to the point where you could get the right answer. Later, in 1973, you had to wait almost a minute to get the right answer.

In 1974, when you had to wait 3 or 4 minutes to get any valid reading, somebody in Production Test finally complained to Arnie that you couldn't get very many units tested in a day. So Arnie went to trouble-shoot the test fixture. And he was puzzled for a while. What could cause such an erroneous reading? Soon, he realized that the push-rod was the culprit. If you pushed it back and forth, just a tiny bit, the integrator went berserk. But how could that be? The push-rod was made of Teflon. And it slid in Teflon bushings. How could there be a big error caused by the push-rod?

But as it turned out, that was indeed *exactly* the problem. When the push-rod slid in its bushing, it generated thousands and thousands of volts of static electricity. Now, on most ordinary insulators, those charges would drain off shortly. But because Teflon is such a good insulator, the charges would bleed off over a long, *long* time (through the air). Some of this charge would go into the summing point of the amplifier - for many seconds.

As the Teflon got drier with time, the time constant got longer and longer until he had to fix it. Arnie replaced the Teflon push-rod and Teflon bushing with a grounded metal push-rod, in a grounded bushing, with just a tiny sliver of Teflon insulator on the end that pushed against the switch contacts. The problem was banished. It just goes to show that if you have the *best* materials, and the *finest* concept, and you misapply things just a *little*, you can get some *terrible* results.

Recently, I was testing some of my operational amplifiers, LPC662's, with MOSFET inputs. The bias current was consistently down in the 2- or 3-fA area. It was so small that it really was hard to measure. I had a 10-pF integrator running, similar to Arnie's, but I was trying to get 20 times greater resolution. The resolution was marginal, as there were some jumps in the signal. The signal had long tails and additional errors if you tested a good amplifier after a bad one had pegged. And the switches didn't always give zero error on a damp day. So I wrote down a list of the fixes I needed, and I set my new technician Paul to work on them.

Paul made some imaginative and bold improvements. I had suggested that he should plot the ramp on a strip-chart recorder. Paul set up a digitizing scope and programmed it to spit out the answer scaled directly in femtoamperes.

I asked Paul to set up a simple circuit to drive a 6-V reed relay so there wouldn't be much charge coupled into the circuit from the voltage that drives the coil. Paul set up a clever adaptive circuit to take advantage of the small difference between the relay's pull-in and drop-out current, so that he fed the coil 2.6 V all of the time. You only had to hit the coil with a small pulse of voltage, positive or negative, to close or open the contacts, respectively.

I cautioned him that if the wires wiggle, they can couple a lot of charge and noise into the input. Paul strung the whole circuit up on rubber bands, as a shock mount, so that people walking on the floor nearby would not ruin the measurement.

Also, I cautioned him that we would soon need a good, low-leakage socket, guarded with Teflon insulation. Again, Paul gave me better than I asked for, with a big slab of Teflon for all of the components to be mounted on or above.

I explained to Paul that the slow recovery from overload was caused by the silver-mica feedback capacitor which had poor dielectric absorption. I gave him a capacitor that I had made - filled with air - about 0.5-in.-by-2 in.-by-4-in. of air, to make a 5-pF capacitor. It had copper plates and guarded copper side-frames.

Now, first of all, why am I telling you all of these details? If I design a tester with greatly improved performance to help me test a really high-performance product, why should I tell all our competitors so that anybody in the world can test their products using the improved tester? Why should I give away all of these hard-earned secrets?

Here's a preliminary answer: It's probably true that some competitors might learn how to test better and faster if I give them my techniques. But my customers will also learn faster. There are more of them, and it's more important to teach them, because they're still trying to come up the learning curve. There's not much point in keeping secrets about testing if our customers are kept in the dark. It's just not fair to make your customers guess what is a good way to test your products.

Note that that is *not* the same as telling the customer exactly how we test it (we have testers, big expensive Teradyne setups, with monstrous interface boxes and complex software, and it would be much too complicated to tell everybody exactly how we run each test). But we do feel obligated to give any customer a good, valid test circuit that gives the same data as our production tests.

Okay. Paul set up this fixture. But there were a few little problems. For one, the output ramp would occasionally give a jump at random times. This jumping seemed worse than previously. Also, I asked Paul to test a whole group of parts, and he said, well, it would take longer than one day to test those parts.

OH?? I knew Paul could test those parts in less than a day - unless there was something wrong. I asked, well, why can't you test a part in a minute or two? He replied, "The output is off-scale and doesn't even come on-scale for 2 minutes." That didn't seem right. It wasn't until 3 days later that I slapped myself on the forehead at 6 a.m. - it was the Teflon factor. Paul had added lots of Teflon around the circuit, and the charge stored on its surface was the major cause of the long tails. When I got to work, I asked Paul to cover up as much of the Teflon as he could with aluminum foil - and ground it. He said the settling got a *lot* better. So he then removed all of the Teflon, and the slow settling went away. Just like Arnie's problem and Arnie's solution, 16 years earlier!

The next problem was with those darn' jumps. Now, we could program the tester, not just to test the ramp for 60 seconds, but to test for six 10-second segments. If the answer was the same for 3 or 4 of the segments, then that is probably valid data and we should just ignore segments where the data had a big JUMP. Yes, we could do that. But, where did these jump errors come in?

The jumps were only 10 mV or so, always in the same direction, and at random times. Older fixtures did not have as many jumps. Why? The answer seemed to be related to that nice big feedback capacitor I had made. The circuit did have fast settling - not such a long tail as the older silver-mica feedback caps. But Paul spotted some literature - some Keithley data sheets - and some notes in Jiri Dostal's book* about cosmic rays and charge.

Dostal observed that when a cosmic ray or alpha particle or other energetic subatomic particle passes through matter, it often causes a discharge of electrons. If there's a sensitive detector nearby, some charge may come through the air and cause several thousand electrons to arrive at the detector.

Not just one electron, but several thousand - hey, that was the size of the jumps we were seeing - 5 pF x 10mV is about 50 femtocoulombs, equal to 300,000 electrons. So we researched a little more and realized that if we made a smaller volume of air adjacent to the delicate summing point of the amplifier under test, we should be able to cut down on the rep rate of these little jumps. So we're now preparing two feedback capacitors. We're not sure which one we will use, but they should both work quite well.

One has an air dielectric, but it's only 1 in. by 1.2 in. with 0.080-in. spacing between the plates. It will have less than 1/10th of the volume of the old air capacitor. The other feedback capacitor will use about 5 inches of twisted pair, using one piece of bare bus wire, and another wire with sleeving made of ... Teflon. If you put it in the right place, Teflon is really good stuff. Some time I will tell more about which capacitor we used, and the other details we need to test for femtoamperes. Sockets?? Relays?? Ha!!

Comments invited! / RAP
Robert A. Pease / Engineer

*Jiri Dostal, Operational Amplifiers, Order from Butterworth-Heinemann (1-800-366-2665). About $50.

Originally published in Electronic Design,
February 14, 1991.

RAP Update: *When we published in February of 1991, I knew I would add some more comments on the measurement of low-level currents, some time later. I didn't realize it would take until 1994. We decided not to make you wait so long in this issue, so we put that column NEXT.*

THE BEST OF BOB PEASE

What's All This Femtoampere Stuff, Anyhow?

Awhile back, I mentioned [1] that we needed a clean test fixture to measure an operational amplifier's input current in the low femtoampere region. But aside from a neat little integrating capacitor made of copper and air, what else did we need?

Here's a list:

A circuit to let us make a high-resolution measurement.

- Ultra-low-leakage sockets.
- A relay to reset the integrator.
- A box to hold and cover up the whole thing.
- A little computer to interpret the data.
- And a scheme for calibration.

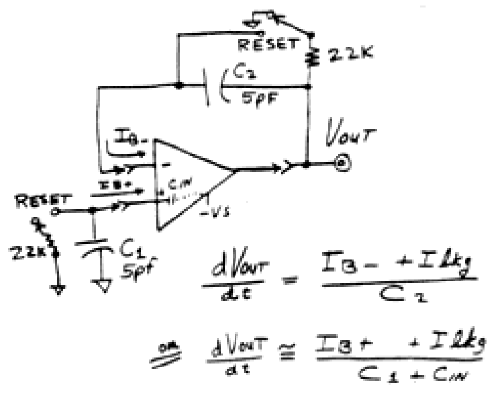
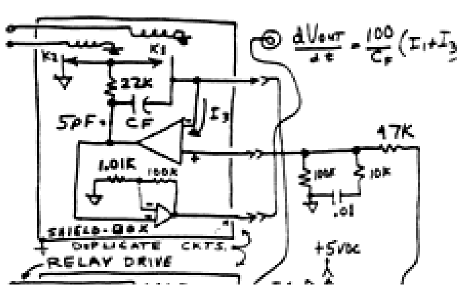


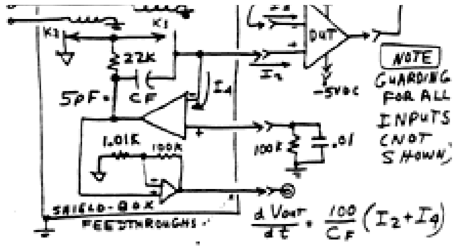
Figure 1 Basic Test for Sub-picoampere currents

If we take one op amp and force it to integrate the current at its negative input, it can do that job quite well (*Figure 1*). But what if its socket is leaky? How can you tell if the error is the leakage of the amplifier or the leakage of the socket?? You'd like to be able to autozero that socket's leakage error out of the circuit. But you can't do that if the amplifier is unable to measure anything when it's not plugged in. A further weakness is that when you try to measure the current at the amplifier's + input, the equation for dV_{out}/dt says that the amount of stray capacitance at the + input affects the scale factor. So, the circuit of Figure 1 would not be very practical.

FIGURE 2. PRECISION FEMTOAMPERE INTEGRATOR RAP ≈ JULY 1993



Let's move on to Figure 2. Here, we use two low-leakage amplifiers to test both inputs of one op amp - the Device Under Test, or DUT. When the DUT is removed, the socket leakage and fixture leakage can be calibrated out, in an autozero cycle, so long as they are small and stable. However, this scheme is excellent primarily because we can pretend to plug in a DUT without actually plugging in anything, and then say, "What is the bias current of *this* amplifier?" The answer had better be ZERO, give or take a few dozen attoamperes (an attoampere is 10^{-18} amperes, about 6 electrons per second). Now, in this circuit, the voltage



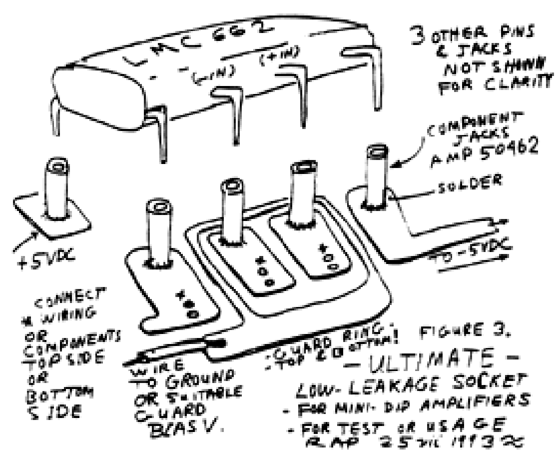
at the + input and at the - input are both constant voltages, so the capacitance from these nodes to ground don't affect the accuracy of the measurement.

Of course, we have to get some good test amplifiers with low noise. The LPC661 and LMC662 are quite adequate, with only small femtoamperes of input bias current that doesn't drift much, and not much noise.

We also need some insulation. If we can't use a lot of Teflon (as I mentioned in my Teflon column) what can we use? Well, we can use some air. It does not leak much, if you only have a little of it. Now, if you have a *lot* of air, it may permit "leakage" of some electrons, occasionally, due to cosmic rays. But if we keep the total amount of air around the delicate nodes down to a couple cubic inches, that's not so bad. The other material we like to use for an insulator is the body of the plastic-DIP ICs. This has an impedance up near 10^{16} ohms, which is about as good as you need. If the part gets dirty, or dusty, or gets fingerprints on it, just wash it in your dishwasher and you can get the package back pretty close to when it first came out of the molding procedure. When you buy an LMxxx in a plastic DIP package, untouched by human hands, it's really a *very* clean package. Ceramic DIP packages, on the other hand, aren't nearly as low in leakage, more like 10^{14} ohms - not very good for precision work at subpicoampere levels.

How about a socket? Can you buy a good Teflon[2] socket? If you could, that might simplify things. However, for many IC packages, you can't buy one, so you'll just have to make one, which is MUCH better than anything you can buy.

If you make a pc board in the pattern shown in Figure 3, and then solder some little component jacks[3] onto the printed-circuit lands, you can get a socket with less than a femtoampere of leakage, due to the guarding. The guard ring is at the same voltage as the inputs, give or take a couple of millivolts, so there's no direct leakage path from the power-supply buses to the inputs. (Additional notes on guarding are found in various NSC data sheets, such as LF198 or LMC662, available on request.)



As long as those sub-femtoampere leakages are fairly constant from one minute to the next, accuracy won't be hurt at all. This pc board can be made of Teflon material or polyimide if the highest precision is needed. Even glass epoxy board material usually works very well, due to the guarding *on both sides* of the foil.

How do you make a low-leakage capacitor? In the earlier column, I said that we had made a big 5-pF air-dielectric capacitor with copper-clad walls. For the improved version, we made a *small* box with copper-clad walls, still about 5 pF, and there's NO detectable leakage from one plate to the other. When we made a little Teflon capacitor out of several inches of Teflon-insulated twisted-pair wire, well, that also was up near 10^{17} ohms. Not bad. We evaluated both of these and they both worked well. But my sneaky technician is always trying to find something a little better than my best idea. He tried a 4-inch segment of Teflon-insulated coax cable. In terms of dielectric absorption, it was not quite as good as the air capacitor. But in terms of spurious jumps, it was better, as there was a minimum amount of air around the summing point with fairly optimum shielding. So, once again my technician outsmarted me! I love it!

Okay, wise guy, where do you buy your relay? Or do you make *that*, too? Well, we were prepared to make or modify an unshielded relay, but we were able to buy a standard Coto relay, model 1240-12-2104.[4]

This model has a shield between the coil and the reed, which seems to cut down the capacitance to about 0.1 pF.

Then turning the relay off does not really couple very much charge at all into the summing point, electrostatically.

Additionally we shield and guard everything so that there's a wall between the input and the rest of the relay (K1).

Then we add another relay K2 to ensure that the other end of the relay is held at 0 volts during the test, even if the integrator's output goes off to 2 or 3 volts.

So, the 10^{14} ohms from one end of the reed to the other has no effect, since there's never any voltage across the relay during the test. Also, we drive the relay's coil with the minimum amount needed for pull-in and drop-out - not 12 volts and 0 volts, but 5.5 volts and 2 volts. This helps decrease the jumps.

What do we do to compute the result? We have a Teradyne tester programmed to read the integrator's delta V_{out} over six 10-second periods. If any 4 give about the same data, it's programmed to admit that the data are valid. We're prepared to ignore cases when a JUMP occurs. But if it's too jumpy, we just reject that part. Right now, after a preliminary study of a few thousand parts, we have yet to find a really bad part at the 20-femtoampere level. That's encouraging, both from the standpoint of the fixture and the amplifier.

How do we put this all in a box? We use a lot of copper-clad to help us build up boxes of every necessary size to shield out all electrostatic interference. We keep power transformers FAR away to cut down on magnetically-coupled noises. We set up four channels of femtoampere testing to look at all four inputs of a dual op-amp. We made things modular, so we can easily pull out a test channel or a socket for cleaning - or for replacement. As with any precision tester, we're reasonably meticulous in our assembly.

We guard the power-supply leads away from the signals and the inputs, because any mechanical motion of the power-supply bus can couple into the summing points. After all, as Q = C x V, we say that by definition I = dQ/dt. Now normally, the major component of dQ/dt is C dV/dt, but there is also a term V dC/dt. If there is a big voltage-such as 5 volts - then V dC/dt can be a significant term.

For example, if dC/dt is 0.01 pF per millisecond, due to vibration of wires, then 5 V x 0.01 pF per milli-second can cause a "noise" of 0.05 pA, or 50 fA. That "noise" goes away if you guard the power- supply buses, and/or if you prevent unwanted motion or vibration.

How do we calibrate the fixture? For a full-scale signal, you can add in a current through a capacitor. In other words, you can get a full-scale signal from this setup by applying a 0.1-volts-per-second ramp to a 1.0-pF capacitor, which represents 100 fA or 0.1 pA. We have an old General Radio standard capacitor; type 1403-K, accurate to 0.1%.

To get calibration at the "Zero" level, do not insert a DUT, close up the box, and do the test. The number of femtoamperes during this "dummy test" should be consistently the same as during an "autozero" test, so the delta should be very small, down in the noise, and consistently below 1 fA. That's important.

We think we can get good results in production with this fixture, although it's pretty early. We can't say that every problem has been vanquished, but we're sure we can solve every problem.

Comments invited! / RAP
Robert A. Pease / Engineer

1. "What's All This Teflon Stuff, Anyhow?," Electronic Design, Feb. 14, 1991.
2. Teflon is a trademark of E.I. DuPont de Nemours.
3. Type 50462; AMP, P.O. Box 3608, Harrisburg, PA 17105.
4. Coto Corp., 55 Dupont Dr., Providence, RI 02907.

P.S. If you're interested in an op amp with I_B guaranteed less than 0.025 pA, ask about the LMC6001. - RAP

Originally published in Electronic Design,
September 2, 1993.

RAP Update: *One reader wrote in to recommend that for best results, you should add a lot of extra plated-through holes, stitched all around the perimeter of the guard ring. This will help prevent leakage through the VOLUME of the board material. And another reader recommended milling slots instead of the guard ring. That's a pretty good idea, too!*

THE BEST OF BOB PEASE

What's All This Cost-Accounting Stuff, Anyhow?

Once upon a time, I was down at Lewis' Restaurant in Norwood, Mass., waiting in line to order a Lewisburger, which was a fantastic hamburger with blue-cheese dressing and potato salad and ham. A voice came booming across the noisy restaurant, "Hi Bob." I replied, "Hello Maurice, what's new?" Maurice wandered over and said, "How come you are still using the wrong formula, the *old formula*, for Factory Cost?" I responded, "Old formula? I never heard of a new formula. You mean the formula of Parts Cost + 450% of Labor Cost is obsoleted?" Maurice said, "Oh, that's been obsolete for months. Didn't anybody tell you? The *new* Factory Cost is 2 x Parts Cost + 3 x Labor Cost." Well, I ordered my Lewisburger, and ate lunch and bantered with my friends. But on the way back to my office, the wheels began going around in my head. How could they change the formula for Factory Cost and not inform people? How could they accept that, after "a few months," people were still using the incorrect formula, but it was no big deal? And they wouldn't bother to tell a guy unless they happened to bump into him at a restaurant? So I went to see my boss, Richard Randlett, to ask him if he knew what was going on.

He said, yes, he had heard about the new formula, but he didn't know it was officially in effect. And, besides, he didn't want to bother us with unimportant details. We should keep on engineering our designs using good judgment, as usual, and not worry about this "New Factory Cost Formula," and other academic things like that. Not a big deal. Well, okay, I went back to work. But within an hour, I was back at Richard's office.

"Hey, Richard, you know that low-cost converter I am working on?" Yeah. "Well, I was going to use a double-sided pc board, but with the new formula in effect, it would be cheaper to use a single-sided board and a few jumpers. The parts cost will go down quite a bit, but the labor will only increase a little."

Richard sat there. He thought about it for a few seconds. Then he saw red! "No, don't make that change!!" I replied, "But, Richard, the new Factory Cost Formula says it's wise to add a few seconds of labor to save a lot on parts cost." But Richard pointed out that even though that was what the bean counters were telling us to do to save money, it would be wrong. He told me to keep on optimizing the costs, assuming that Labor Costs would be multiplied by 4.5 compared to the Parts Cost. Meanwhile, he would try to get this resolved, and get the formula changed back to a reasonable proportion. He'd get me an answer within a month.

Well, one month later, Richard was still trying to get the problem resolved. Two months later he was gone, and three months later, I resigned. So to this day, I don't know how this was ever worked out. But I did know that I could not do my job if nobody would tell me the rules, and if the rules kept changing to contradict themselves. One set of rules told me that it was wise to add jumpers instead of plated through holes. And a second set of rules told me that was foolish and costly, and I should do it the other way. And if no one could tell me which rules were valid - hey, that's a problem. I needed to solve that problem, but nobody could help me resolve it. So I voted with my feet and left that company, and I haven't worried about that kind of problem. Until recently.

Of late, I was collaborating on a small regulator chip where we wanted to trim the output to high accuracy. That would take about 10 Zener- zap trims. And those would tend to take up lots of die area - probably a 50% increase over the circuit area.

Conversely, if we put in laser trims, that would keep the die size small, but the cost for trimming each die would rise considerably. How much would it rise? We did not have the cost data. And when we got the cost data, it was kind of outdated, and we did not *entirely* believe it. But the time for trimming with 10 laser cuts would basically take an extra second, due to the need to get the laser aligned with the die. And the cost of testing on a tester with a laser is about double - about 4 cents/second - versus 2 cents/second on a tester without a laser.

That is true, even for the tests when you're not using the laser. This is because the whole machine must be paid for, even if you're not utilizing all of the tester. So, 3 seconds x 4 cents/second is noticeably different than 2 seconds x 2 cents/second. For an 8-cent difference, you can pay for a much bigger die area!! So that convinced us there was probably a cost advantage if we could avoid laser trimming.

But those considerations were overruled by a more important consideration: The need to fit the die in a small package. There were some small plastic packages that the larger (cheaper) die would not fit into. Still, we realized that in the future, we will be sharpening up our pencils more often. What is the right way to keep the costs low? What are the rules in *our* business? We're not sure, but we're trying to get some of these rules nailed down. Then when it is important, we will have the rules available - and believable. And that's not a trivial statement.

What are the rules in *your* business? Do you know what they are? Do you believe them? Are they ever subjected to thoughtful scrutiny, or are they so old and dusty that you know darned well that nobody has thought about them for many years? Do people change them without understanding all of the ramifications and repercussions? Maybe it's time for a sanity check.

Comments invited! / RAP
Robert A. Pease / Engineer

Originally published in Electronic Design,
February 28, 1991.

RAP Update: *When I wrote this column in 1991, Teledyne Philbrick was still in business. Then in 1992 they went out of business. I can't imagine why ...*

THE BEST OF BOB PEASE

What's All This Mentoring Stuff, Anyhow?

Once upon a time, a new engineer came to work in our group. A woman. Now, in some areas, it's really not a surprise to have a new engineer or a woman engineer, but in our group, that did not happen very often. So when Jane arrived, we all tried to be polite and cheerful, for a change, and not just scream at her and give her a hard time, as newcomers are sometimes treated. Now, Jane was a bright young woman, but there were a lot of things that she had to ask questions about, so she would ask various people. Sometimes she would ask me, and sometimes she would ask Andy, another of the oldtime experienced engineers. We didn't just fall over ourselves to help this bright young engineer. But we did realize that the more questions we answered, and the faster we could bring her up the learning curve, the quicker we could get a lot of help out of her and turn her into a *real engineer*.

So we were reasonably cheerful at answering some of her dumb questions (like where do you find things that aren't filed or indexed rationally?), and some of her very thoughtful questions (why do we keep telling customers this or that when it's not true??). And we tried not to just throw answers at her, but to explain the reasons behind the answer.

One day, I wandered over to get some info out of a book, and Jane asked me a question. Andy had the answer quicker than I did, and I was standing around reading the book, while Andy explained the answer to Jane. When he was finished, I said, "Hey, Andy, you know, Jane is your protégée, right?" Andy agreed. I continued, "And Jane is my protégée, too, right?" Andy agreed. I then said, "And, Andy, do you know what that makes us?" Andy could not think of the correct word. I said, "That makes us dirty old men." And all *three* of us broke up into laughter. Around here, no-one and nothing is taken very seriously....

Actually, there *is* a word that applies, so if a person is my protégé (male) or protégée (female), then I am a Mentor. I attended a nifty conference on Bipolar Circuits and Technology in Minneapolis in September. I must say, although it doesn't get *nearly* as much publicity as ISSCC, it's getting to be nearly as good as ISSCC, so long as you are really interested in bipolar circuits (if you're a hard-core MOS enthusiast, there's no reason for you to come to Minneapolis in September). The after-lunch speaker this past year was Jim Williams of Linear Technology Corp., Milpitas, Calif. Jim talked about several topics, but his most serious pitch was that we must do a lot of mentoring. We can't just hire a bunch of kid engineers, ignore them, throw garbage at them, and then chew them out. We probably never *could* do that. But in the 1990s, it's reasonably easy to see that the nurturing of new or young engineers is a major part of our jobs.

When I was a kid engineer at Philbrick, I had a number of excellent teachers, engineers who taught me many different aspects of the profession. I must say, though, I was a rather *green* engineer, because I never had a hobby of ham radio, as many engineers did. In fact, I only transferred from the Physics department to become an EE in the fall of my senior year.

At Philbrick, Dr. Achard helped me appreciate technical writing. Bruce Seddon taught me a lot about worst-case design.

Al Pearlman answered lots of my questions about transistors. Bob Malter did not have much time for dumb questions, but I studied his designs and asked a few questions that were not *too* dumb. I mean, learning how to ask questions that are not too dumb is a significant part of every student's education. After studying and learning from a whole bunch of people for over a year, I was just barely able to design my way out of a paper bag - with a little help. It took me a few more years before I understood the whole picture, well enough that I could design amplifiers without too many fatal flaws, or latch-up modes, or features that did more harm than good.

So if we also want to hire good engineers to work on linear or analog circuits, we can't just find them in thin air, and we can't just hire them from our competitors. And we *certainly* can't just find them coming out of colleges. I mean, when a student graduates from a good engineering school, the best I can hope for is that the student has learned some good study habits, some good attitudes toward work, and some ability to analyze several kinds of circuits. But not everything. Can I hope that the student really knows how to design an op amp? Well, I hope that an engineer I am interviewing knows a little bit about designing *something*. If he (or she) can design and analyze some things pretty well, there's good hope I can teach them enough to come up the learning curve quickly. That's only fair. If I can make *them* look good, then they can make *me* look good.

So I should try to avoid the "mushroom treatment," not heap manure on them and leave them in the dark. I should teach them sometimes, throw problems at them other times, challenge them, and try to set a good example. I should avoid letting them get stuck, or hung up, or discouraged. I may not be able to answer every question. I may demur, or duck certain questions, and tell them to go figure it out for themselves. It's a little bit like when you have kids. You can't teach your own kids everything, but you try to steer them in a course where they can learn what they need.

I remember when our sons were just learning to read. For a while, my wife and I agreed that *each* of us would read everything that Benjamin read. After about a month, we agreed, well, one *or* the other would try to read everything Benjamin read because he was just too omnivorous for each of us to fit in the time to read everything. A month after that, we sort of gave up, as we could not possibly keep up with his appetite for reading. We tried to read samples of what he was reading. But, we had gotten him turned on and he was off to the races, devouring every kind of book and magazine that was suitable for young people, and many grown-ups' topics as well. Now that both my sons are taller than I am, they throw me an occasional bone, some good things for me to read that they can recommend. Turnabout is fair play.

Now, when we assign projects to engineers at work, I can't keep up with all of the details, and I can't know all of the answers. But I have to keep in touch, to tell if there's trouble, to facilitate the search for answers, and to prevent the guy from getting discouraged. This is even necessary for an experienced engineer! Because there really aren't many easy projects that our customers want us to do, every engineer gets some very challenging projects. Challenges are great for young engineers, but mentoring would advise you against loading on an unfairly heavy load. Similarly, I have to keep an eye on the project, to make sure the engineer doesn't make a false assumption and go barrelling down a path that is dead-end. Everybody recognizes that after it has happened, but it's a little harder to see it in advance.

Wow, Pease, it sounds like you really are in charge of a big group. How many people does Mr. Super-manager Pease have working for him? Well, about 2 engineers, 2 technicians, and one guy who is half- way up from technician to engineer. But, I must say, by default, I have given some of my technicians a lot of liberty, and they have responded by coming, up with some brilliant moves, interspersed with a few occasional marvelous blunders. So, I have 2 boys at home, and 5 boys at work, and, oh boy, do we have fun.

Comments invited! / RAP
Robert A. Pease / Engineer

Originally published in Electronic Design,
April 25, 1991.

THE BEST OF BOB PEASE

What's All This "SMWISICDSI" Stuff, Anyhow?

A long time ago, I went out to dinner with Dave Ludwig, an old friend of mine from Massachusetts. We went to a fancy Italian restaurant. After we had ordered our entrées, the waiter asked, "Would you like a salad?" I declined, but Dave said he would like one. "What would you like in your salad?" Dave said lettuce and tomatoes.

In a few minutes the salad arrived. Yes, it had lettuce and tomatoes. It had three kinds of lettuce, and tomatoes and chick-peas and croutons and onion slices and green onions and Italian cherry peppers and slices of hard-boiled egg, and three kinds of salad dressing on the side. I sat there with barely suppressed astonishment, and Dave just sat there with a quiet, resigned smile. After the waiter departed, Dave explained: There was no point in complaining or griping or hollering, because at the best, the manager or the headwaiter would just come over and say, "Hey, you don't have to eat anything you don't want, and you don't have to pay for anything you don't want, so, what's your complaint? Show Me Where It Says I Can't Do It." And he explained that he was an aficionado of these kinds of stories, which we will of course abbreviate to "SMWISICDI."

He pulled a faded clipping from his pocket. The newspaper story was about the advantages of home ownership. "If you own your own home, you can play the piano at midnight." I thought about it. I said, "Dave, I can't play the piano worth a darn. But this story says that I can play the piano at midnight if I own my own house."

Dave smiled and agreed. "You just *think* you can't play the piano. But, have you ever tried at midnight?" I had to admit that I had not. But, one of these days, I will try playing at midnight, to see if I'm any better than at any other time. What I suspect is that at 12:00:02, I'll suddenly be a rotten pianist again.

Now I, too, have gotten interested in SMWISICDI stories. In fact, last week I mailed 5 ounces of SMWISICDI stories and clippings to Dave. For example, I clipped out a story about how the Israeli Army solved the problem of what to do when Palestinians throw stones at the soldiers. The Israeli Military invented an automated stone thrower to retaliate. An eye for an eye, a tooth for a tooth - and a rock for a rock? What if the U.S. Army sent out a Request For Quote on developing, manufacturing, and deploying a rock- thrower? What if Jack Anderson got wind of this, and confronted the Joint Chiefs of Staff? They would just tell him, "Show Me Where It Says I Can't Do It."

Last week, Wanda Garrett, our senior applications engineer for amplifiers and regulators, got a phone call from an unhappy customer. He had used one of our ICs to design a switching regulator, and it didn't work well at all. The output had glitches and burps and excessive ripple and noise. The regulation was poor, the loop stability was rotten, and the efficiency wasn't even very good.

After a lot of inquiry, Wanda discovered that this person had built up the switcher on one of those solderless breadboards. OHHH!! Patiently, Wanda explained, that is exactly what you expect when you use one of those solderless beasts. The inductances are awful, the capacitances will cause crosstalk between adjacent buses, and if you try to build a switching-type regulator, *of course* it will work badly. And the customer replied. "SMWISICDI."

Now, Wanda was a little taken aback. She had to admit, of all the things that we might have told people they should not expect to work, this was one that we didn't specifically warn against. But, to put the shoe on the other foot, she asked, "Where does it say you *can* do this?" And the customer replied that in the solderless breadboard's promotional brochure, it says, "Ideal for high- frequency and high-speed/low-noise circuits." Wanda observed that was probably not quite true - neither for linear circuits, fast digital circuits, fast ADCs, nor switchers. Then she pointed out to the customer that the LM2575 data sheet does spell out: "As in any switching regulator, layout is very important. Rapidly switching currents associated with wiring inductance generate voltage transients that cause problems. For minimum stray inductance and ground loops, the length of the leads indicated by heavy lines should be kept as short as possible. Single-point grounding or ground-plane construction should be used for best results."

So we really *did* tell every customer that you need a good layout, right in the data sheet. Of course, if the customer *believes* that solderless breadboards are really great for high-frequency circuits, then we have a problem - which Wanda was able to resolve and explain. The solderless breadboards do cause many troubles.

First of all, most fast ICs, whether linear or digital, require a good ceramic power-supply bypass capacitor, right close to the IC. But with those long buses inside a solderless breadboard, it's hard to get a bypass capacitor with less than 3 or 4 inches of loop. That won't help a switcher or any other fast circuit. Then, the capacitance between adjacent buses - typically 2 to 4 pF, depending on the size - is going to cause stray coupling that will probably make the circuit unhappy. That's my experience. Furthermore, when you have a switching transistor turning off, its collector or drain can easily slew at 600V/µs or more. If your "catch" diode is spaced more than an inch from the inductor and transistor, the L di/dt can cause dozens of volts of overshoot, which may overstress the switching transistor (exceeding its voltage ratings), not to mention generating some horrible spikes in the air. And those white slabs - they are *not* Teflon. They aren't polystyrene or polyethylene, either. They are made of nylon, or something similar, so the leakage can be pretty bad on a warm or humid day. Even worse, if you push a whole lot of wires into those little solderless connectors, the little scraps of solder will get scraped off until there's a whole pile of solder scraps hidden inside. Then they can start making intermittent short-circuits between adjacent buses - won't *that* be fun to troubleshoot.

So Wanda explained all of these reasons not to use a solderless breadboard for making a switcher. She sent the customer a little PC board that was neat and compact to help him get a prototype of the circuit working - one of the LM2575 "Simple Switchers." Note, we normally think that these "Simple Switchers" cannot miss - they're very easy to apply. But, if you try to build it on a solderless breadboard, even a simple circuit can be hurt - ruined - by the strays of a poor layout. Simple, yes. But foolproof and tolerant of a truly bad layout? No.

Then she warned the rest of us Applications Engineers that customers might be having trouble when using solderless breadboards, ultimately complaining "SMWISICDI." I'm just passing on this warning to you readers.

Finally, Wanda said she was going to try to put a disclaimer in our linear databooks and applications handbooks, that the "solderless breadboards" are unsuitable for any applications other than medium-speed, medium-impedance-level, and medium-precision circuits. It may sound silly, but I know that she'll find a way to put in a caution flag where it's appropriate. I mean, Wanda is the Czarina of Linear Data Books. She can put anything she wants in there. Show Me Where It Says She Can't Do It!

Comments invited! / RAP
Robert A. Pease / Engineer

Originally published in Electronic Design,
May 9, 1991.

THE BEST OF BOB PEASE

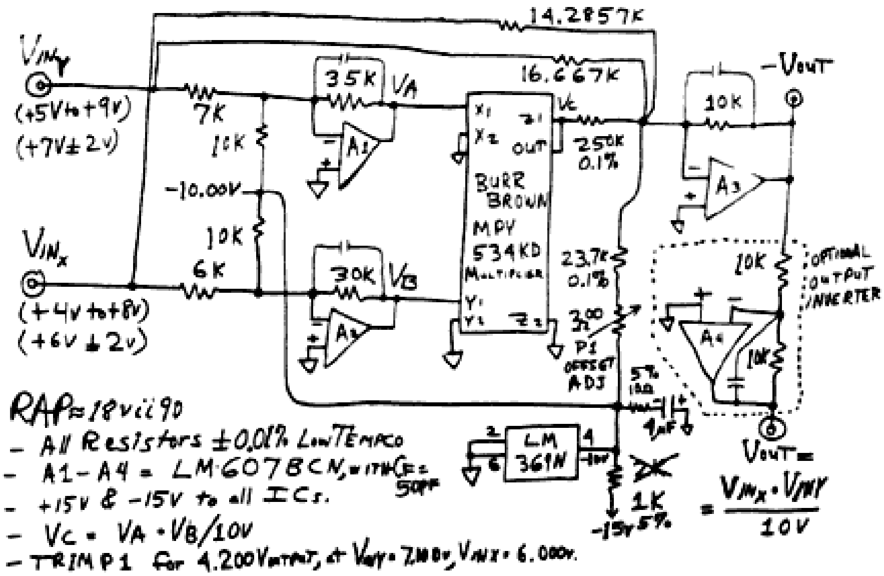
What's All This Multiplication Stuff, Anyhow?

Several months ago, I got a strange call from a "customer" (I get a lot of strange phone calls). He said he needed a multiplier circuit to do some simple multiplying, such as 5 V x 8 V, and he needed 0.02% precision. He said he had already talked to several companies that make multipliers, and they didn't have any circuits with precision nearly that good. Then he asked if we had any ideas. I gathered that he was kind of desperate, and that he had called us *even though* he knew that National doesn't make any multipliers.

I asked, "Oh, what is the range of each of your signals?" He said, "Oh, one input goes from 5 V to 9 V, and the other input goes from 4 volts to 8 volts." I replied, well, if you want 0.02% accuracy, that's a piece of cake. I could hear his jaw dropping. "How do you plan to do that?" Ah, I replied, it's really quite easy. Your dynamic range is narrow enough, so we can do an expanded-scale amplification of your signals and feed them into a decent multiplier. Then take the output voltage from the multiplier and combine it with some constant offsets and some linear-gain signals, and add them all up with some precision resistors, and there's your output.

He said, "Precision resistors - aren't they the ones that cost $10 each?" I said, "Heavens no, a couple bucks gets you some good ones." So the first thing I sent him was a description of how easy it is to buy precision wire-wound resistors (copy available on request with a SASE). I explained that the delivery can be quite good, because there are several competing companies (some of them are right down the road from each other, in southern New Hampshire) that can sell you resistors with excellent accuracy, 0.01% or better, and at reasonable prices. Delivery is also excellent, if you want to pay a little surcharge for that. When I need good resistors, I usually look in the EEM or the Gold Book, and shop around at two or three of the vendors to do a sanity check and make sure I have not over-specified or under-specified the resistors I need. I sent him a copy of that page in the EEM, "Precision Wire-wound resistors," so he had his choice of a dozen good suppliers.

Then I sent him a schematic similar to the one below. I told him I've done something like this before, and you can't go wrong.



- What do we want from our MULTIPLIER?

- We want $V_{OUT} = \frac{V_{INX} \cdot V_{INY}}{10V} \pm 0.02\%$ but only in a limited range, $4V \le V_{INX} \le 8V$ and $5V \le V_{INY} \le 9V$.

- Let's define new VARIABLES:
  - Let $(-V_A) = (V_{INY} - 7V) \cdot 5$
  - Let $(-V_B) = (V_{INX} - 6V) \cdot 5$

  and then multiply $V_A \cdot V_B$

Then $V_C = \frac{(-V_A)(-V_B)}{10V} = \frac{V_A \cdot V_B}{10V} = \frac{25(V_{INX} - 6V)(V_{INY} - 7V)}{10V}$

So $\left[\frac{V_A \cdot V_B}{10V \cdot 25}\right] = \left(\frac{V_{INX} \cdot V_{INY}}{10V}\right) - \frac{6V}{10V} V_{INY} - \frac{7V \cdot V_{INX}}{10V} + \frac{42V^2}{10V}$

REARRANGING -

$\left(\frac{V_{INX} \cdot V_{INY}}{10V}\right) = \left(\frac{V_A \cdot V_B}{10V \cdot 25}\right) + 0.6 V_{INY} + 0.7 V_{INX} - 4.2V$

- So all we have to do is generate V_A & V_B, feed them to the multiplier, and take a summation:

$V_{OUT} = \left(\frac{V_{INX} \cdot V_{INY}}{10V}\right) = \frac{V_C}{25} + 0.6 V_{INY} + 0.7 V_{INX} - 4.2V$

That is easy to do -

A_3 sums all these voltages with the required gains - the gain from V_C to V_{OUT} is $\frac{1}{25}$;

- the gain from V_{INY} to V_{OUT} is $\frac{6}{10}$;
- the gain from V_{INX} to V_{OUT} is $\frac{7}{10}$;
- and the 237K adds in a 4.2 VOLT offset, which is trimmed for best accuracy:

When $V_{INY} = 7.000V$,
$V_{INX} = 6.000V$,
$V_A \cong V_B \cong V_C \cong 0$,
so just trim V_{OUT} to 4.200V using offset ADJUST P1.

A4 lets you have an inverted POLARITY.

RAP 2iii91

I never heard from him again. So I like to think that it worked okay for him. Then, as I began thinking of good topics and good ideas to write a column about, I remembered this problem. I fished a couple inches down in the file of papers on my desk and dug up the problem and the solution. Now, I had told this guy, "This is a guaranteed design. No problem." But, I'm not going to feed *you* any paper designs that have not been built and tested. I dropped by Haltek in Mountain View and bought a few of the resistors that I needed. Then I gave the whole batch to my technician and told him that it had to work. I said to come back when the output error is less than 2 mV.

Note, I don't usually tell my technicians that, because I'm perfectly capable of making mistakes, *every* kind of mistake.

I usually tell the tech, "Leave extra room in case we have to change some things in the input area ..." or whatever. But in this case, I just told him to leave the leads of the resistors at full length, as a sort of a strain-relief loop, so when they're soldered, it doesn't heat up the body of the resistor.

How does this circuit work? It works beautifully (no, that's not what I meant). It works by taking advantage of the full dynamic range of the multiplier. If you merely feed in a signal in the range of (+5 V to +9 V) to the terminals of the multiplier, you're using only 1/5 of the usable range or span of the multiplier. So, let's take the signal input, subtract 7 V, and amplify it by a gain of -5. *That* signal, which we feed to the input of the multiplier, now has a range of +/- 10 volts. Therefore, we're exercising the multiplier over its entire rated operating range. We do likewise for the other input. Now to get the signal at the output of the multiplier combined into the output, a gain of 1/25 is needed. The *errors* of the multiplier are also attenuated by this factor of 25 - that's the key to getting the accuracy you want. Most of the signal goes through the linear gain stages, and only a little of the output comes through the multiplier.

A reasonably-priced ($40) multiplier, such as Burr Brown's 534KD (see, I told you National doesn't make any multipliers) with an accuracy spec of 0.5%, can provide a performance of 0.02% in this circuit. Now, the amplifiers are pretty inexpensive (National's LM607BN with V_{OS}<=60 µV is barely $1.20) and the 13 precision resistors are going to cost you about $30. But, they get you to a place you could not get to otherwise.

Paul built up the circuit, and tested it at several values of V_{IN}. I must admit, he had to change one resistor value provided a 2k resistor to feed the LM369, and Paul figured out quickly that it should be 1k to provide 5 mA. The -10-V bus refused to regulate because the loads on that node drew more than the 2.5 mA I was providing through the 2k.

Vin Y	Vin X	Vout	Column 5	Verror
5.0000	4.0000	-1.999399	-2.000000	0.000601
6.0000	4.0000	-2.399693	-2.400000	0.000307
7.0000	4.0000	-2.799666	-2.800000	0.000334
8.0000	4.0000	-3.199520	-3.200000	0.000480
9.0000	4.0000	-3.599620	-3.600000	0.000380
5.0000	5.0000	-2.499626	-2.500000	0.000374
6.0000	5.0000	-2.999929	-3.000000	0.000071
7.0000	5.0000	-3.499720	-3.500000	0.000280
8.0000	5.0000	-3.999440	-4.000000	0.000560
9.0000	5.0000	-4.499300	-4.500000	0.000700
5.0000	6.0000	-2.999830	-3.000000	0.000170
6.0000	6.0000	-3.600000	-3.600000	0.000000
7.0000	6.0000	-4.199930	-4.200000	0.000070
8.0000	6.0000	-4.799750	-4.800000	0.000250
9.0000	6.0000	-5.399350	-5.400000	0.000650
5.0000	7.0000	-3.500170	-3.500000	-0.000170
6.0000	7.0000	-4.200100	-4.200000	-0.000100
7.0000	7.0000	-4.900130	-4.900000	-0.000130
8.0000	7.0000	-5.600000	-5.600000	0.000000
9.0000	7.0000	-6.299500	-6.300000	0.000500
5.0000	8.0000	-4.000470	-4.000000	-0.000470
6.0000	8.0000	-4.800290	-4.800000	-0.000290
7.0000	8.0000	-5.600360	-5.600000	-0.000360
8.0000	8.0000	-6.400360	-6.400000	-0.000360
9.0000	8.0000	-7.200230	-7.200000	-0.000230

Ideal Output V

Referring to the box of data, you can see that the worst output error was about 0.7 mV or 0.007%, about 9 times better than the accuracy of the multiplier used by itself. It's always nice to know that when you tell a guy, "This circuit can't go wrong," it really does work the way you said it would.

Comments invited! / RAP
Robert A. Pease / Engineer

P.S. I was talking about this circuit with some friends, and they agreed you could do this with digital multipliers, but that would not be cheap nor easy, either. But then I countered, how about one ADC and an MDAC? (multiplying DAC) - those things can be inexpensive and quite accurate. I'll build one of those and see if it's worth writing about.

Originally published in Electronic Design,
August 8, 1991.

RAP Update: *I've been intending for five years to build the new Multiplier with the ADC and MDAC, and I finally got it working. You'll see this column in Electronic Design in a few months.*

THE BEST OF BOB PEASE

What's All This Box Stuff, Anyhow?

There are many things I do with cardboard boxes. I stow papers in some of the nice boxes we get our Xerox paper in, and we stow circuits and parts in other boxes. And when people complain that our printers are running too loud, we glue some foam rubber inside a big box and clap it over the printer. That usually makes 13 to 18dB of improvement. The complaints are hushed, along with the printer noise.

But that's not the box I want to talk about today. I want to talk about the big (5 cubic-feet of volume) cardboard box with the Calibration Stickers on it. Most days, this box sits up on top of a tall cabinet, but about once a month we pull it down and put it to work.

About 5 years ago, we introduced a new temperature sensor IC, the LM34. It comes in a small TO-46 hermetic transistor package, and also in TO-92 plastic. And we had the production parts meeting an accuracy spec of +/-1°F, on a decent fraction of production. But how do you test a temperature sensor? And, how do you calibrate the tester? You calibrate a voltage detector by putting the same voltage into two units and making sure that you get the same answer from them. So, with a temp sensor, you have to put two (or more) parts in the same temperature environment and make sure they all give the right answer. In our case, we had several kinds of temp sensors, with a precision platinum RTD (Resistance Temperature Detector) as our primary calibration standard. It cost about $800 15 years ago, and I shudder at today's replacement cost.

So we put a little centrifugal blower to blow air through a piece of corrugated plastic hose and over some of the ICs and also over one or more of our precision calibrated platinum thermometers. We set up two sockets side-by-side so we could put in two units and cross-compare them with quicker response, because devices in the same package will have about the same time-constant.

After a few days, one of the technicians was trying to take some precise data in order to give them to other engineers as "Golden Units." The technician griped that he was getting inconsistent results - and they seemed to be related to when the parts were not shoved all the way down in the socket. Well, the I x R drop could change a little - but this part only drew 55 *microamperes*, and the IR drop could only be 100 nanovolts, whereas we were seeing 300 microvolts - equivalent to 0.03 degrees, for less than an eighth of an inch of movement.

We finally set up some parts with long leads, eschewing the socket, and moved the Device Under Test around in the airstream. We found that there were temperature *gradients* in the air flow coming out of the tube. We tried a longer hose, but that did not make the gradients much better. We thought about using a different kind of hose. But before we could do that, I decided to try a big box for the air to stir around in, to circulate and mix and swirl. Then, after a while, the air poured out onto the DUT's sockets. When we looked for gradients, they were gone, at the level of 0.003°F. So we taped the whole thing together securely. But one day we saw somebody trying to take some cardboard boxes away to make the lab look neater. We realized we had to make sure *our* box would be recognized as valuable. So we made up a big Calibration Sticker and slapped one on all four sides.

Now, we could have had a stirred oil bath, but that's messy and bulky, and the settling time isn't really much faster than moving air. And when you can use a big left-over cardboard box, the price is right, and it's more fun, too.

Could we have perhaps used a somewhat smaller cardboard box? Maybe, but we would have to do a calibration on it, and that wouldn't be worth the effort.

Now, around room temperature, this cardboard box is fine, but at hot and cold temperatures, we normally use a little oven. But everybody knows there are terrible gradients when you run it at 125°C, or -55°, or even at room temp! So we put in a box to surround the DUTs. Small help. Then we added a metal plate (about 1/8-in.-thick aluminum) so we could strap the platinum thermometer (we had a compact one, about 8 in. long) to the same plate that the DUTs were set into. Still, there were errors. The hot air coming from the oven's duct would blow on one comer of the box and heat it worse than another side of the box. And the whole process was quite slow if you kept the box cover closed. If you want to guess how many hours of tests we ran to discover which parts really had what error at what temperature, it was *plenty*.

We finally boiled the testing problem down to two problems - we had to get a quick response when we changed the temperature, as if the box were open, and we had to get minimum gradients when we were near the final temperature. We solved the problems with a box in a box. The outside box had some small slits and baffles, so the oven's air could not blow directly on the inner box. Then we put a lever on the cover so we could open the cover to get fast response for 98% of the temperature change. After that, we turned the lever and closed the cover to get a nice slow settling.

And all it took was a box inside a box, inside the oven. Could we have used cardboard for that? Well, in concept we could have, but it would get pretty flaky after just a few hours at 125°C, so of course we used copper-clad material, which was reasonably stable and easy to work with (the covers did keep warping a little bit, and we had to keep flattening them out). When the boxes were closed, the gradients between the metal plate, the 25 parts mounted in it, and the platinum sensor were really quite acceptable, <0.05°F.

Comments invited! / RAP
Robert A. Pease / Engineer

Originally published in Electronic Design,
August 22, 1991.

RAP Update: *In 1996, we had to test some more temperature sensors. We had a big oven that was not too bad for gradients - less than 1°C of error. But we wanted errors a little smaller than that. So we inserted copperclad walls to partition off a "box" inside the oven. We put in a small fan to circulate the air inside the box. Then we put in another blower to blow oven air into the box. After the air temperature inside the box was nearly settled out, we turned off the power to the blower and left the fan running. After we replaced the blower (whose plastic blades melted at +150°C) we got excellent results. And, no fancy levers to open a box's cover!*

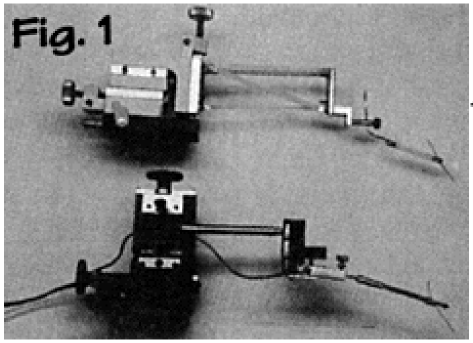
By the way, I DID do a complete write-up on the analog computer for the Platinum Sensor in the Analog Supplement of Electronic Design, June 27, 1994. If you missed that and you are interested in a copy, send me a SASE ...

THE BEST OF BOB PEASE

What's All This Copper-Clad Stuff, Anyhow?

The other day, one of our junior engineers told me enthusiastically, "I solved that oscillation problem on the new circuit. I just put down the probe on that sensitive node I suspected, and the oscillation went away." I said, that's great, but how many picofarads do you think that is? He replied, "I don't know, how many?" I told him to measure it on the Impedance Bridge.

He came back in a few minutes, kind of glum, because the probe had 3.2 pF, and he knew he didn't have room to fit in that much capacitance on the chip, which was already rather crowded. I said, "Oh, don't feel bad, maybe it only needs less than 3 puffs. Try a probe with less capacitance." He went out and measured every kind of probe that we had ever bought, and they were all kind of gross, 2 or 3 or 4 puffs. I said, "No problem, try this prober with a new arm that we just made up." We had fabricated the lever arm out of small strips of copper-clad, with insulation provided by peeling the copper off the glass-epoxy material. He went over and measured 0.22 pF. Then he dropped this probe tip on his circuit and it turned out that even 0.22pF was enough to stop the oscillation. Because he had room to fit in that much capacitance, he was in pretty good shape.



These probe stages are commercially produced, but the upper probe tip has a capacitance of 0.3pF, 10x better than the store-bought one. Because it's easy to make truss structures out of copper-clad material, you can make an arm to any size and to any desired rigidity.

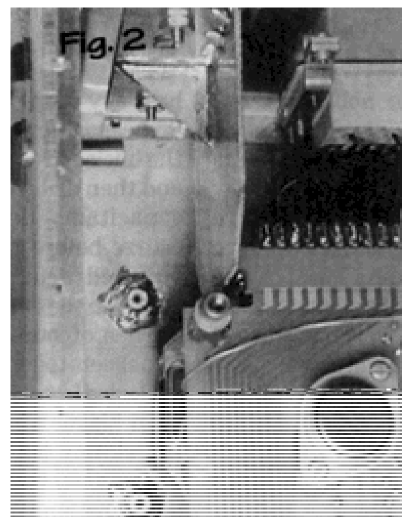
The moral of this story has nothing to do with oscillations, but rather about copper-clad, printed-circuit-board material - glass-epoxy board material. Now, I sort of take this stuff for granted, but I realized that this rather magical stuff is extremely useful. Without it, we'd have lots of problems. I always wanted to write a story about copper-clad for Pop 'Tronics, or one of the other popular electronics magazines for hobbyists, but now that I think of it, this is a better place to write the story. I mean, we engineers can *bluff* a lot and pretend we know more than most technicians, but if we get to Crunch Time needing to produce a miracle, it's nice to know how to solve problems that even the smart technicians can't. And if we weren't aware of all the good things you can do with copper-clad, maybe we couldn't envision the kind of little fixture we will need to pull off that miracle. I'll try to list several examples of useful, valuable things you can do with it.

First, I'll mention that here around Silicon Valley, several places sell the board to hobbyists, over-the-counter, for about 1 cent per square inch. So, if you want to a make a 6-sided box about 4 in. x 4 in. x 4 in., that will cost you less than a buck - not too bad. Of course, we're talking about the conventional 1/16-in.-thick glass-epoxy material. If you shop around, though, you can get the 1/32 in. and the 1/8 in. and whatever else you need.

Next, I must admit that the tools and techniques for working with it aren't very obvious. If you try to cut up a slab of copper-clad with a saw, you'll probably dull the blade pretty fast. But heavy shears or tin-snips do quite well. Metal nibblers (I'm delighted to say they're available at every Radio Shack) are priceless. In our lab we have a big shear; it can cut precision lines across a big sheet. However, you may not need one of those.

Thermal approaches are also valuable. A good hot iron (with a little solder to help the heat transfer) can easily remove a strip of copper, leaving some pretty high-grade insulator. In the first example, a strip of epoxy board 1/2 in. wide by 4 in. long, with a stripped area just 1/2 in. square, had only 0.2 pF. If we had *tried* to get low capacitance, we could have made the unclad area 1/4 in. wide by 1 in. long and then drilled holes in it, getting the capacitance down below 0.1 pF. Of course, before you peel off an area of foil, you need to cut with a good knife or saw to define the edges.

Then, of course, when you want to join two sheets together, you need a good hot soldering iron with a decent size of tip, 1/4 in. or bigger (those cute little ones with the skinny tip don't get the foil hot enough fast enough, which tends to cause delamination when you try to soak the heat in there). You can put little dabs of solder along a seam to make a mechanically strong joint. If you want to make something air-tight and water-tight, you need a good continuous bead of solder. It's possible, but a lot of work is required.



Here is a support for P.C. boards inside a box. Most of us don't own a welder, but we can all build neat copper-clad structures with a soldering iron.

Okay - what can you make with copper-clad? You can make BOXES of just about any shape and size. Inherently, these boxes give you good electrostatic shielding, which is an added bonus. Just remember that the copper gives you no magnetic shielding: If you put one of these boxes near a transformer, such as on a soldering iron, the magnetic flux at 60 and 120 Hz comes booming on in and can (temporarily) ruin a quiet breadboard. If you need shielding from magnetic flux, add some iron, or push the offending transformer far away.

You can make any kind of boxes - square, L-shaped, multi-shielded with cute little compartments and walls, and holes in the walls, and feedthroughs, connectors, etc., etc. These boxes can be extremely strong if you put on a cover that bolts on tight, and/or solder them with heavy seams. You can make 3-sided boxes, or 5-sided boxes. You can bolt on real hinges, or make poor-man's hinges out of copper wire.

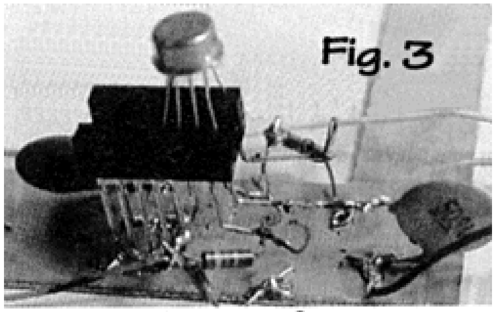
You can peel off strips of copper to make zones where a slab of copper is insulated. You can add heat sinks, fins, or any kind of connector. One of my all-time favorite discoveries was that you can use a metal nibbler to cut slots in the side of a sheet of copper-clad, and then slide 5-way binding posts into the slots. They look neat and sit secure; no drilling is required. You can use some of these techniques to get quick results, saving a huge amount of time compared to conventional metal-working techniques.

The next major thing you can do is make structural beams - brackets, levers, cantilevers, I-beams, L-brackets, spacers, shims, push-rods, flying buttresses - just about any kind of levers or beams or supports. Cut first, solder second, drill as needed - it's an awfully creative medium to work in. The technicians in our lab all look at each others' mechanical designs and say, "That's neat." Now that reminds me of some even wilder arrangements that will occasionally be useful.

I was recently helping a neighbor with a serious Meccano set project, and I realized that when I was a kid playing with my Erector Set, I built all kinds of structures. It was a lot of fun, but if I could have played with an equivalent amount of copper-clad and a soldering iron, I could have invented some *marvelous* machines and structures, just before I burned the house down.

Other things I like to build with copper-clad are breadboards and circuits. When people discard the 1/8-in.- or 1/4-in.-wide strips that they cut off the edge of a sheet with the shear, I scoop them up and save them and use them for little ground buses and power buses. When you solder them to cross-braces (which have insulating stripes peeled off), they're quite rigid and rugged, and very neat for op amps or logic designs.

I'm also compelled to state that some of the *cleanest, lowest-leakage* (sub-picoampere) layouts in the world use the *air* over a piece of copper-clad as the insulator. You can buy a clean polyimide board or you can get teflon pc boards or Teflon stand-offs. But plain old air above a crummy piece of copper-clad is just as good an insulator, and usually better.



Here's a view of a wire-wrap socket, with the leads bent at various angles, for your convenience in making soldered connections.

Another trick I like to use with copper-clad, for a quick-and-dirty applications circuit, is to use a 16-pin wirewrap DIP socket for a 14-pin IC. I take the two pins on one end, and one of the other pins that will be grounded, and solder them to the copper-clad ground plane. All of the other pins I bend up at varying angles, for ease of soldering. I tack a couple of capacitors to the ground plane to use as power-supply bypasses. Then I tack some power-supply wires on them, and I have a breadboard in about 2 minutes, all ready for me to slap in the resistors and other components.

Now, I think you readers ought to know, I don't just sit at home on an evening and type out these ideas, then shove them into print. First I type out a good draft and make 30 copies and show them to my friends. At this point of the story, I threw copies to my Brain Trust, and invited them to show me some more things you can do with copper-clad.

Dennis Monticelli pointed out that when you peel the copper off and file down the tip, you can make a non-metallic screwdriver or a non-magnetic tool for adjusting RF circuits. Fran Hoffart explained how he uses copper-clad for shims and spacers. And at the last minute, I recalled a little framework I had made, to hold up a 35-mm slide in front of my camera, so I could take a photograph of the slide's image and thus make my own copies of slides.

In conclusion, there are almost an infinite number of things you can do with copper-clad, pc-board materials, and I wouldn't mind hearing your neat ideas, too.

Comments invited! / RAP
Robert A. Pease / Engineer

Originally published in Electronic Design,
September 26, 1991.

RAP Update: *Some prices are up. Halted Specialties (Santa Clara, Calif., 408-732-1573) still sells hobby-grade copper-clad in 6 " x 15 " sheets, but the price is 2 cents per square inch. And Electrical Insulator Supply (Fremont, Calif., 510-490-5855) sells 3' X 4'sheets for about $42, or 2.5 cents per square inch.*

THE BEST OF BOB PEASE

What's All This Reflex Response Stuff, Anyhow?

I must have been quite small when I learned that if I dropped something heavy, I should jump so as to pull my feet out of the way of the falling object. For example, if I dropped a brick that fell toward my right foot, I didn't have to worry about my left foot, but my right foot had better clear out quickly. Obviously, just about everybody learns this early enough that you have no recollection or memory of how you learned it.

At a somewhat later age, I learned that if I dropped my glasses, or my watch, or any delicate object, it was pretty easy to swing one foot underneath that object. Even if I could not entirely prevent my glasses from hitting the floor, I could deflect them so it would only be a glancing blow. And I have developed that knack, so it's pretty automatic for me.

Then, the other day - in the summer of 1990 - I dropped something, and I did not move my foot either to catch nor to avoid the object. Well, I asked my leg, what is this that you're so blasé about? I reached down and picked up - a stick of butter. My leg had apparently made a decision that a 4-ounce stick of butter was not worth worrying about, one way or the other. Smart leg!

I mentioned this at work, and a friend (who has a lot of experience as an auto mechanic) said, "Okay, here's the fourth situation - the fourth quadrant. Let's say you are working on a Porsche, and you leave the starter motor up on a bench. Suddenly you notice that the starter has just rolled off the bench and is on its way to the floor. It weighs 30 pounds. It costs $900. NOW, what do you do with your leg?"

After some consideration, I figured that I would try to kick the starter with my toe, pretty hard, about 16 inches off the ground, so my toe would not get crushed, but it would have a chance of slowing down that heavy object. But I haven't gone to try it out.

Now, there's a very good and very serious application for this kind of pre-planning, pre-judging what kind of a reflex reaction you will make, instantly, in a particular situation. Let's say you're driving along a freeway, and suddenly you spot a dog in front of you. You may blow your horn, but some dogs really don't pay much attention (some of them are deaf, and others are stupid enough, they might as well be deaf). Okay. What do you do? You might hit the brakes, but if there were a truck on your tail, he could do *lots* of damage to you. You might swerve. That's a better way to avoid the dog (unless the dog dodges in the same directions as you do - I've seen that happen). But what if there's a car passing you? You could easily wreck your car and any number of other cars, too, depending on how many cars are around you. Or, if you dodge really hard, you could go off the road and cause additional trouble. A woman was observed trying to dodge a dog on Route 93 in Medford, Mass., about 20 years ago. She missed the dog but went off the road, down an embankment, and was killed. Bad move.

Now, I'm not suggesting that you just hit the dog. In many states, if you hit a dog,

you have to file a report with the police, and you might have to cart in an injured animal to the vet - no fun at all. Nobody really wants to cause pain to the dog, even if the dog is out where it shouldn't be. So, it's worth some effort to try to avoid the dog. But, what is the right answer?

The answer, I'm convinced, is to keep aware at all times of how much traffic there is behind you and beside you. If you're convinced there's nobody beside you, you can cut the wheel hard and avoid the dog. If the road is empty, you can also brake. Just try to avoid losing control. You might damage your car if you hit a big dog, but you might wreck it if you lose control completely.

And if you know there's heavy traffic all around you, well, you can try squeezing to one side of your lane to give the dog a chance to miss you. And all of the time you must have your thumb on the horn. Maybe the dog isn't deaf, just a little hard of hearing. And, after all that, if you do hit the dog, you have tried your darnedest to avoid hitting it. You did your best. But you can't do your best without being aware of traffic, and without planning in advance.

Now, if you're really aware of what's around you, you will also be prepared to dodge a deer, or a concrete block, or a loose wheel - or a child. Obviously, it's worth a lot to try to avoid a deer, because at 50 mph, almost every car will have several thousand dollars of damage if you nail that deer. And you'll be lucky if you don't wind up with the deer in the front seat with you. As for dodging a child - I hope you never have to do it. But just in case, I hope this column helps you to plan what to do. I know that in Massachusetts there's a truck line (the Crystal Freight Co., Wakefield, Mass.), and on every truck they have painted a scene with the caption: "Crystal says: After the bouncing ball... comes a running child." The scene shows a kid about to chase a bouncing ball out into a busy street. I used to laugh at that because it seemed so far-fetched. Then one day, *two times*, a bouncing ball sprang out from behind a parked car, into the street, right in front of me, In each case, a kid stood hesitantly by the car, wise enough not to run into the street. But I stopped laughing at Crystal and her silly saying after that.

Here's another angle on safe driving. Suppose you think you see *something* up ahead in your lane, and you're not sure if it's a blob of cardboard, or a dog, or whatever. As soon as you get at all suspicious, bring your foot over and give the brakes a tiny *tap* and start looking around for a clear lane behind you or on one side. If there's somebody behind you, it will catch their attention pretty quickly, so if you *do* have to hit the brakes hard, the driver behind you will be alert, too. Sometimes this is called defensive driving, and it sounds a little silly, but if you can use these techniques on the rare occasion there really is a dog or large object blocking your lane, you won't feel so foolish about tapping your brakes a little early, before you get all your plans made up.

When the N.Y. Giants played the S.F. 49ers in December 1990, the football experts said that Giants quarterback Phil Simms was playing much better that year. He had learned to throw the ball away or take a sack, rather throw into a crowd. Now that's a sensible reflex reaction. But on the game's last play, with the Giants losing 7-3, Mr. Simms could not find an open receiver and wound up getting sacked. The wisdom of refusing to throw into a crowd is imperfect if there's only one play, and you don't have any other chance to win. Every habit should be accompanied by an awareness that there are times when it doesn't apply.

Now, at this point, I wanted to give you some sage advice on how to use pre-planning and reflex response to help you in the electronics business. I had written this far, and could not think of a good example. But Frank Goodenough read my first draft and came to the rescue. He pointed out an old saying, "Never try to catch a falling knife." No matter how fast you think you are, it's very unlikely that you can grab for a falling knife 10 times without getting your hand seriously sliced at least once. Even if the knife isn't moving very fast, your hand is coming over rapidly, and it's astonishing how deep a cut you can make in that situation. In other words, it ain't worth it, and you had best plan your reflex response in advance so your head will automatically tell your hand, "Don't try it."

In the electronics business (see, I told you I would get there eventually) there's a good analogy: "Never try to catch a failing soldering iron." The odds are about as poor as trying to catch a falling knife, and the payback is equally painful. So, it's worthwhile to have a holster where the iron can be kept safely without likelihood of falling. Then drill the idea into your head, that if the soldering iron *does* fall, well, *let it*.

Frank related the story of the technician who was kneeling on the floor in front of his bench, looking for a part he had dropped. When he found it, he reached up and set it on the bench. Then, being an agile and sprightly fellow, he decided to *spring* to his feet. He put his hands on the bench, and gave a great LEAP - followed by roars of pain. He had inadvertently put one of his hands down really hard on the business end of his soldering iron, which was not in any holster. He was lucky to get out of the heavy bandages in a few weeks, but he got a very painful lesson about leaving hot items where they can be contacted accidentally.

Frank also proposed that I extend the analogy to a stack of lab equipment - pulse generator on top of three power supplies on top of a scope on a cart. If you live in California, you know there's always a 0.05% chance of having your set-up topple in case of a 'quake. Even if you don't work out here, somebody could stumble and bump into the cart. And then you have the privilege of diving to see if you can *intercept* a couple of those valuable pieces of equipment before they hit the floor. It's a little outrageous, but valuable things do sometimes take a dive. Just make sure that your head *automatically* decides that if there is a soldering iron, *that* is not a good thing to try to grab. And perhaps you could set up your equipment so that the stack is unlikely to topple. Maybe you can wire it together, or tape or strap it up so it cannot fall.

Once upon a time, when virtually all electronic equipment ran on vacuum tubes, it was easy to remember that you could easily get a shock from almost any node of a circuit you were troubleshooting. So the rule developed: When probing or trouble-shooting a circuit, *always* keep one hand in your pocket rather than hold onto a chassis or rack. Then if you brush against a high voltage, it will not cause a lot of milliamperes to flow *right past your heart*. The odds of being electrocuted used to be greatly reduced by this simple precaution.

These days, the new transistorized circuits are all at low voltage - except when they aren't. There are line-operated switch-mode power supplies, and high-voltage boosters that can put out +/-80 volts - and suddenly that old precaution of keeping one hand in your pocket is beginning to look pretty smart again.

So, whenever I start work on a high-voltage circuit, I tack in a neon lamp in series with a 100k resistor across the high-voltage busses. Then when I see the neon's glow, I'm graphically reminded that this really is a high-voltage circuit, and that the power is still ON (I don't care what the power switch says) and I should revert to the mode of High-Voltage Cautions. If I grab onto a really hot wire, the shock might not injure me, but I might convulse and jerk backwards. That's not a good idea if I'm standing on top of a ladder, for instance. So, looking for the glow of a neon lamp is a way to remind me to be serious, and I recommend it for you, too.

Please do try to keep aware at all times while you're driving, whether there's anybody beside you or behind you, so if you do have to make an emergency swerve, you will know if it's safe. It may save your life, or it might save your car. Be careful out there! And, keep one hand in you pocket when working on high-voltage circuits.

Comments invited! / RAP
Robert A. Pease / Engineer

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RAP Update: *I am going to include this Column as a key Chapter in my next book, "How to Drive Into ACCIDENTS - And How NOT TO " - More on this, later.*

THE BEST OF BOB PEASE

What's All This Dead Car Stuff, Anyhow?

Every year, in January, I compile a list of all the Dead Cars I've seen along the highways over the last calendar year. If you want to see a copy, send an SASE and I'll mail it. This year will be the 22nd annual list, going back to when I lived in Massachusetts in 1969. It lists every car according to their manufacturer, and sometimes by type.

For example, I try to keep the GMC cars separate from the Fords or the Chryslers, but I can't possibly segregate the Chevys from the Buicks - for all I know, they have the same engine anyhow.

I do separate the Volkswagens from the Saabs, which was my original intention. Back in 1969, I was trying to show some of my buddies that the Saabs of that era were less reliable than VWs, even though the Saab engines had "only 7 moving parts." I found that there were lots of dead or abandoned Volkswagens along the roads, but there were also quite a few dead Saabs. It seemed that there were more Saabs than one would expect from the number of Saabs on the road. Over the years, I kept on listing all of the cars I saw, dead or abandoned, foreign or domestic.

Now, what's the significance of these lists? Do they prove that one car is more reliable than another? No, not really, because even though you could tell how many cars are registered in any state, that doesn't tell you the number being *driven*. But I have had a lot of fun keeping notes on the Dead Cars. And my friends find it amusing to look at these lists.

Just the other day, I was writing down the data for one dead Mercedes Benz and one abandoned Ford with a flat tire. My passenger asked, "You mean, every time you see an abandoned car, you write down a note?" I replied, "Sure... doesn't everybody?..."

In the last five years, I began to keep a list of the cars I saw with no brake lights. I carry an envelope that I can hold up to warn a driver, "YOU HAVE NO BRAKE LIGHTS." I really don't like to see cars driving around with no brake lights.

It's all too easy for them to collect an innocent car on their rear when they hit their brakes and the following driver can't make this out all that well. So an accident can happen, and in my neighborhood, insurance rates go up even though many of us have had no accidents at all.

On the other side of the placard it says "YOU HAVE ONLY ONE BRAKE LIGHT." After one brake light burns out, what happens next? The other one burns out, and the car is left with none. So I like to warn these guys to get their brake lights fixed. In 1990, I notified 69 cars that they had no brake lights, and 144 cars that they had only one brake light.

There were about six guys with no brake lights that got away - sometimes they turn off in traffic before I can catch up with them, or sometimes a light changes against me. I hate to let a car with no brake lights get away. Still, I think I'm doing something useful, even though my wife sometimes gripes that I beep my horn too much just to tell a guy he has only one brake light.

But think about this: A guy has only a right brake light. He starts to signal for a right turn. Then he hits his brakes. In many cars, the brake light and the blinkers are connected to the same bulb, so when he hits the brakes, no change occurs. In some cases, one brake light burned out is as bad as no brake lights at all.

What do I do about brake lights? On each of my four cars, I've rigged extra brake lights up high so that they're really noticeable to the drivers behind me. If 1 or 2 bulbs burn out, I still have a couple left. Best of all, I can look in my mirror and see if the extra bulbs light up when I hit the brakes, so I can tell if the brakes' pressure-switch is working. Now, with a broad pen and a blank envelope, or a piece of paper taped to an envelope, *you, too,* will be able to warn drivers: "YOU HAVE NO BRAKE LIGHTS" and "YOU HAVE ONLY ONE BRAKE LIGHT."

Just what kind of car do *you* drive, Pease, to get good reliability? Ah, yes, I drive a car with exactly the right amount of modern electronic, computerized equipment - a 1968 VW Beetle (my wife drives a newer car, a 1969 Beetle).

Now, as an engineer, I suppose I should say good things about all of the fancy electronic fuel injection and spark computers and diagnostic computers and Lambda sensors. But I get 31 mpg and the car goes just as fast as I want, and that's good enough for me. The bottom line is that I prefer a car that has proven itself by running reliably for 244,000 miles (*now* up to 336k). In fact, until a couple months ago, it was still running on the original engine, and the original crank and pistons and cylinders (though it's true I had replaced the cylinder heads).

Sometimes I do connect a Heathkit electronic ignition system to minimize wear and tear on the breaker points. But right now it's on the blink, so I just went back to the old conventional (Kettering) ignition system, points and coil and distributor and "condenser." I set my own timing and I adjust my own valves. That's one good thing about old, simple cars - if something does go wrong (which is rarely) you can fix it yourself.

Do you ever count your own car, Pease, when it's dead? Yes, but that's not very often. One time my coil burned out. One time my distributor got loose and lifted out of its spigot, and it took me a full hour to figure out that when the engine turned, there had to be a reason why the distributor and its rotor did not. Another time a fuel hose fell off, but I fixed that and got going quickly, so I only counted it as 1/2.

There are several cases where I count a car as 1/2. For example, if a guy with a Volvo is talking to a guy with a Datsun, and they both have their hoods up, I may count 1/2 Datsun, 1/2 Volvo, 1 Helper. I count people who are obviously helping out as a Helper, not as a Dead Car. If I'm not sure it's a Rabbit on the other side of the road on a rainy night, I may count 1/2 Rabbit and 1/2 Modern Boxy Car (1/2 Modbox). If I can't even tell if it was probably foreign or U.S.-made, it gets scored as "1 car."

Do I think that electronics systems are going to improve the reliability of vehicles? Well, maybe. I recall the story of one of the first trucks that had an anti-lock brake system. They were driving innocently down the road when a nearby driver keyed the transmitter on his CB radio and the truck immediately locked up all its brakes. It turned out somebody had decided it would *hurt* the reliability to add bypass capacitors across all of the sensors and the inputs of the sensor amplifiers.

That's what you learn from MILHDBK-217 ... remember? So when the transmitter went on, all of the *amplifiers* went berserk. Oh, the amplifiers were perfectly "reliable," but the system had not been engineered properly. It was a miracle that nobody was behind the truck when it locked up all its brakes.

Are the new electronic system better for the environment? Maybe so. Maybe a new sedan can travel down the road emitting even less smog and emissions than my VW, so long as its computer is working right. But in 10 years, what happens when you can't get parts for the computerized systems? My car will still be running just fine. I think I'll stand pat.

After all, I have all of the tools and techniques I need to keep old VWs running forever. Forever? Well, there are old VWs around here that are over 35 years old, and if I can keep my good new beetles running 35 more years, they may outlive me. You would not want to bet that I can't keep them running. Meanwhile, if I see another VW broken down along the road, I stop and see if I can help.

Sometimes I have a tool or a gallon of gas, or the spare part they're in need of - a fan belt, or some points, or a clamp for a fuel hose. So I try to help solve their problem. If we can't figure out what's wrong, I leave them a SASE so they can write to me and explain what was the problem once they find out.

For example, one guy sent me a letter stating that the 1969 bus he had just bought was merely out of gas. The gas gauge was broken, but the previous owner, of course, had not warned him about that.

So, when I see a dead, abandoned or broken-down car along the freeway, I score it. I categorize and count it. Now, if a guy is just changing a tire, or pouring in a spare gallon of gas, I list that problem, but I don't count the car as dead or abandoned. In 1990, I saw 24 people that ran out of gas, 139 with a flat tire, 211 pulled over by a cop, and 16 with a broken drive shaft (remember, none of my cars has a drive shaft). I counted 293.5 GMC cars, 146 VWs, and one Citroen. What are the corresponding totals for 1991? I'll let you know as soon as I have them all added up.

Comments invited! / RAP
Robert A. Pease / Engineer

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THE BEST OF BOB PEASE

What's All This Applications Engineering Stuff, Anyhow?

(... Or, Why Being an Applications Engineer is Sometimes Like Being Nibbled to Death by Ducks.)

When I first started to work for National 16 years ago, I thought I was going to learn how to design good monolithic ICs. And I did, eventually. But the very first day on the job, Pete Lefferts gave me National's new 1976 Linear databook, with a list of 10 ICs taped onto the front cover. "These are the ICs that our group is responsible for. In our group, we design engineers also handle the applications engineering for our parts," Lefferts said.

Well, that setup sounded pretty good to me, because up to that time I had been pretty much an expert at applying ICs. I soon figured out how to field and answer most of the calls cheerfully. Of course, there were some calls too technical for me to know the answers. So, I just took good notes and then got some help from other more knowledgeable guys. I learned how to steer the customer to the right op amp (whether we made it or not). I learned how to explain to a customer that a TO-3 regulator could dissipate 20 W, *but* only if attached to a heat sink. I even learned to refer to an LM741, rather than a µA741.

The most important thing I learned was that if you want to avoid lots of "dumb" phone calls, you should write a very good, clear, comprehensive data sheet. When customers ask for needed information that wasn't included, it's not a *dumb* question, but rather a *dumb* data sheet. At least 30% of the calls were caused by a lack of sufficient information in the data sheet. So I learned to put *lots and lots* of good info, necessary info, into my data sheet. The penalty for not doing so is having to answer "dumb" questions forever.

That reminds me of the Quality Control procedures for the "riggers" - the people who pack parachutes. Obviously, packing parachutes is a very serious, very responsible job. How do you make sure that the guy packing 'chutes never gets sloppy, never goofs off? Ah, very simple: At the end of every month or so, each parachute rigger is invited to select one chute at random from a pile of all the chutes he has packed, and then he goes up and jumps out of a plane. Ah, if only there were QC procedures as good as that one, one that we could design for other jobs! If only we could all have such a good incentive to do perfect work. But in general there is not ... if you can name one, you tell me.

Anyhow, in the last five years, our Linear group has moved further away from the concept of having every Design Engineer do applications engineering, too. This certainly makes some sense. There are some people who are really good at designing silicon, and it's not fair to tell them they can't do it if they're not also good at talking with customers on the phone.

So now we have gone into a little bit of specialization. Unfortunately, it often means that an apps engineer gets on the phone to discuss a big project, and soon needs "a band-aid to put on his ear." There are times when an hour on the phone is needed for a special case, and that really is tough on the ear. In other cases, an apps engineer gets on the "MAC," and works on several data sheets for a sprint

lasting several days. I don't think I would enjoy that. Still, there are detailed technical problems that are appropriate for me to answer, and I still help out on specialized facets of applications engineering. I just don't get to take so many "cold" calls.

But what is the crucial thing about the applications engineer's job? I guess it's that he (or she) is an *interface*. Whenever the design engineer wants to design a piece of silicon to make a customer happy, the apps engineer should help facilitate the process, by showing the best way to teach the customer how to apply the circuit. He has to write a clear data sheet, list all of the features and specs, spell out cautions, and show what new applications are suitable.

What if the proposed silicon is lacking a necessary feature? Then the apps guy has to holler "WHOA!," until the need for that feature (or the lack of that feature) is resolved.

One time I was doing a redesign of a regulator, and the apps guy wanted me to add in protection so all of the pins would be ESD-proof, up to 2000 V. But I argued that if we added that protection, the circuit would not work in some existing sockets. Finally we compromised. I agreed to add all of the ESD-proofing I could so that the part could work in existing sockets. We wound up with a part that would pass only 800 V by itself, but when plugged into a usage circuit, its ESD tolerance was improved up to 2 kV because some pins linked together.

Other times, when a customer has difficult questions about an IC, the apps guy acts as a filter to make sure that all of the relevant questions get asked. Then the design engineer has all of the information he needs before he starts to work on the problem. The apps engineer is quite valuable when he gets all the facts lined up for the experts. Of course, most of the time, the apps engineer gets the facts and solves the problem by himself - he is the first-line expert.

What other things do apps engineers do? They design and evaluate circuits. They write and rewrite data sheets and applications notes. They teach other people by giving seminars and writing magazine articles. They communicate with every kind of user, from the grouchiest to the nicest, from the laid-back to the desperate ones. Their customers include op-amp experts, and also expert chemists who need a little advice about how to interface simple op-amp circuits to their systems. They hold the customer's hand. They won't let him fail.

Apps engineers act as a psychologist, and sometimes as a psychiatrist - they cajole and debate, and they know how to convince people to do things. They also bread-board things. And they run computers. They simulate things. They interpret ideas and data and people's wishes.

Do they get rich and famous? Usually not. Most of the time, they get (at best) begrudging thanks from the customer who did not like to be told that he needs a heat sink to keep his 20-W regulator from getting hot ... or from the IC design engineer who is mad that his project is delayed because the apps engineer talked him into redesigning his output stage to add a necessary feature.

On top of everything else, the apps engineer has the thankless job of deflecting and absorbing a thousand complaints. Like an offensive lineman in the National Football League, the best he can say is that he didn't let the quarterback get sacked today, despite the opposition's best moves. Maybe he even has the chance to make a brilliant play. But most of the time, people just beat on him, as if they were trying to wear him down. They ask every kind of picky, niggling, quibbling question. They bring his sanity into doubt. Sometimes they make his day less than fun. Sigh.

Apps engineers don't just get steamrollered. Sometimes they get nibbled to death by ducks. They may even get ulcers. But usually they have a personality that lets them survive these stresses. After all, just because we put all of the info in the data sheet - does that mean that people READ That Fine Data Sheet? If all else fails, call the Apps Engineer? If all else fails, read the data sheet? Never happen!!

I recall one friend, Jim, who had been an apps engineer for many years, and he gradually decided that he was not in a mood to talk to customers on the phone. One day his phone was ringing and he was sitting at his desk trying to ignore it, when his boss walked in. After a few more rings, the boss said, "Jim, do you know who is on that phone?" Jim replied that he did not. The boss said, "Jim, the guy who is calling you on that phone, is a *customer.* And you ought to answer that phone. Because that customer is *me.*" And he went on to explain why an apps engineer really *has* to answer the phones. Jim was able to talk his boss into not firing him outright, but he was given a month to find a job he could agree with.

There's still one last thing that apps people do, and I think it's the most valuable: They listen to people tell them what they "need" and what they "want." Then they try to figure out what the customer *really needs* to make him happy. That may be *quite* different from what the customer *says*.

Sometimes the customer is unrealistic. Sometimes the apps guy is "lucky." Sometimes there's no brilliant or easy answer. But when I was doing a lot of apps work, I considered it my most valuable privilege to hear 19 people ask "simple" or "trivial" or "nasty" questions, and to answer them the best I could, just so I could hear *one* customer ask a REALLY GOOD question.

Sometimes the question points out a deficiency in a data sheet, leading to an improved data sheet, so every user gets the advantage. Sometimes it leads to an applications note, or a magazine article. Other times it leads directly to a new product. Other times it leads to a debate, or an argument with your boss, or a screaming contest. Out of that argument often comes some better way to do something. But you never can tell which caller will be asking the really valuable question. Sometimes it's the op-amp expert - and sometimes it's the chemist.

My boss will probably be pleased to hear that the amount of time I'm "wasting" on apps engineering is less than a couple hours a week. But when someone asks me to put on my Applications Engineering hat, the calls I get are really some of the most interesting and valuable ones. That time isn't "wasted" at all.

Comments invited! / RAP
Robert A. Pease / Engineer

And now, here's a comment from Kerry Lacanette, Applications Engineer for Data Acquisition Circuits at NSC:

Bob, I don't think the customers are as bad as a reader might infer from your discussion. I can think of lots of those annoying "duck" calls in which a series of customers would ask "why don't you build a ... ?", or, "Do you have an ... IC with a pin that does ... ?" or some other question that we thought we had spelled out clearly in the data sheet. While we may have been annoyed by some of these calls at the time, or we carefully explained to the customer why they couldn't have what they wanted, these customers were really voting - voting for features, products, and better data sheets. We have occasionally counted these votes, and brought out better products because of them.

"Nibbled to death by ducks?" Yeah, I feel that way on a bad day. But would I prefer to take only the "good," "intelligent," or "challenging" questions? Nope. - Kerry.

Kerry, I agree with you completely! You have helped me complete what I wanted to say. Another way to look at it may be that just because a question is "dumb," it doesn't mean the "answer" is dumb. The answer may be challenging or complicated or valuable - and vice versa. Thanks for your comments. - RAP

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RAP Update: *I got several comments and letters from several Applications Engineers. They tended to agree that being an Applications Engineer is quite challenging ...*

THE BEST OF BOB PEASE

What's All This Muntzing Stuff, Anyhow?

Recently, a young engineer wanted to show me a circuit he had been optimizing. We reviewed the schematic and the breadboard, and we studied the waveforms on the 'scope. We realized that one of the resistors was probably doing more harm than good, so he reached over for a soldering iron. When he turned back to the circuit, the offending resistor was gone! How did it disappear so fast? Ah, I said, I always keep a pair of small diagonal nippers in my shirt pocket. And when I want to disconnect something, it only takes a second to snip it out or disconnect it on one end - just like Earl "Madman" Muntz. The kid looked at me. "Earl WHO?" And I explained.

Back in the late 1940s and early 1950s, television sets were big and expensive and complicated -a whole armful of vacuum tubes, lots of transformers and rheostats and adjustments that had to be trimmed, and many complicated circuits for signal processing. And all to drive a crummy little green-and-white 5-in. or 7-in. picture tube, where the whole family could crowd around to watch.

Earl Muntz was a smart, flamboyant businessman. Anybody who could make a success of selling used cars in 1939 or 1946 had to know something about salesmanship, and Muntz had built up a $72 million business in Glendale, Calif.

For example, Muntz would advertise a particular car with a special price as the "special of the day" - a car that *had* to sell that day. If the car was not sold by the end of the day, Muntz vowed to smash it to bits with a sledge-hammer, personally, *on camera.* Needless to say, with tricks like that he was able to generate a lot of publicity and interest, and sell a lot of old cars, too.

So when Muntz started his plans to sell TV receivers in 1946, it was obvious that he would be looking for a competitive advantage - in other words, he had to have an angle. He wanted to get the circuits simple - the manufacturing costs low - and he knew he needed a lot of promotion.

He realized that a receiver designed for "far-fringe reception" (40 or 50 miles out) had to have at least 3 or preferably 4 Intermediate Frequency (IF) stages (with a pentode for each stage, *plus* a transformer, 5 capacitors, and 3 resistors), and loops to hold the frequencies stable even when the signals were very weak.

Muntz decided to relinquish that "fringe" business to RCA and Zenith and other established manufacturers. Instead, HE would design for Manhattan and other urban areas, where you could look out your window and see the doggone transmitting antenna on top of the Empire State Building, or equivalent.

HE knew he could get engineers to design television receivers that would be very inexpensive, very simple, and would still work quite satisfactorily in these strong-signal areas. Then he could get away with *two* IF stages, and they would not need fancy loops, and the tubes could all be biased up with cheap-and-dirty biases.

As the circuits shrank, the power supply shrank. And as the price shrank, his sales volume began to grow, leading to still further economy of scale in manufacturing. Muntz dropped his prices so fast, so low, that his competitors again accused him of being a madman, cutting prices and competing unfairly.

When people watched Ed Sullivan or other pioneering programs of the era on their tiny 7-in. screens, who came on at the end of the hour to promote his new, low-priced 14-in. (diagonal measurement) TV sets? Why, Earl "Madman" Muntz himself!

"You can have TV in your home tonight," he would say. "Your living room is our showroom." And, wearing red long johns and a Napoleon hat, he would vow, "I wanna give 'em away, but Mrs. Muntz won't let me. She's crazy."

Muntz was a smart merchandiser, and he knew that his competitors' jibes could be turned to work to his advantage. He knew that his TVs were not built of cut-rate parts - in fact, his receivers were carefully engineered to be at least as reliable as the competitors' sets that cost twice as much - and they would perform just as well, so long as you stayed in a strong-signal area.

And how did Muntz get his circuits designed to be so inexpensive? He had several smart design engineers. The story around the industry was that he would wander around to an engineer's workbench and ask, "How's your new circuit coming?"

After a short discussion, Earl would say, "But, you seem to be over-engineering this - I don't think you need this capacitor." He would reach out with his handy nippers (insulated) that he always carried in his shirt-pocket, and snip out the capacitor in question.

Well, doggone, the picture was still there! Then he would study the schematic some more, and SNIP... SNIP... SNIP. Muntz had made a good guess of how to simplify and cheapen the circuit. Then, usually, he would make one SNIP too many, and the picture or the sound would stop working. He would concede to the designer, "Well, I guess you have to put that last part back in," and he would walk away. THAT was "Muntzing" - the ability to delete all parts not strictly essential for basic operation. And Muntz took advantage of this story, to whatever extent it may have been true, and he publicized his "uncanny" ability to cut his costs - in yet more televised advertisements.

For several years, Earl Muntz kept impressing his engineers to build in only the circuits that were essential, and for those years, his TV receivers were competitive and cost-effective. All because of his "Muntzing," he would say in his ads. But really, that was just one aspect of good sharp engineering. And of course, he had to know where to start snipping. Although he was not a degreed electrical engineer, he was a pretty smart self-taught engineer, and his marketing and advertising campaigns capitalized on the story: He knew how to engineer what people needed - right down to a price.

For example, only in the last 10 years has Automatic Fine Tuning become universally available on UHF as well as VHF tuners, so that manual fine tuning is unnecessary. But as early as 1958, Muntz TV bragged that there was no fine tuning on their best receivers, on all 12 channels. Did Muntz build in AFT before his time?? Heck, no - he just left out the fine tuning knob. The tuners were all tuned up at the factory. Then if the tuning drifted on a hot day, or the tuner components aged, you just had to call in a serviceman to tweak it with a special screwdriver.

So, Muntz had the gall to leave out an important feature, and then he bragged about the apparent simplicity! You can fool some of the people some of the time ...

Muntz got rid of the Horizontal Hold AFC circuit to cut costs. He got his engineers to use a straight Hold circuit, which actually worked well under strong signal conditions and was easier to troubleshoot than the temperamental AFC loops of the day. He pioneered and took advantage of the Inter-carrier sound (Parker System) so that audio tuning was automatic and no separate tuning was needed. This was a necessity before he could drop the fine-tuning knob ...

For some production adjustments, his test technicians would clip a trim pot onto the circuit, twiddle it to get the alignment just right, and then remove the pot and solder in a fixed resistor of the required value. All very fine, AND inexpensive, but as the carbon resistor aged, and the circuit aged, the TV receiver would go "on the fritz." Then the TV repairman would have to make a special trim, much more expensive than just tweaking a pot. The repairmen were happy to get all this repeat business, but eventually the customers figured out that a low initial cost was not necessarily the best investment ...

Finally, as the TV receiver business matured, Muntz realized he had sold all of the cheap sets he could, and he got out of the manufacturing business. After a brief bout with bankruptcy in 1954, he got back in the business of selling TV and electronics, "HiFi and Stereo," in a Los Angeles store, until his death in 1987 at the age of 77. The store is still open, operated by his family and heirs.

These are SAD days, because kids don't get a chance to build their own TVs or radios or FM tuners. Heathkit used to make it easy to build their kits. I myself built three Heathkits and a Knightkit 10-W amplifier, as well as a couple other kits. And I helped some of my friends when they were having trouble with their Heathkits. NOT because I was an expert on circuits in those days at MIT, because I was really pretty ignorant of electronics - I was a struggling would-be physicist then, in Course 8. I just thought this electronics stuff was kind of fun! But I was interested because these kits were such *interesting* stuff.

These days, you can hardly buy a kit. Heathkit went out of the kit business in January of 1992. The kits were more expensive than the assembled circuits you could buy from any number of stores. BUILD your own TV? How bizarre! The Japanese could build them, with very high quality and very low cost, and even if you threw in your own labor for free, a Heathkit cost more to buy!!

Let's go back to the scene where Mr. Muntz was trying to justify which parts could be safely left out of the TV set. If he snipped out a resistor that appeared to be unnecessary, but it was actually needed for operation on low line voltage, or when the frequencies shifted on a hot day, then I really believe Mr. Muntz would not prevent the designer from justifying it on a real need basis. But frivolous circuits - *they* were too expensive to keep.

Now let me make some observations about adding features and "frivolous" circuits, which is what I tend to support. An example: If I design a new circuit with 8 new features, I may argue to the marketing expert that these features will surely sell lots of these parts to new markets.

He may ask, "Bob, which of those 8 features will make it sell so well?" And, I'll admit, I have no way to guess exactly which ones, but I believe that 2 or 3 of them will be very popular. No matter how much he grills me, he can't shake me loose from my ignorance - I really do not know which of the 8 added features will make the basic chip a great seller.

BUT, things have changed from the days of Earl Muntz. Today, I can add 5 transistor functions here, and 8 there, and 14 here, and 27 there, and altogether they will not add 2% to the area of the chip, nor the cost, and they won't hurt the yield.

They may not even impact the test time all that much. They will surely have no affect on reliability if I design them properly. In Earl Muntz's day, though, NONE of these statements were true. Things sure keep a-changing, don't they??!!

Comments invited! / RAP
Robert A. Pease / Engineer

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THE BEST OF BOB PEASE

What's All This Ground Noise Stuff, Anyhow?

Recently I got a letter from a reader, James Hansen in New Boston, NH. He introduced himself as a digital and analog/digital system design engineer, and said a few nice things about what I write, and then said he had a favor to ask.

I'd like to know how you blue-blooded analog types get those marvelously clear and beautiful low-level waveforms on the scope. I've used everything from crummy scopes through lab-quality scopes, but none of them, regardless of what I've tried, ever produced the squeaky clean displays like the ones I see in the data books.

When I crank up the gain, there's always noise in my displays - usually common-mode noise - that I don't think is really there, but I am not always sure. I'm talking about a lifetime of experience here, in a variety of locations, equipment and breadboards, not just one system that came down the pike yesterday.

I use my very own tried, true, and trusty 465B scope, for which I personally paid Tek some $2600, years ago. In spite of all the TLC I've given this scope, the 50 mV scale is useless if there is anything besides battery-powered flashlights running in the building.

What I find is damped ringing spikes running at either the clock frequency of whatever is under test, or 60 Hz, with the peaks running typically about 3/4 full scale at 50 mV/division, all mixed on top of the real signal. When the gain is backed down to something like 5 V/div, the visual effect is a thick or slightly fuzzy line. This doesn't really bother me much when dealing with large signals, but it is bad news when you need to look at something little.

I've shorted the probes with the shortest ground strap available, and I still see the junk by touching the common ground point - or anywhere else on the chassis. Sometimes I can cut down the amplitude of these dudes a bit with tons of bypassing, but I never come close to eliminating it. I've tried using the scope differentially, I've floated it and/or the test bed, played games with various grounding schemes, and a hundred other things, all to no avail.

So before I die, just once I'd like to hook my scope to the output of a 12-bit DAC and see those uncluttered, beautiful, sharp, clear 5 mV stairsteps like those in the databooks. Is this possible? Do the databook guys cheat, like, touch up the picture?

How does one absolutely, positively know if the junk on the screen is real, or some instrumentation artifact? I've chased this kind of noise for days only to discover (actually, 'proclaim' is a better choice of words) that it wasn't real. Do other people run into this sort of problem, or am I the only soul on earth cursed in such a way?

If you don't care to write the story on this - it would be a boon for humanity - how about giving me some hints, and I'll write it up for publication in the magazine of your choice.

Anyhow, this is the challenge. Will you grasp the ring or beg off? With thanks for your past and future good humor, unknowing help, and encouragement! I am, sincerely yours, James M. Hansen, Project Engineer.

Well, I recognized a guy with a real problem. And it's not just his problem; I'm sure other people have it too. So, remembering the philosophy and the immortal words of LaVerne Baker, "Jim Dandy was the kind of guy, never like to see a pretty girl cry - Jim Dandy to the rescue," I called up Jim Hansen in his lab. I told him I thought I could help him, but this was going to be one of these Onion Syndrome deals - you peel off a couple layers, and cry; then you peel off a couple more layers, and cry some more.

I told him the first thing to do, to get the waveform really quiet, was to put a screwdriver across the master clock in his digital section. He said, after thinking a bit, "Bob, that will cut down the noise a lot, but then I won't be able to get any signal to feed to the DAC, to exercise it." I agreed that was surely true, but if it really did cut down a lot of the noise, that was a good clue. NOW, there may be a little more noise buried *behind* the local noise, but to a certain extent you do have to clean things up, one after another.

If you try one experiment to cut down the noise, and you can't see any improvement, you may have to do that experiment again later, because it was masked by some other source of noise you cleaned up at an intermediate time. THAT's the Onion Effect at work. But, specifically, I told him, his noise is caused mostly by 3 main problems - a noise source, a transmitting antenna, and a receiving antenna. We can improve all 3 of these.

Let's assume that, as an example, we really do want to add a little 12-bit DAC onto an existing digital system, and we want the analog output to be quiet, and we want to be able to SEE that it is quiet, in real-time - not just by the use of some averaging function on a fancy digital scope.

The first part of the problem is to recognize that the digital system is generating a lot of noise, some of it at more-or-less clock rate, with voltages moving 5 volts in just a few nanoseconds, and other stuff at various rep rates. Example: a low-duty-cycle pulse might drive a couple hundred milliamperes of current into a load, for a few microseconds every millisecond. Even if the current's path does not describe a very big *loop* (in terms of area), there will definitely be a big amount of magnetic flux coupled into the air. If the circuit was laid out so the current pulses are routed through adjacent parallel busses for Drive and Return, or through twisted pairs of wires, that can help a lot, though.

Now if you have a bus that is nearby the clock or other fast-rise-time signals, you definitely can get capacitive coupling, and even if you have really good bypass capacitors on your power bus, they will also let the current pulses couple magnetically to your signal. So if you put a scope probe anywhere near the computer, the probe can pick up some noises. The electrostatic (voltage-related) part of this noise can be largely eliminated by putting the computer in a sealed metal or copper-clad box. Now you may not want to do that, and you may not be *able* to, but you may not literally *have to* do that. Instead, you may be able to just wall the noises out by putting your DAC inside a smaller metal box, so you literally segregate the DAC from the noisy world. The computer's Digital ground and the DAC's Analog ground should be kept completely separate until you link them together at one point - and that point should preferably be right at the DAC. That way, digital noises will not have to flow through the analog ground system, in general, and they will be shielded away from the DAC and the other analog circuits.

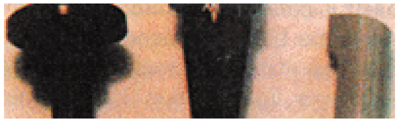
Unfortunately copper or aluminum will not reject or attenuate magnetic noises. You might try some iron, but it may take 1/4 in. of steel to do the filtering if you have 60 or 120 Hz noises, and even 1/16 in. is not really guaranteed to shield out high-frequency magnetic flux. When you are really serious, you may have to buy some mu-metal foil or thin sheeting.

What is the realistic thing to do, then? Well, one thing that does cause magnetic coupling to fall off rapidly is *distance.* You may be able to move the DAC to another board, or another quiet area of your system, farther away from the noisiest digital signals. Or, to be more realistic, if this DAC is going to add into some kind of video display amplifier, you'll want to bring the DAC right over by the load it will drive. That way, after you get the analog signal coming out clean, the signal will be right where you want it. NOW, maybe the DAC has to be driven from a busy computer bus. How can you put the DAC exactly half-way between the busy bus and the pre-amplifier? The answer is, layout. You have to plan and lay it out exactly that way, if that is exactly what you want. For best results, you would indeed have to bring in the digital signals on one side of the DAC, and feed the analog signals directly from the DAC over to its load. But that's still just part of the problem. Let's say you bring your probe over near the DAC, and the scope display is reasonably quiet. But as soon as you touch the probe's ground to the signal ground, horrible noises appear. (This is what I think was Jim's major problem).

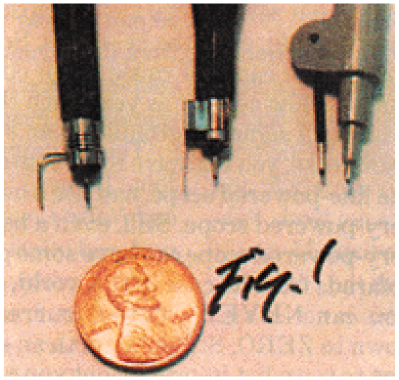
There are 3 main aspects of this noise coupling. One, as we have discussed, is to try to get the digital signals to not radiate so much noise; and the SECOND is to try to get less current flowing through the ground path. A majority of scopes have a ground path from their signal grounds, back through the line cord to the ground pin of their power plug. When your scope is plugged in, the ground of the scope is grounded to the building, for safety. But if there is any other source of noise in your building, the noise can couple in through that ground pin. Touching your probe to any other ground enables ground currents to flow through the entire length of the probe, and through the probe's ground wire - a ground loop.

One good thing to do is to use a 3-prong-to-2-prong adapter on the line cord. In some places that might cause trouble or danger, especially if there are high voltages around. But it's worth a try, and this is probably the best way to eliminate 60 Hz ground loops and "ground current." When you do this, hang a fat label on the scope so other users will be warned of this semi-floating condition. Also, be warned that some high-frequency noise currents can still come right in through the power line. Power transformers don't have zero picofarads of capacitive coupling, even the best ones. So a noisy room can still cause large currents to flow as soon as you touch the probe to a signal or ground. In an extreme case, you will have to give up on the line-powered scope, and use a battery-powered scope. Still, even a battery-powered scope can have some picofarads from its case to the world, so you can NEVER cut that current down to ZERO. Still, it's worth an effort to see what improvement you can get by this approach. Then we will go on to the best part of the fix.

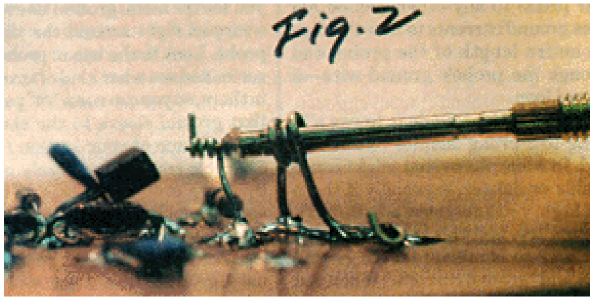
The best part is to get the probe's ground wire down to zero length. When you buy a scope, the probes usually come with a 6-inch ground wire, a 12-inch ground wire, and a whole fistful of funny little pieces of metal and plastic that you quickly shove into the back of a drawer and never look at again. WELL, it's just about time to dig them out and look at them. They will be helpful.



The major problem in this noise test is that the current noises flowing through the scope's ground wire are generating all the large noises, as they flow through the inductance of the ground wire. Shortening that wire is the main solution. Don't just swap the 4-inch ground wire for the 12-inch wire; that's still bad. Instead, unscrew the plastic ferrule or sheath that protects the tip of the probe. (Your probes may need to be disassembled a little differently than mine, but they can all get dismantled in a similar way.) Now you see the metal ground sleeve that is wrapped right around the tip of the probe. Look in the bag of probe accessories and see what kind of small clip is in there, so you can run a 1/4" path from that ground sleeve to the chassis or groundplane of your system (*Fig. 1*). Slap this small clip securely onto the tip of the probe. (if it falls off into the soup and shorts out and wrecks your circuit, we warned you here ....) Then connect the tip of that clip to the signal's ground. The noise will be improved by a factor of 20 or 50 compared to what you had before. The main point is, not only is the inductance of the ground strap reduced by a huge factor, but also the coupling of the current into the loop comprised by the probe tip and its ground. That's why probes work so well in the first place.



If you can't find those little probe accessories, you are not in trouble. Form and wrap a piece of bus wire (#20 or 18?) around the ground sleeve of the probe, say, 3 or 4 turns. Then solder that loop to your system ground (*Fig. 2*). Curl another piece of thin bus around the small wire of the probe tip, about 3 turns, and tack-solder *that* to your signal. Then you can slide the probe into those sheaths, and let the weight of the probe hold it there. You will have a very short ground path for the price of a penny - and you can fabricate it yourself in just a few seconds, any time you need one!



When I pointed this out to Jim he said, "Why isn't this written down anywhere?" I pointed out that I did mention this in my Troubleshooting book*, on page 15, that if you want to see clean step response with a scope probe, you have to use this VERY SHORT ground path; and that it is also good for minimizing the pickup of noises in the air, too. Maybe I did not emphasize that as much as I should have!

Now, if you called up the applications engineers at Tektronix or any other good scope company, and ask the right question, they would surely be helpful and give the right answer. But you have to know how to ask the right question. Is it written down anywhere? Maybe there are some books on how to use your scope wisely. Not very many.

Now that you have made this major improvement, you will usually want to go back and try all the other experiments, to see which aspects of layout, scope floating, transmitter loops, guarding, shielding etc., will *now* make the biggest improvement on the observed noise. Because things that made no effect before, can make a difference now.

These inductively-coupled noises will never match exactly if you use 2 probes, so that explains why you could not run the scope preamp differentially to get the noises to cancel. However, John Christensen in our apps group pointed out that you can usually improve this inductively-coupled noise by a couple more octaves, by running a separate, heavy ground wire from the scope to the system ground. If you can get *most* of the ground current to flow in this path, rather than the probe's ground wire, that's where you can get an advantage. Nick Johnson suggested also that a high-frequency FET probe is usually designed with very short ground paths and will thus be good at rejecting noises, also.

Now, let's say you can look at the ground and it's reasonably quiet. Then you look at the DAC output and it is noisy. There are about five new places to look.

1. Does the DAC have a quiet power supply? Many DACs have a PSRR of 70 or 80 dB - at dc. At 5 or 10 MHz, if the PSRR is as good as 6 or 3 or even 1 dB, it's a miracle. Look at the noise on that power supply. Are you feeding a +5-V digital- power bus to your DAC, with 87 mV pk-pk of noise on it? And then complaining because the noise on the output of the DAC looks only a little less bad than the 87 mV? For shame!

2. You can try some heavy bypassing. Sometimes a couple 0.1 µF disc capacitors, plus 10 µF of tantalum, plus 220 µF electrolytic, can cut the noise to an acceptable level. (And remember, only YOU can decide what that is ... "good enough" is not necessarily anywhere near "perfection"). If the bypassing alone does not work, then:

3. Try some decoupling resistors, perhaps 33 or 120 ohm, or ?? even a ferrite bead, in series with the path of the power from the supply to the DAC. If this is not enough improvement, try:

4. A *completely separate* set of twisted-pair wires from the power supply to the DAC. Put 100 ohm in series with that wire.

5. Try a completely separate power supply for the DAC. Repeat all the bypassing. Maybe one or more of these things will solve the problem; maybe none of these will help right now, but they may help later. Remember the Onion Syndrome.

And finally, sometimes the DAC is fed signals from a noisy set of busses that are all-the-time jostling and buzzing, and there is talk-through from these busses into the DAC output. Don't be surprised; there is almost never a spec on that, and this talk-through can be LOUSY. The solution is to make sure the DAC gets its digital signals through a set of drivers or buffers that are running off the same quiet power supplies that the DAC is getting. The bit lines that the DAC sees can get a *lot* quieter, thus reducing the talk-through effects.

One of the things I like to do is to bring the signal right to the scope. It avoids the 10x attenuation and the possibility of bad phase compensation of the 10x probe; and it avoids the bandwidth limitation of the 1x probe (most of them have barely 10 MHz of bandwidth, and mediocre settling time) and it avoids the capacitance of shielded cable. If you can bring your system to the scope, that has some great advantages, and I recommend it. Maybe you cannot do that. But, it's usually not essential.

What if you do all these things and there is still a little more feedthrough from some systematic noise than you can tolerate? Maybe after you have done all these things, it's time to go back and find out exactly WHAT signal is making the noise, and try to figure out how it is coupling in. Is it a current flowing through a big loop? Maybe that loop can be closed up, or you can use twisted pair or coax cables to get minimum transmitter effect from that signal. Maybe it is capacitive crosstalk from a couple adjacent pc-board runs, and the signals can be shielded or guarded.

This is probably a good time to mention a book by John Barnes, *"Electronic System Design: Interference and Noise-Control Techniques."*[**] It's quite good, practical, and offers several excellent ideas for many kinds of practical problems. He gives a number of good examples throughout. I am delighted to recommend this book; in some respects, it can be considered as a companion to my book on Troubleshooting.

What if you try all these things and there's still some vexing noise, and you turn off the clock and turn off the *power supply,* and there's still that noise there! Well, that sure gives you a clue, doesn't it? Noises can get conducted into your system by the power supply leads. Maybe you should UNPLUG your power supplies. Certain kinds of noises are brought in by your soldering iron, so, you may unplug THAT, and/or move it several feet away. Transformers for power supplies AND soldering irons can generate a lot of 120/180/360 Hz noise that couples insidiously (magnetically) into an otherwise low-noise system.

And DVMs are often pretty noisy, whether or not they are connected to your signal, so try turning that off. Is there a computer or terminal nearby? Turn that off, too. As you can see, this is rapidly turning into a game of, "Is there anything that *cannot* be causing that noise?" Maybe that flashlight of Jim Hansen's really is the only item that is unlikely to be the culprit. (And if you shine *that* on a diode, the light can cause dc currents to flow.) Anyhow, at least we have shown that it probably is NOT the oscilloscope causing all that high-frequency noise, all by itself. It's just a matter of, do you want a good antenna, or do you want a minimum antenna that will reject the noises in the air!

Now, did that help, Jim? Jim says YES. He was enough of a good sport to admit that part of his noise was caused by an oscillator that he had built up several months ago. He had quit using it, but had never disabled or disconnected it from power. He'd forgotten all about it, until these troubleshooting tips led him to the source of the noise. A second source of noise was a transformer whose flux was coupled into a signal fed to a high-gain preamp. The 180 and 360 Hz waveshapes were a dead give-away.

Comments invited! / RAP
Robert A. Pease / Engineer

P.S. Some publications do consistently publish faked-up "scope waveforms." You can tell because the rising edge of a step is the same brightness as the flat part, which of course looks silly when you think about it. But in data sheets, I don't know anybody who uses scope camera pictures that are not for real. Graphs are, of course, hand-drawn, and sketches of rise-times and fall-times can be re-drawn, but not when they try to show cleanliness of response. - RAP

* Troubleshooting Analog Circuits, Robert A. Pease, 1991, $28.95 includes tax and postage. Available from The Author, 682 Miramar Ave, San Francisco, CA 94112.

** Electronic System Design: Interference and Noise-Control Techniques, John Barnes, 1987, Prentice-Hall. About $48.

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THE BEST OF BOB PEASE

What's All This Quality Stuff, Anyhow?

WELLLL - I have been figuring for years that someday I would write about "quality." But aside from saying that we're all, of course, in favor of the HIGHEST POSSIBLE QUALITY, what else is there to say? Wouldn't that make a very short column? Yet despite the truism just listed above, very few of us readers drive a Rolls Royce.

So perhaps we should admit that we're all interested in very good quality at a reasonable price - a Volkswagen or Ford price, maybe even a Cadillac, Acura, or Mercedes price - very good quality, *appropriate* quality, but not necessarily the *highest possible* quality.

I still recall very plainly that VW used to advertise and brag that they had more QC inspectors than they had cars, and those old VW beetles had pretty good quality. Of course, it might be that the inspectors forced the production engineers to go back and solve the design and manufacturing problems. Maybe that's a back-door way to achieve good quality. Anyhow, I still like my old Beetle, running reliably at 287,000 miles. It's not the highest quality, maybe not as good as a Rolls Royce, but it is *appropriate* quality.

I recollect the story of one of the pioneering transistor companies, back in the '60s. They had agreed to ship to their customers transistors with an AQL (Acceptable Quality Level) of 2%, which was pretty good for those days. So the tester would test 98 good parts and put them in the box. Then, following her instructions, she would add 2 bad transistors to finish off the box, thus bringing the quality to the exact level desired. This went on for some time, until one of the customers got suspicious, because the two bad transistors were always in the *same corner of the box*! Then things were changed ....

Now let's get serious. I propose that not everybody really wants to buy parts with the highest quality and the smallest AQL. Let's consider a few practical examples. If I'm testing some gates or flip-flops, the output had better be about right, with a very high confidence, on every test. If I make 20,000 bad dice in 1,000,000, and I only reject 19,700 of them, you as a purchaser might be quite displeased to get an incoming quality rate of 300 ppm. So, it is pretty clear-cut that for ordinary commodity ICs, the parts and the testing should be very good so that no bad parts get to the customers. Many IC manufacturers do well at this.

Ah, but what about precision analog components? Precision op amps, 16-bit DACs, low-noise references? Can they always be tested with full precision and confidence?

What about a high-gain op-amp, such as OP-07? If the output swing is a 10-V step (either + or -), then the maximum input error (delta V) must be less than 50 µV. Further, it must be less than 50 µV with a VERY HIGH confidence level every time you measure it. What if it is 34 µV p-p sometimes when you test it, and 38 µV p-p other times, and 30 µV another time? Then if you see 47 µV on another part, it might change to 51 µV p-p if you test it again, and that would be a fail of the test. So, your testing must be done with good repeatability and low noise.

Is it realistic to try to meet an AQL of 0.01% on such a test? Is it reasonable? Is that what you want to pay for? Would an AQL of 0.2% be just as reasonable? Let's look at another spec. The OP-07A is guaranteed for 0.60 µV p-p of noise voltage, max, in a bandwidth of 0.1 Hz to 10 Hz. When you test an amplifier for noise in a fairly small bandwidth like that, you must not expect to get exactly repeatable results. So if you measure 0.42 µV one time and 0.48 µV another time, you have to be very careful about the repeatability. If there is much *noise*, the guard-bands must get bigger and bigger until the spec is a LOT more conservative than what you're actually measuring. As it is, the OP-07s have 0.35 µV p-p typical, yet we're barely able to guarantee 0.6 µV p-p.

What if we said that this spec was only guaranteed at an AQL of 0.5%? Could we then guarantee 0.45 µV p-p? Would you prefer to buy that as a spec? Would that part be of any significantly lower "quality" than the one with 0.60 µV max? I myself would sooner buy the part with the looser (0.5%) AQL and the tighter spec, as I think it is a more realistic kind of spec with more realistic testing. The yield to the manufacturer might be better, the testing might cost less, and the actual noise performance might be better. What do *you* think? Comments invited.

At one time, one of the major suppliers of precision analog parts used to guarantee reference ICs with a certain long-term stability. In the fine print, they said that 90% of their production would meet that spec, even though they did not test for this. I dunno, but 90% seems a little rough as a quality level. Still, at times, that may be an *appropriate* quality level. But the company has stopped saying that ....

Now, I will get into the MEAT of the topic. I recall reading the writings of such people as W. Edwards Deming, Genichi Taguchi, and several other promoters of "quality." They argued that we should not rely on testing for high quality. We should not be trying to "test high quality" into our products, but instead we should build them with such high quality that testing is superfluous. That's what Mr. Deming said, and he was considered "the dean of the quality movement." When I first started writing this column in August of 1993, Mr. Deming was very much alive and kicking, and I was hoping to start a dialog with this feisty old-timer. However, Mr. Deming unfortunately died on December 20, 1993, and I'm disappointed that I cannot duel with him verbally. Still, maybe some of Mr. Deming's colleagues will be in a mood to hold up his end of the arguments, or explain what Mr. Deming thought.

NOW, Mr. Deming's philosophy seemed to say to the entire semiconductor industry: "Do not rely on testing. Just build everything perfect." Well, when we build good op amps, we may get a yield of 80 or 90 or maybe 93% at "wafer-sort," when we probe and test the chips on the wafer. We ink any dice that fail any test, and lots of good dice remain. After we assemble all of the good dice, we test the packaged circuits *again*, repeating many of the tests to weed out anything that may have gone sour, or worsened after assembly, or that may run poorly at a hot or cold temperature. Now we have a yield loss of only 1 or 2 or 3% at this "classification test" after assembly. Still, this is *infinitely* far away from Mr. Deming's philosophy. Why are we semiconductor manufacturers so thick-headed? Why can't we get anything right? Hmmmmm.

If you buy LM324 quad op amps in moderate volume from NSC, you pay about 38 cents and you get 4 good op amps with a quality level of about 99.9996% per package (about 1-ppm reject rate per amplifier). That may not be the best op amp you can buy, but it's pretty darned good at the price. And I claim that it's the testing that makes these amplifiers so good.

If you looked in our "scrap pile," you would find some amplifiers that literally meet the published spec - but we have installed tests to make sure they're rejected. Hey, we reserve the right to reject op amps even though they meet the published specs, because we determined that there's something not quite right about them. Do we get this excellent quality by doing *no* test, or *minimum* testing? *Hell no.*

Ten years ago, we were shipping some of the highest-quality amplifiers in the industry, with an AQL perhaps 99.92%. Pretty good in its day. But we're doing better now - by a factor of 100 or 200. WHY? Because we have better tests. If you took some 1984 op amps and ran them through our 1994 testers, we might pass some that we failed before - because our tests are better. And we would surely fail some that were passed back in 1984 - because our testing is better.

Over the past few months, I've asked several friends who work in Quality functions, test engineering, etc., and looked around myself trying to find out the answer to these questions: If the whole semiconductor industry is acting in contradiction to the "no testing" philosophy, has anybody made statements specifically rebutting it? And, has anybody explained that Deming's advice *does not apply* to the semiconductor industry.

As of yet, I haven't found anyone who has ever heard this stated. SO, you're going to hear it right HERE for the first time: There may be many kinds of manufacturing where testing to achieve high quality is the wrong way to do it. But in the semiconductor manufacturing business, testing is EXACTLY the right thing to do to get high quality.

NOW, I will not say that testing is exactly the *cause* of the good quality. We design these circuits to be of very high quality, very manufacturable. Our wafer fab usually has excellent quality, so these ICs usually do work well with high yields. But if a run has fewer parts than normal that meet all specs, we don't let that affect the quality of the parts we ship. We do our testing, and the test results tell us what's causing us yield loss.

When we go back to solve a basic design or manufacturing problem that hurts the yield, that may also help the real quality, too. Yet I claim that it's the testing that drives the quality. What kind of IC, or car for that matter, would you buy if you were assured it was so good that no testing was needed?? How would the manufacturer know that the quality really was very good if he did not do tests?

If a Taguchi expert told you how to change your design, but decided not to check his results because his engineering was of such high quality that he didn't have to do any checking, would you buy *that*? NOTE - almost all of our customers are now accepting our testing as quite adequate. So when they buy circuits from us, they do not have to retest them for conformance to the guaranteed specifications at their "incoming inspection." That seems reasonable.

But of course when the customer assembles 22 or 46 or 79 components onto a board, then it's time to do some more testing for that assembly. I recently heard several friends complain about the poor quality of some electronic stuff they bought recently - some made in the U.S.A., and some imported, too. Right out of the box, the equipment failed to work, and you could tell that it had never been tested. Are you readers seeing that, too? Are some manufacturers starting to take "no testing" literally? If they talked themselves out of final test, a final *functional* test, that's pretty scary ....

I had a talk with Melodie McClenon, manager of our Data Acquisition Test Engineering group. She agreed that we do find it important, occasionally, to add tests. They're necessary to screen out the few parts with bad quality which customers occasionally reject and gripe about. Often, a test is added to guard retroactively against some kind of a "Quality Accident," where a customer finds quite a few parts out of spec. Later, some manager may propose to delete that test as "superfluous." Melodie says she sometimes has to fight like heck to keep the test in, and she can usually do this by proving that the test, while usually unnecessary, is keeping a 1-ppm failure rate from being shipped.

I agreed that, if on most days, the test takes a few milliseconds, and cuts out a 1-ppm reject mode from being shipped, and it's ALSO able to help avoid the possibility of some disastrous bad parts from being shipped on 1 day out of 1000, that sounded like good judgment to me. I told her that I was on her side, and if she needed anybody to help her, I would fight like hell for her. It's always good to find a friend with ideas worth fighting for.

I have heard some guys argue that we should improve the yield of our op amps to 100%. I'm skeptical of that idea. At present, we have optimized for the lowest total cost for a good die, including the cost of testing. If we try to optimize the yield, with special wide spacings, special coatings, special processes, special redundant circuits, and so on, we might get a much lower percentage of bad dice, and a slightly higher percentage of good dice. But there would be fewer good dice per wafer - and fewer per dollar. Would these fewer dice be of higher quality? Higher reliability? How much better? And, if they are a little better, how much extra would you like to pay for them? Would you like to buy some with no testing? Just think about all of the money you would save by cutting out the testing ....

Other people have argued that it's bad to have a low yield, because the quality must be bad. Nobody would want to buy an IC made with a yield worse than 50%, right? *Well*, almost every computer in the world has a processor chip that came out of fab with a wafer-sort yield much lower than 50%. That low a yield would sound pretty dumb for an op amp or gate or counter. But for a big processor, a yield of 10 or 20 or 30 or 40% may be quite rational, and very reasonable compared to making smaller dice with higher yield. It certainly doesn't mean that the dice which pass all tests are of poor or marginal quality. So far, we're doing exactly what Mr. Deming says not to do - yet our quality and reliability keep getting better, and cheaper. And everybody in the Semiconductor industry is doing the same.

One engineer pointed out that to plan to ship a part with the "correct" amount of quality, one might want to know if the intent is to ship a "Yugo," or a "Rolls Royce," or perhaps a "Honda Civic." If we wanted to sell the LM324 as the Yugo of the industry, we could surely increase the yield by shipping parts that just met every published spec - but that might be wrong. The LM324 may have a Yugo level of specs, but we want to make sure it's tested out to a high grade of quality, a "Honda" grade of quality and reliability. Therefore, when you buy one, it comes with some *awfully good* quality. Do you know anybody who actually builds in worse quality on cheaper parts? Our customers, such as HP, Delco, or IBM, would never stand for that ....

Recently, I was surprised to learn that most of the early NSC linear ICs did not have any protective coating of Vapox or Nitride over the die. So, 24 years ago, LM108AHs came with a metal wire just flying through the air above the die, above the aluminum metallization, with no Vapox passivation over the die.

Were those old LM108s and LM101As less reliable than what we make these days? Maybe. But they have shown us a lot of proven reliability. Are new LM308ANs in epoxy mini-DIP packages less reliable than dice in hermetic packages? Well, the new mini-dip ICs are all lead-bonded with automatic machines, with much less variability and better repeatability than the old human-controlled lead-bonders. These ICs are ALL awfully reliable nowadays, and have excellent quality.

(Note, technically we must avoid confusing *reliability* with *quality*. Yes, a part that fails after a customer puts it to work can make the customer just as unhappy as a part that never met spec in the first place. But we have to treat those two problems *separately*. We want to provide parts with excellent quality *and* excellent reliability, and we have to be careful not to hurt one while helping the other. For example, if we do a burn-in test, we must make sure it doesn't harm a part's reliability.)

Now, a great majority of what Mr. Deming said makes excellent sense to me, and I'm pleased to recommend his ideas as an excellent legacy of his career. He observed, for example, that when making cars or airplanes or lawn mowers where the quality is randomly poor, and you're forced to go back and rebuild or replace the engine or the transmission (or the paint) before you can ship the product, it's a LOUSY way to do business.

So, do any readers have any opinions on testing? Have you seen anybody else's good convincing statements or arguments on this topic? I'd love to hear from you. I do know that NSC has always done some testing on every component they shipped, and it's unlikely that we'll change that statement. In fact, *more* testing usually helps provide higher quality, compared to *less* testing.

As a final note, I sent an early letter on this topic to Mr. Deming at his home. He did not reply at that time, but it's not possible to draw any conclusions from that. I just wish I had been able to find a good excuse to talk to him earlier!

Comments invited! / RAP
Robert A. Pease / Engineer

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RAP Update: *This column generated a LOT of interest and fan mail. About 62 letters. A number of readers wanted to argue that I was wrong. "Bob, if you just increased your quality a little bit more, you wouldn't have to do testing..." WRONG. I will be publishing "QUALITY II" in a few months...*

THE BEST OF BOB PEASE

What's All This Smog Stuff, Anyhow

NOW some of you folks who live in other states or in other parts of the world may wonder, "What's all the fuss about smog? We don't have much smog around here." But this may affect you, too. Don't be so quick to dismiss this topic.

For a couple dozen years, California drivers have had to worry about getting their car through an emissions or "smog" inspection every two years. Oftentimes, just keeping the car tuned up properly was adequate to get you through the smog test just fine. Or, if you failed, you could get it fixed up, and try again. Recently, a number of bureaucrats agreed on some new procedures to decrease the emissions, pollution, and smog still further. It's called "Smogcheck II." These regulations were apparently not approved or voted on by any elected lawmakers, just approved by bureaucrats. They also seem, in some respects, to have been put together by people so as to not make any sense. It also seems they are not FAIR ... or rational.

Some of the earliest warnings turned up on the Internet. People claimed they had seen these regulations that were cleverly worded to get all the old cars off of the road and confiscate them. Some of the laws specially written for New Jersey were (allegedly) worded so that you could not even sell your car out of state; it would be illegal to even keep your own car in your driveway after it failed a smog test. Needless to say, a great amount of screaming and worrying went on that this was completely unfair. Yet other bureaucrats argued that these fears were exaggerated -- nobody was actually going to do any confiscating. But they never honestly told us what the laws and regulations were going to do. Very sneaky. All this stuff made me very nervous.

Finally, here in California, similar rules were put into effect without any warning -- with no real notification -- and with poor planning. We began to read about these new regulations in the newspapers. "All these regulations are trying to do, is to get Gross Polluters off the road. Surely no one would disagree with that." Well, that sounds plausible. That sounds reasonable. Hmmmm.... Then we began hearing people complain --"My car went in for a smog test, and even though I had it tuned up pretty well, it failed the test limits by just a few percent -- and it was labelled a Gross Polluter."

Soon after, we began to learn other little "details." If your car is labelled as a "Gross Polluter," you cannot just get it repaired yourself. You have to take it to an Official State Repair Shop, where they do the repairs AND the testing. Furthermore, the bureaucrats underestimated the amount of repair work needed. There were not many Official State Repair Shops, and the waiting list to get your "Gross Polluter" into one soon got up to two, four, or even six weeks. The State Repair Shops were so overloaded, they did not even answer their phones. They just played a recorded message, "Tell us your phone number and we will call you back." Some people observed that after 10 days, nobody ever called back. In other words, bad estimating, bad planning, and too much bureaucracy.

Why is it that a failure by a mere factor of a few percent causes a "Gross Failure?" Other people were saying that a car has to fail by a factor of two to make a "Gross Polluter." WELL, it turns out that there are two ways to get in trouble -- if your car fails by a factor of two, then it is declared, instantly, a Gross Polluter. Or, even if it is not a Gross (factor-of-two) Failure, if it fails the Pass Limits twice, even by a small margin, then THAT makes it a Gross Polluter, too.

NOW if failing twice gets you into real trouble, then it is worth a lot of effort to make sure you do not fail. You want to get your car tuned up as carefully as possible. But the Fearmongers -- and the newspapers -- all said that the smog testers are all connected by a computer link to the main DMV (Department of Motor Vehicles) computer in Sacramento. Any failure is reported instantly. So you can't even use a smog tester to tune up your car to make sure it will pass. What a mess! No wonder the Fearmongers were worried! No wonder that hundreds of motorists turned out at rallies in Sacramento to protest.

It turns out there are a lot of gripes and allegations that are not accurately stated -- not quite true -- quite misleading. It is NOT LITERALLY TRUE that all emissions testers are linked up to Sacramento. If you go to a tune-up shop, or any good repair shop, you can get your car tested and checked to see if it is passing. If it is, then you can take it in to an official Smog Test Shop, and your car is likely to pass. Since it is worth a lot to avoid even one Fail, then it is VERY advisable, to get your car checked -- and adjusted --before you take it in for the official smog test.

However, if there is a little miscalibration between one sensor and the other, you could have your car pass at the tune-up shop, and fail during the official test. THIS would be annoying. But it can happen. Some people have griped that many old cars -- like a TR-6, a Jensen-Healey, a rare old Thunderbird, or a '70 Corvette -- are just on the margin of passing on a good day. And any tiny glitch -- or sensor miscalibration -- can cause them to fail. NOW, if YOU do not own a TR-6 or an old Thunderbird, you might say that you are not concerned. Don't be too sure about that.

The bureaucrats say, "We are not confiscating any cars." And the Fearmongers say, "We have proof that the Government is confiscating old cars -- but we have promised not to tell the names." Very puzzling.

It is a fact that if you own a car that is a Gross Polluter, and you give up on trying to repair it, and you don't want to sell it out of state, you can sell it to the state -- for $450. And they will crush that car. Then they will sell the right to that pollution to some industrial company. Maybe that is fair. Maybe not.

But why can't I form an "industrial company" whose purpose is to enable cars to run? I'm sure a guy with a Ferrari, or other car that is being persecuted because of these new rules, would be happy to buy a polluting chemical factory and take that off the road. He would like to make that trade-off work backwards ... Why not??

Maybe one of these days someone will bring in a '94 Rolls Royce that is a "lemon," and cannot be made to pass the smog test. The state will buy it for $450, crush it, and the ensuing publicity will make the whole thing look foolish.

But it already looks pretty foolish. If the government tells you, "You failed your test by 10%, two times, and that makes you a Gross Polluter," that seems a little unfair. Then when the bureaucrats say, "And you cannot repair it yourself, you cannot get it repaired by anybody but the Official State Shop," that is really LOUSY. I cannot see the reasoning behind that.

THEN when it turns out that the Official State Repair Shop is booked solid for the next five weeks, and you are not supposed to put your car on the road until it is fixed -- that is really unfair -- that is de facto CONFISCATION. I don't like it at all. I don't know how to fix it. The people that are enforcing these rules are completely insulated from criticism or complaint. Maybe somebody who is in business will take these idiots to court. Sue those idiots! That sounds good to me -- throw out that arbitrary stuff.

OK, now I know about all these rules. Can I get my car through "Smog?" My 1968 VW Beetle with 340,100 miles on it?? I tuned it up. The engine has pretty good compression. The (platinum) spark plugs are almost new -- only 105,000 miles old. I checked the gaps at 0.028 in., I cleaned off their insulators, and put them back in. I set the timing. I took it in to Mt. View Foreign Car.

The first thing I noticed was that the limits for a Gross Polluter are NOT always 2x the Pass Limit. For some model years, the Gross Polluter Limit was 1.2x the Pass Limit. For others it was 1.5x, or 2x, and for other models, 2.5x. So it seems that these regulations are arbitrary, and not a fixed constant factor or value. H'mmmm, arbitrary....

My carburetor was set a little rich. The CO percentage was running up near 4%, just barely inside the test limit of 4.5%. Not a very safe margin. So Aram, the technician, tweaked the idle volume control screw to get 1.5% -- a little too lean -- and then pushed it back up to 3%. Pretty safe. Stable.

I took it in to one of the smog test shops -- "SmogPros." After the usual 40 minute wait, they got through with testing it. I asked, "Can I pay?" The guy said, "We have to wait to get the report back from Sacramento." I had to cool my heels for another half hour. "We don't know how long it will take, because the computers in Sacramento are overloaded." I bet....

After the half hour, the guy said, "You can see the report." The car did not pass. The emissions were OK. But the print-out from Sacramento said, "Emission equipment missing ... hole in air cleaner." Well, I had taken that car in there and passed smog several times before, and never had any problem. The guy pointed out, "A 1968 VW is supposed to have a throttle positioner." Well, I've had the car over 12 years, and it never had a throttle positioner on it, and they passed it every time previously. So, this was just a sign that they are being VERY picky. Very METICULOUS ... very TOUGH. As for the hole in the air cleaner, well, I could have put on some tape, so nobody could see that there was a hole. But that was not the major problem.

That was Thursday. I got the guys at Mt. View to order a throttle positioner. They installed it. That was Friday. On Monday, it passed. I pointed out to the smog testers after I passed, "The new regulations are supposed to fail old cars. I bet you haven't passed many with 340,000 miles on them."

So, anybody who owns a car in California, or some of the eastern states such as Massachusetts or New Jersey where these "Regulations" are being imposed, had better watch out. The rules, and the INTERPRETATIONS of those rules, are really pretty nasty and unfair. Don't be trapped or caught by rules you are not aware of. When your car needs a smog test, you should probably get your car tuned up and checked out EARLY. Then, when you have a safety margin -- and when it is properly equipped with all required equipment -- get it through the test EARLY. If your car needs a throttle positioner, make sure it has all the necessary equipment installed before you go for your test -- avoid wasting time.

I have no idea why the rules do not let a guy get anybody who he wants to repair and tune up his car to be clean, and then come in later for an "official" test. In fact, even though they tell you that you MUST bring it in to an official repair shop, well, if you fixed it yourself, and then brought it in for an "official repair," and it just happened to test perfectly clean, you could tell them, gee, they must have made an error when they tested it....

I don't know why a 10% failure has to be considered "gross." But I guess that's because I am not a bureaucrat. If I were, all this stupidity would surely become perfectly clear.

What does this mean for people who live in different states? It seems that all cars will have lower value, because some old cars have to be sold "out of state." In other words, if you live in Montana, and you have a good old 1986 Cadillac, you may think it is worth several thousand dollars. But if the guy next door is able to buy a 1987 Cadillac for $1000 because a guy in California (or New Jersey or Connecticut) had to get rid of it -- then your car is NOT worth nearly as much as you thought it was.

The guys who sell cars are going to love this. They think you will cheerfully buy a new car to replace that 10-year-old lemon that nobody can get through smog. Well, if I just had to sell off a perfectly good, reliable, comfortable old 1986 car for $1000 because nobody -- not even the Agency -- could get it to pass smog, then I am surely not going to cheerfully buy a new car. I may not be able to afford one....

Will the lines at the Official State Repair Stations get any better? I doubt it. Maybe if they let you get your own car repaired, that will help. But for the next 1.6 years, there will be a LOT of cars every month that are introduced to tough tests. Only after all cars have been through the new system once will the repair mess get better.

Will it be true that some cars are more valuable, because it IS possible to keep them well tuned up, and in spec? I guess so. What kind will that be? I don't know. But obviously, my old Beetle seems to be doing OK. If you know a mechanic who can get your Beetle through the test by twisting a screw in the right way -- that sounds good to me. What are the test limits for a 1968 VW?

1968 VW TEST LIMITS

Hydrocarbons LIMIT		CO LIMIT	
@IDLE	700 ppm	@IDLE	5.50%
My results	34 ppm	My results	0.34%
@2500 rpm	600 ppm	@2500 rpm	4.50%
My results	16 ppm	My results	0.21%

-- So -- don't just tell me that all old cars are dirty and fouling and polluting. A well-maintained old car can be both fairly clean and economical.

Anyhow, while this story is copyrighted, please feel free to pass it around to your friends as a public service. There is entirely TOO MUCH misinformation, disinformation, and ignorance on this subject. And if anybody learns stuff, let me know. I KNOW that I don't know the whole story, but I know enough to be of some help.

I wish the bureaucrats and legislators would level with us. I wish they did not try to argue that a car that is 4% less than the Spec is GREAT, but a car that is 4% over spec is a GROSS POLLUTER. I wish they did not try to pretend that when the DMV tries to order you off the road until their 2-month-backlogged repair station can look at your car, that is not a form of CONFISCATION. Even if you could get your car fixed, they won't let you. And they will not tell you what you need to know. That is the WORST kind of bureaucracy.

I wish the Smog Fearmongers did not exaggerate so much. They bend the truth, and tell partially-true stories, almost as badly as the bureaucrats do. I wish not so much Bullbleep was going on....

Latest developments: In Sacramento, 46 legislators said they want to put these regulations on hold until they can rewrite them. The bureaucrats just say, No Way. I think I'll go chew on my representative's ankles.

Also, one guy pointed out that some lawyers are putting together class-action suits. They are zeroing in on the administrative errors of depriving people of their property, WITHOUT due process, AND with no right of judicial review, because of the insufficient repair facilities. Hmmmm.... They also are working on the aspect of discrimination based on unequal treatment of property based on age. Why are some of the Gross Polluter limits set arbitrarily high -- or low?? Such a mess!

And as Anatole France said, "The law, in its majestic equality forbids the rich as well as the poor to sleep under bridges...." It sure is strange when we find ourselves pulling for the lawyers!

I'm in favor of clean air and low pollution as much as anybody. But let's be fair about how we do it.

All for now. / Comments invited! (czar44@me.com)
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RAP's comments:

The continuing skeptical observations of RAP (and of my readers) show that there are still terrible CONFLICTS and INFORMATION GAPS between bureaucrats and drivers -- in California and other states and Provinces.

The official smog-check announcements *still* bleat that a "Gross Polluter" is a car that emits MUCH more pollution than cars that pass -- but ignore the fact that a car that is 5% under the limit is "just fine", but a car that is 5% over is "a Gross Polluter".

Oh, the bureaucrats still tell us that "The State of California can not confiscate your car. The fearmongers are exaggerating". Well, here in California that is literally and technically true: the State of California cannot confiscate my car because it failed its smog tests. But in some cities (such as San Jose or Santa Cruz) there are "Abatement Officers" who can ABATE your un-registered car right out of your DRIVEWAY. If you can tell the difference between that and confiscation, I'd like to hear it.

The case that bothered me was a guy who told the Smog Technician, "Just do a test without the computer connected to Sacramento." He suspected there were some leaky hoses that would prevent it from passing. But the technician decided to leave the computers connected, because he thought it would pass. It failed. Now this car is flagged as a Gross Polluter, and the owner has to take it in for a treadmill test every year (not just every second year).

The owner asked the DMV to remove the "Gross Polluter" label, because the Technician had gone against his instructions. "Impossible".

I suggested that he should take the Technician to Small Claims Court. Sue him for $1000. Or whatever he can get. After all, would YOU buy a car that is a "Gross Polluter"? (Even though it is now perfectly clean....)

Some cars are hard to get into spec. My advice is still to sell the car out of state, and find a comparable car that can be made to pass.

A vehicle (such as an RV) that has been parked for a long while will have its gas tank full of fuel without the volatile ingredients in the gasoline. When you start it up, it will run LOUSY. If it doesn't clog its carburetor or injectors, it's a miracle. Its chances of passing any smog test are tiny. So park your RV with an empty tank. Add new gas when you want to get it through the Smog Test. And always get it PRE-tested, to be sure it will pass, before the OFFICIAL test. Even if it was passing, the last time you ran it.

Further, if you are storing a car, it's a good idea to leave it with the gas tank empty, because a full tank will soon be separated into the volatile stuff that boils off and goes into the air and turns into bad smog, and the sludge that sits in your tank and won't run the car.

What if you want to keep the gas tank from rusting? Then you need a dessicant. Where do you buy that? GOOD QUESTION. When I find out, I'll list it HERE: _______________

You guys who don't live in California think you got no problems. Maybe this year. Beware of the future. Beware of bureaucrats. They are getting closer to almost all of us, every year. / RAP

THE BEST OF BOB PEASE

What's All This Measurement Stuff, Anyhow?

Our town newspaper, the *San Francisco Chronicle*, has a Trivia column that runs twice a week. Recently, a couple items caught my eye: "If you have 9 pennies and your scales say they weigh an ounce, then you know your scales are in calibration." I reached in my change bucket and grabbed 9 pennies and put them on my gram scales. It came out to 26.1 grams -- *rather* less than 28.35 grams -- definitely less than 1 ounce. Hmmm. What is going on? Surely the Trivia Man has to be correct. One penny has to weigh as much as the other, doesn't it?

It turned out that some pennies -- the old copper pennies before 1982 -- DO weigh about 1/9 ounce. Actually, they're about 3.06 grams, so 9 of them are about 27.5 grams, still 3% lighter than an ounce. The newer ones, since about 1982, weigh about 1/11 ounce, or 2.49 grams ±0.01. So you can fool around and actually calibrate your scales now that you know which kinds of pennies weigh what. One time I got some pennies with glue on them. I put them on my stove burner and burned the glue off. No problem. Note, the amount of electricity it took -- perhaps 1 kW x 60 seconds -- is less than the cost of the pennies, by a factor of perhaps 10.

Then, months later, I got some more pennies with glue on them. When I put them on the stove, the pennies began to droop and melt. What the hey? Somebody is making counterfeit pennies? I complained to the Secret Service that somebody seems to be counterfeiting pennies. It was only LATER that I realized that the U.S. Government is making counterfeit pennies. Zinc instead of copper. No wonder that some melt (the new ones), while the older copper ones do not. I'd forgotten about that, until the weight of the pennies reminded me.

The Trivia column then said, "How thick is a millimeter? It's as thick as your thumbnail." Hmmm. My thumbnail was a little too long -- and it needed to be trimmed. So I trimmed it off. I looked at it. It surely did not seem to be nearly 1 mm thick. But I didn't have any precision calipers or micrometers. So how could I tell how thick it really was?

I took a small steel ruler, about 1/4 inch wide, and stood it on end. I used the ruler to make a differential measurement between the thickness of the thumbnail and the thickness of several sheets of ordinary copier paper. This was done by standing up the ruler with one corner on the thumbnail and one corner on the paper stack.

NOW, we know that a stack of 5 reams (2500 sheets) of paper is 9.8 inches high. I have lots of old Xerox boxes that are 9 inches high but the paper is taller than the box. So we know that 39 inches of paper equals 10,000 pieces of paper. Each sheet is 3.9 milli-inches thick -- give or take 5%.*

When I compared the thickness of the thumbnail to 3 pieces of paper, the ruler stood up with a tilt to the left. When I compared it to 5 pieces of paper, it tilted to the right. When I compared to 4 sheets -- neutral. Of course, I had to turn around the ruler to make sure it had no bias. And I swapped around the base to make sure *it* had no bias. In conclusion, my thumbnail is about 15.7 milli-inches thick, or 0.38 mm. Not 1.0 mm. I sent a note on this to the Trivia expert, stating that he was wrong by nearly a factor of three.** No reply yet.

Then Mr. Trivia said, "What is there that weighs a gram? One paper clip." I got suspicious immediately. I grabbed a collection of paper clips and put some on my old Cenco Triple Beam Balance -- scales that can measure up to 111 grams, with a resolution of 0.01 grams. The small paper clips all weighed 0.5 grams. The big ones all weighed 1.5 grams. I never did find one that weighed 1 gram. So Mr. Trivia does not have a very good batting average with me....

My point is NOT that you need fancy scales or meters to make a pretty good measurement. You need *thinking* to make pretty good measurements. A good scale or meter just makes it *easier*.

Back in the 1960s, some guys could not make any measurement without a precision differential voltmeter -- a Fluke meter. Remember those knobs that you had to servo by hand to match the unknown voltage? When a guy could not make a measurement without one, we called that "Flukemia." But then digital voltmeters came along. Now we have a whole generation of engineers and technicians that only know how to measure things with a DVM. That is a far cry from engineers who know how to prove that 9 pennies weigh 1 ounce, under difficult conditions....

That reminds me of a lecture I once gave -- "What's all this Measurement Stuff?" -- to a local group of engineering students, sponsored by the IEEE Measurement Society. I asked these students, "What are the biggest sources of error in measurements? Thermocouples? RFI? Bad connectors? Non-infinite input impedance?" I left the slide up on the screen for several extra seconds.

The next slide listed: "Ignorance... Apathy... Carelessness... Sloppiness... Stupidity...." This always draws chuckles. But it is partly true -- when one is measuring things, the INSTRUMENTS usually aren't a source of error. It is our foolishness in misapplying them that causes errors.

One time I was evaluating an expensive DVM. About £4000 worth. This was a nice DVM that not only had high guaranteed accuracy, but it had a display that would tell you how accurate it was. For example, on a 1-megohm scale, it told us that its accuracy was guaranteed less than 0.01% when measuring 1 megohm.

I slapped on one of our lab's 1-meg resistors -- a precision wirewound resistor. The reading was 999,800 ohms. Hmmm. Now, it's uncommon to find a 1-megohm wirewound resistor that has drifted that much (-200 ppm). When I go down to Haltek and buy old wirewound resistors, I *like* to buy old ones because a resistor that's 5 or 10 years old, and still in spec, is at least as good as a brand-new resistor because it has some proven long-term stability.

I slapped this 1-meg resistor onto our HP 3456 DVM. It read 1,000,005 ohms. But we had to admit that the HP3456 is only specified to an accuracy of 0.02% on that scale. Maybe the HP was wrong?

I decided to use jiu-jitsu to prove which DVM was telling the truth. I had some new 100 kilohm wirewounds that were specified at 0.002%. I measured 10 of these. BOTH DVMs agreed that these resistors were all nearly perfect, ±5 ppm. Then I clipped the 10 resistors in series. The HP said 1,000,000 ohms. And the expensive English DVM said 999,800 ohms. Yet it swore that its own accuracy was no worse than 0.01%. Well, we sent in a nice calibration report when we gave that DVM back to its sales guy. We never did hear any explanation or apology from him.

So whenever I measure things, I like to do some little self-calibration test, just as a sanity check. I like to measure some things whose accuracy I think I know. Like the capacitance from the earth to the moon....

All for now. / Comments invited! (czar44@me.com)
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P.S. I received a lot of answers after asking the question, "What is the actual capacitance from the earth to the moon?" There were a few odd ones at 0.8µF or 12µF. But about 10 guys said it was 143 or 144µF. They used the formula:

$$C = 4 \times \text{Pi} \times \text{Epsilon} \times (1/r_1 + 1/r_2 - 2/D)^{-1}$$

valid for $r_1, r_2 << D$

NOW, my original estimate of 120µF was based on this approximation: The capacitance from the earth to an (imaginary) metal sphere surrounding it, 190,000 miles away, would be 731µF. (If that surrounding sphere were pushed out to 1,900,000 miles away, the capacitance would only change to 717µF -- just a couple percent less. If the "sphere" moved to infinity, the C would only decrease to 716µF.) Similarly, the C from the moon to a surrounding sphere 48,000 miles away would be 182.8µF. If the two spheres shorted together, the capacitance would be 146.2µF. I guessed that if the spheres went away, the capacitance would drop by perhaps 20% to about 120µF, so I gave that as my estimate. But removing those conceptual "surrounding spheres" would probably only cause a 2% decrease of capacitance. That would put it in close agreement with those 10 guys that sent in the 143µF figure.

But THEN 6 readers wrote in LATER -- from Europe -- all with answers of 3µF. I checked their formulae, from similar books, in several different languages. They were all of the form:

$$C = 4 \times \text{Pi} \times \text{Epsilon} \times (r_1 \times r_2) / D$$

multiplied by a correction factor very close to 1.0. If you believe this formula, you'll believe that the capacitance would be cut by a factor of 10 if the distance D between the earth and moon increased by a factor of 10. Not so! Anybody who used a formula like that, to arrive at 3µF, should MARK that formula with a big X.

Finally, one guy sent in an answer of 159µF. Why? Because he entered the correct radius for the moon, 1080 miles rather than 1000. That's the best, correct answer! / RAP

Originally published in Electronic Design, September 3, 1996.

* In the original text I said that the boxes are 9" high, but I forgot that the paper stands 0.8" taller than the box. So I said the paper was 3.6 mils thick, but 3.9 is closer.

** Originally I said my thumbnail was 14 milli-inches thick, but I divided by 25.4 when I should have multiplied by 0.0254. Silly error! So 15.7 mils x 0.0254 = 0.40 mm. When I said he was wrong by nearly a factor of two, I should have said nearly a factor of three! Barring a few dumb errors, this was about right. / RAP

THE BEST OF BOB PEASE

What's All This Common-Centroid Stuff, Anyhow?

ONCE upon a time, we designers of op amps used to locate as many of the critical transistors as we could along the axis of symmetry. We put the input transistors right along the Center Line (CL) of the chip, or on a pc board along the CL of the board. We tried to put the output transistors on the CL, too, down at the far end of the layout. We realized that any heating from the output stage could cause significant, serious input errors. For my discrete layouts, I designed "ISIS Clips" and "Omega Clips" to keep the input transistors at the same temperature *(Fig. 1)*.

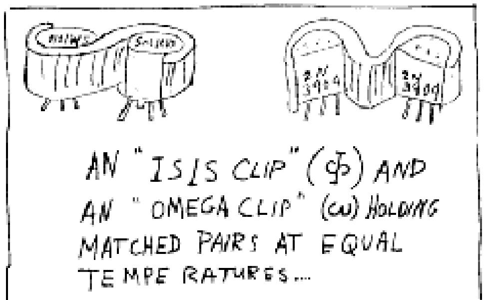


Figure 1

ISIS, the old Egyptian Goddess, was George Philbrick's inspiration. The K7-A6R array of op amps was called the "ISIS" computer. The symbol S with an I across it was a neat symbol for ISIS. Look at it again, and it's the PHI that's the symbol for PHIlbrick. And if you are a fan of Positive Feedback, George Philbrick used to say that ISIS was her own mother. So I designed some little clips made of soft aluminum, with green paint for insulation all over them, in the shape of S -- an ISIS clip. This clip has rotational symmetry.

Conversely, an "Omega Clip" has mirror symmetry, like the Greek letter for omega (see Figure 1). We made these of the same soft aluminum, and the same green paint. Walter Kern made them up.

When monolithic op amps came along, there were some influences to "keep it simple, stupid". I designed a T52AH -- also labelled as Amelco's 809BE -- with just 10 transistors, which worked pretty well. But op amps with 20 or 30 transistors soon had just as good a yield. And they offered more features. So, we kept learning how to add more transistors for better performance.

But when the Fairchild µA725 came along, we designers were really puzzled. Why would anybody use FOUR input transistors? What the heck was George Erdi smoking? If you set up a diff amp with two transistors in parallel at the plus input and two transistors paralleled on the minus input, why would that give an advantage? But the specs showed real superiority -- low offset voltages, good bias currents, and low offset current. Hey, this was about 1971. Not many engineers were climbing inside their suppliers' ICs and studying the layouts. If you didn't, though, you could be stuck with a lousy layout. I know.

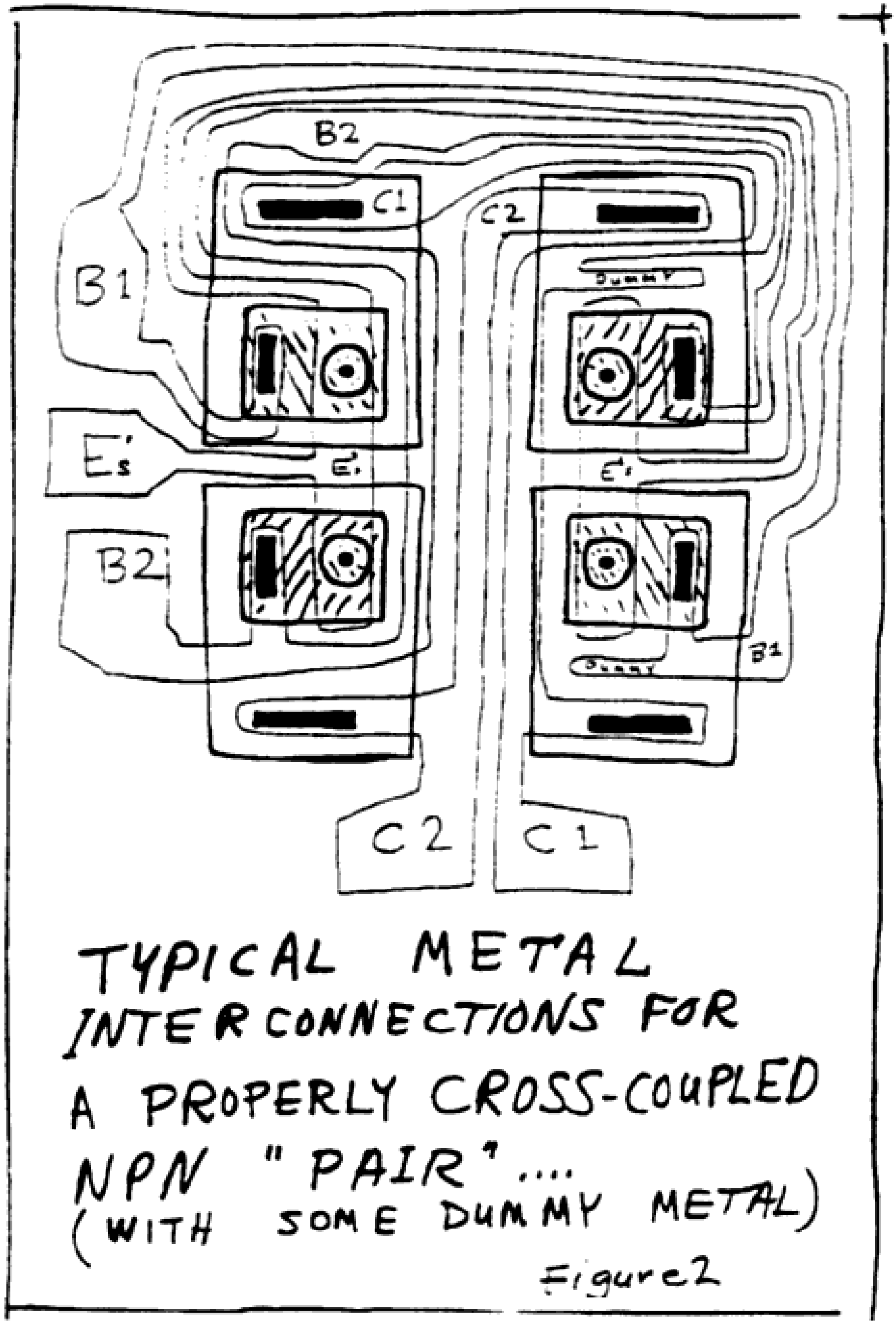


Figure2

The basic feature of the µA725 was the common-centroid layout of the input transistor "pair" *(Fig. 2)*.

If you took those four input transistors and laid them out in an X pattern, it would be denoted by:

AB
BA

Connecting them properly in parallel, you can get the linear gradients of Vos, to cancel. And the gradients in beta to cancel. Gradients caused by heating from the output stage -- and even from other asymmetrical sources of heat -- tend to cancel. Any linear gradients caused by imperfect die attach tend to cancel. (Nonlinear gradients do NOT get cancelled, of course, but these are usually small.) And these cancellations all happen thanks to a common-centroid layout, which is just another way to say that the "Center of Gravity" (CG) of one input "transistor" is at the same place as the CG of the other transistor. (I bet you can figure out that any geometry that is connected to metal labelled "Bl" is a base -- if something is connected to "C2," that must be a collector ...)

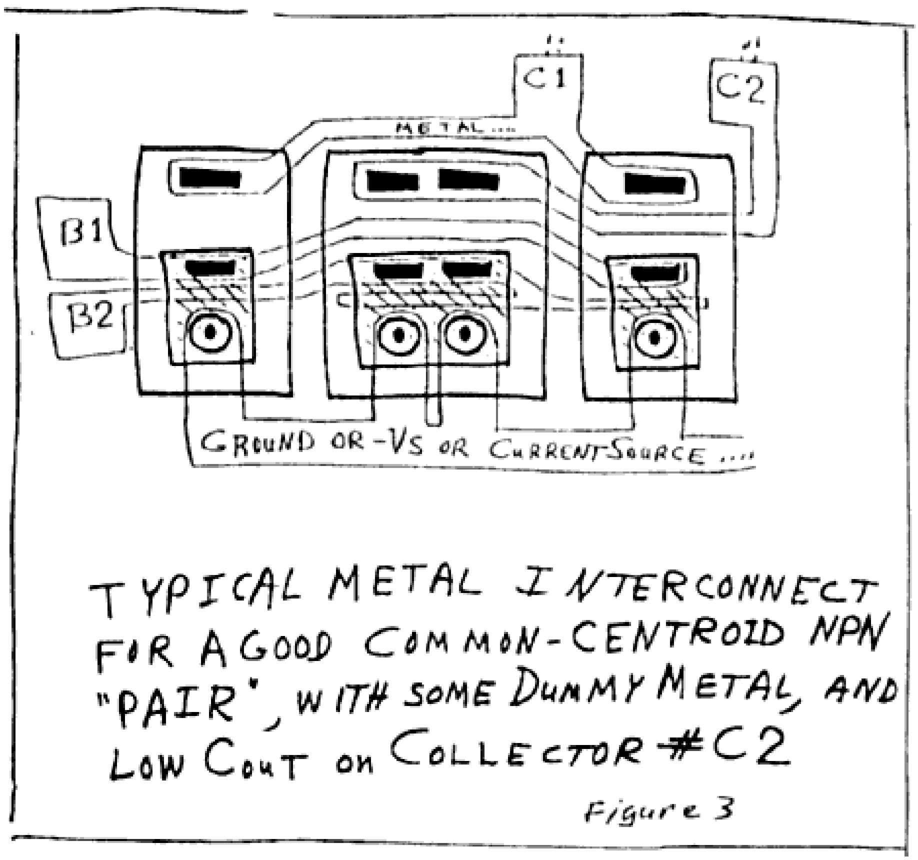


Figure 3

There are many kinds of common-centroid layout, in addition to cross-coupling. You could lay out a "pair" of npns as ABBA. The "B" transistors in the middle not only reject gradients, but they can have smaller output capacitance, since they only need one tub. And in some cases, this long, skinny circuit *(Fig. 3)*
may fit in your layout better than:

AB
BA

In this example, the transistors are still connected as an ordinary differential pair. But if you connect the transistors to act as a current reflector by shorting Cl, Bl, and B2 together, and merging that metal, the interconnections become *very* simple.

Recently, I saw a technical article by some engineers[1], claiming that they had a computer program that automatically provided good interdigitated and cross-coupled common-centroid layouts. "ALAS!" was what they called the program. I looked at their results. All I could say was, "Alas!!" The authors appeared to think that a layout of ABAB or AABBAABB or ABABABAB or even:

ABAB
BABA
ABAB

makes a "common centroid". When I apprised them of their error, they tried to argue that the magazine's computers had misrepresented their results. Uh-uh. They did not understand that *their* computers were clueless. Not only was it a bad program that generated poor layouts, but they did not even recognize that it was a bad layout. And, heck, you don't need a fancy computer to set up pairs or groups of transistors with common centroids. I do it all the time with groups of resistors, using just pencil and paper -- and lots of symmetry.

The Editor at the *Journal of Solid State Circuits* was a good sport, and gave me space for my criticism of that paper[2]; and the authors' efforts to rebut my criticism[3].

Often, there are significant matching errors when using transistors, or resistors, or capacitors, if common-centroid layout isn't used. There are always more-or-less linear gradients across a die. Bipolar transistors have gradients of Vbe and beta. If there's any temperature gradient caused by output device dissipation, that's going to hurt the Vbe matching by 2mV/°C, if the input transistors aren't at identical temperatures. MOSFETs are afflicted by gradients in etching, in Vt, and in oxide thickness. Adjacent resistors can have poor matching due to gradients in etching and in sheet rho. If you want your capacitor sets to match well, you must beware of gradients in etching and oxide thickness. Die stresses cause shifts that relate to linear gradients. Proper understanding of cross-coupling or other forms of "common-centroid" layout can be very valuable to help reject linear gradients across your die. An improper understanding of "common-centroid" layout can be amusing -- or pathetic. If you insist on cross-coupling components that are *not* critical, you can waste lots of die space.

Back in 1972, on Jim Pastoriza's AD550 Quad Current Switch, I observed some of the limitations of laying out a DAC's transistors all in a linear row. When some bits were switched ON or OFF, there were significant thermal tails. Linear mismatches also occurred, due to linear gradients in Vbe and beta.

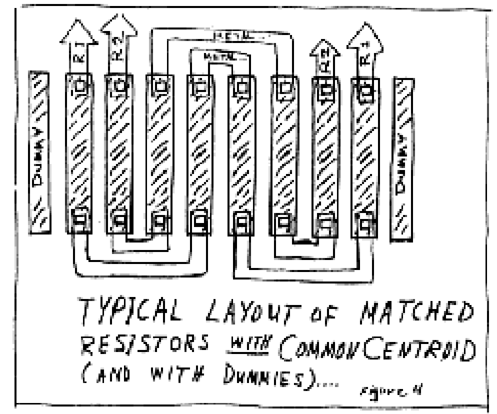
I made my own layout for a monolithic Quad Current switch, with good common-centroid layout. It had 8,4,2, and 1 emitters -- and 2 emitters for the reference. What was the Patent number? 3,995,304? You can tell that it's an old number -- the patent has expired already. The emitters were laid out with the Most Significant Bit (MSB) emitters being A, the LSB as D, and the reference as R:

AAAA
BBCR
 D

RCBB
AAAA

I was able to convince myself that the Vbe matching of this kind of layout was adequate for at least an 8-bit DAC -- without any emitter resistors. It may be as good as 10 bits, if I did some trimming. And much better, if emitter resistors were used. Heck, the first DAC I ever built was 15 bits *plus sign*.

If you use resistors, you should be aware that resistors made in a batch process tend to have linear gradients. So if you have four resistors in a row, and you want a good ratio, such as 1:1 (or 4:1), choose the two resistors in the MIDDLE. Put them in series, and take the resistors on the ends, and put them in series (or in parallel) and the ratio will tend to be more accurate. The tempco will be, too. This tends to hold true for thick-film, thin-film, or monolithic resistors. If you have eight resistors, the matching can get even better *(Fig. 4)*.



Back in '86, Dennis Monticelli asked me which layout I would recommend for the input of his LMC660 op amp:

ABAB ABBA
BABA vs. BAAB
ABAB BAAB
BABA ABBA

Where's the advantage?

I told him they were both good, but I sort of liked the first option. The offset of this op amp set new standards for accuracy of MOSFET inputs. Never a dull moment!!!!

All for now. / Comments invited! (czar44@me.com)

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References:

1. Bruce, J.D., IEEE *Journal of Solid State Circuits*, Feb. 1996, p.271-274.
2. Pease, R.A., IEEE *Journal of Solid State Circuits*, Sept. 1996, p.1364.
3. Bruce, J.D., IEEE *Journal of Solid State Circuits*, Sept. 1996, p.1364.

Originally published in Electronic Design, October 1, 1996.

RAP's 1997 Comments:

I got a nice note from Dave Fullagar, the guy who invented the µA741. He said that the µA725 was the first amplifier to

use the cross-coupled inputs, so I changed the text to agree with his facts.
(In the original version I said it was a µA714, but that came later.)
-- rap

THE BEST OF BOB PEASE

How To Make Your Own Matched Transistors

Of course, for critical applications, transistors should be matched in pairs for VBE at a nominal temperature. Specifically, pick up the transistors with tweezers. Insert them into a socket that's adjacent to a reference transistor running at equal, stable currents, such as 1.0 mA, with better than 0.1% matching.

To see the circuit as published in Electronic Design on June 14 of 1999, go to: http://www.elecdesign.com/Index.cfm?Action=Pease

and then go down to June 14 of 1999 to:

"What's All This Logarithmic Stuff, Anyhow?" at:

http://www.elecdesign.com/Articles/Index.cfm?ArticleID=4321

and find Figure 7. The resistors should be very well matched, and stable.

Any deviation between the Vbe of the DUT and the reference transistor's Vbe is used to grade the transistors into bins such as 1 or 2 mV wide, using the DVM as a difference meter. That may be generally good enough for matched pairs, for amplifiers, or logarithmic converters, but the Watt-meter circuit published in May 2002 really needs Vbe matched well within 0.5 mV, max, so it's a good idea to grade the transistors into 0.2 mV bins. Then, when you take the transistors out of that bin, or from adjacent bins, they are well-matched.

Oops! I almost forgot to say that you have to blow a big air blast--a steady flow of room-temperature air--over the DUTs. In fact, the DUTs waiting to go into the test should be kept in that same moving air.

After these transistors are matched, it's important to install them properly to keep them at the same temperature. Use some epoxy or glue, and some metal or junk as a thermal mass to keep the transistors at a fairly constant and equal temperature, and preferably along with the temperature-compensating resistor.

Another way to get matched transistors is to buy matched pairs, such as LM3046 or LM394. The '3046s are typically matched to within 1 mV, but the specs are about 3 mV max. You get a quad of transistors at this price. The LM394s are somewhat more expensive for a dual of WELL-matched transistors. But, you get a spec of 300 µV max for the LM394CH, as required for the watt-meter circuit. So that's a good standard technique for making matched pairs, such as for logarithmic circuits, or precision amplifiers -- or a watt-meter!

Best regards. / rap / Robert A. Pease

(A version of this was published in Electronic Design Magazine, June 14,1999.)

THE BEST OF BOB PEASE

What's All This VBE Stuff, Anyhow?

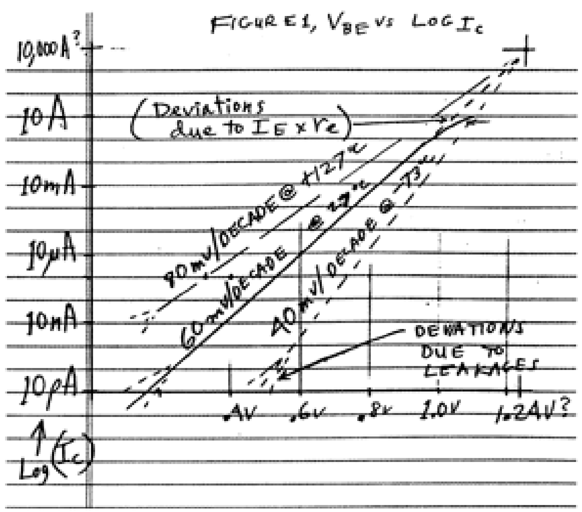
The other day, I was walking past the Applications Engineering area, when I heard a grouchy debate between a couple of guys over in the corner. As they saw me walk by, they called out, "Bob, come on over here, and maybe you can solve this problem for us." I looked at their problem.

"Bob, we were trying to use the standard diode equation to compute the tempco of a transistor's VBE, and it doesn't seem to make any sense." I looked at their standard equation:

$Ic = i_S \times e^{(qVBE/kt)}$

Yes, there was a term for temperature, 't' in there, but it wasn't a very prominent term. Obviously, they had tried to see how this equation responded to temperature. They were puzzled because it does NOT respond properly to temperature. It doesn't give anything *like* -2 mV/degree C. I began assisting them by explaining, "When they give you this equation in school, they neglect to tell you that the i_S isn't a constant, but rather a very wild function of temperature. This function is so wild that they won't tell it to you, because it's not very useful. You can't successfully differentiate it versus temperature. So you're better off NOT having such an unusable equation."

They responded, "Okay, what are we supposed to use?" I replied, "Ah, let's do a graphical approach. Let me make up a couple of sketches." First I scribbled out Figure 1, showing the log of collector current versus VBE.

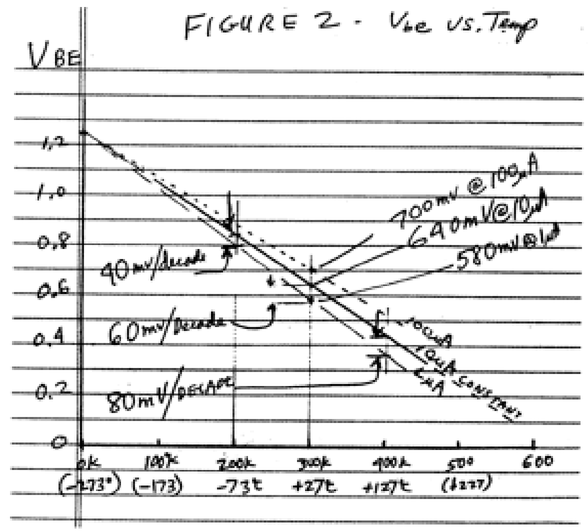


I went on to explain, "That school-book linear plot of VBE versus Ic isn't very useful, because it just shows a severe knee. I never use that one. Look at the middle line of this plot. It shows that at room temperature, the slope of the log of Ic versus VBE is quite linear over seven, eight, or nine decades of current. Only at high currents does the curve bend, due to emitter resistance. And, only at very small currents do you get errors due to leakages. So, in the whole mid-range, you get a wide range of conformity to the slope of 60 mV/decade." The two guys agreed with what I had said.

After this, I pointed to the upper line. "At a hot temperature such as +127 degrees C, the curve is very similar. But, at a shallower slope, the millivolts per decade is *worse*, very close to 80 mV/decade. Indeed, this number of millivolts per decade is predicted by the diode equation." They further agreed that my explanations seemed correct. Plus, I showed the guys that the lower sloping line is sort of like the curve for -73 degrees C, but it's at a slope of 40 mV/decade -- a rather higher gain, with a higher gm. Fine.

Also, it's possible to see that all the curves tend to converge or extrapolate to a single high point at a *very* high base-emitter voltage, perhaps + 1.24 V, at a *very* high current, maybe 10,000 Amperes. Based on this outrageously high theoretical current at an absurd voltage, one could (theoretically) compute what the VBE is really doing--not very accurately, or usefully.

But I pointed out that this curve is just good for giving a ball-park overview of what goes on. Yes, in concept this could be used for computing the actual VBE of the transistor, at various currents and temperatures. But, it's too crude and too broad to be useful. What we want to use is closer to Figure 2.



I sketched away madly to get this figure, showing the plot of VBE versus temperature. This illustrates the bias of transistors at various constant currents, versus temperature. "THIS," I said, "is *useful*--and let me show you where and why." I stated that it was based on the real data, for a real standard transistor, and it's what I use to compute biases for real precision linear circuits, such as band-gap references or temperature sensors. This and a slide rule (or a little hand-held scientific calculator) lets me compute the operating points I need.

I pointed out the middle, solid, sloping line. "This line is based on some measured data. This transistor, when used in a band-gap reference, has a Magic Voltage of about 1.240 V. That's where the band-gap runs flattest. So this line is drawn in order to go through 1.240 V dc at absolute zero temperature. That's where the VBE extrapolates to--if the transistor were cooled off--and that is not real data."

"The other point of calibration is where it goes through 0.640 V of VBE at 10 uA at room temperature, about +27 degrees C. That's a simple, factual, measured data point." Then one guy asked, "But why +27 degrees C? Why not +25?" 1 replied that +27 C is, with an accuracy better than 0.2 degrees C, exactly 300 degrees Kelvin. Therefore, it makes the math much easier to work with, at +200, +300, and +400 degrees Kelvin. They agreed.

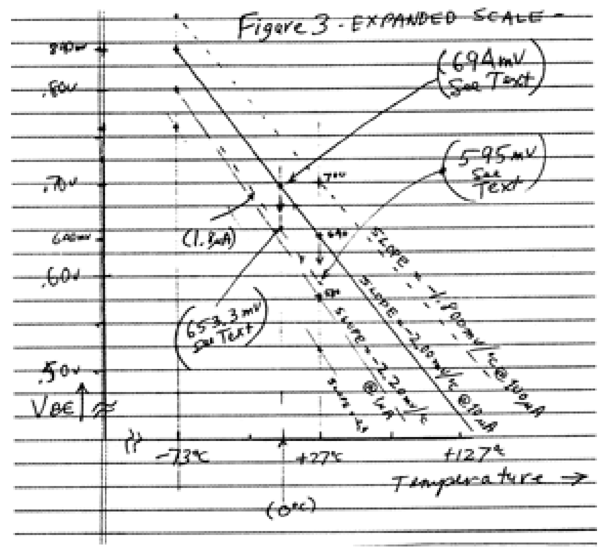
Furthermore, I pointed out that the voltage represented by this line is just the nominal VBE of the transistor versus temperature, at a constant emitter current. This has a nominal slope which is quite close to -2.00 mV/degree C. THIS is a very useful thing to know -- the bias at which the transistor runs at -2.0 mV/degree C -- because we will soon see that at many other operating currents, the tempco is NOT -2.00.

Next I stated to them, that IF the voltage between the solid, slanting line and the horizontal line at 1.240 V is studied, you can see that it's a Voltage Proportional To Absolute Temperature (VPTAT). Therefore, when we want to build a band-gap reference that's 1.240 V, all we have to do is ADD to the VBE a voltage that's VPTAT. Then, we can make a band-gap reference.

This is all you have to do: if you have a VPTAT that's 60 mV at room temperature, and you can amplify this with a gain of 10, then you can add that onto a VBE to make a band-gap reference--as Mr. Widlar proved, about 30 years ago. They agreed, that made sense as well.

I had to admit that the solid, sloping line appears to be nominally linear, and I drew it as more-or-less linear--but it's NOT truly linear. The VBE curve actually is bowed downward at both hot and cold temperatures, perhaps as much as 2 to 4 mV. But for many uses, that's a negligible error, which is easy to make corrections for, later.

I explained further: let's take a look at the upper, dotted line of Figure 2 (and Figure 3). This is for the transistor running at 100 uA. It, too, extrapolates back toward that point at absolute zero. This line does NOT have a slope of -2.000 mV/degree C, but instead -1.800. This line isn't parallel to the other line. It's set above it by 60 mV/decade at room temp, by 80 mV at +127 degrees C, and by 40 mV at - 73 degrees C. This difference is very accurately a VPTAT.



The LOWER dashed line is the line for a bias of 1 uA. It has a slope of -2.200 mV/degree C. It's offset by 60 mV/decade at room temperature, more when hot, and less when cold. The tiny segment of the line is at 0.1 uA, and has a slope of -2.400 mV/degree C (Fig. 3).

So, all lines for VBE at a constant current are all fanned out, radiating from that point at absolute zero. THIS is the curve from which it's easy to compute temperature coefficients and operating points. Now, an expanded plot, Figure 3, depicts only the central portion of Figure 2.

Let's say we want to estimate a VBE at some other biases. I'll take you through some examples. The main point is, though, that you can fairly easily compute the bias for any normal situation.

Okay, we agree that we know the VBE at those specified conditions: 640 mV at 10 uA and +27 degrees C. Let's say I want to compute the VBE of the transistor at the same current, but at a different temperature, like at 0 degree C. In the example shown, the temperature coefficient of VBE is - 2.000 mV/ degree C. A shift of -27 degree C will cause the VBE to increase by (-27) x (-2.0) = +54 mV, up to 694.0 mV. That's not very hard. For any change of temperature, at a constant bias current, simply multiply the change in temperature by the tempco of VBE. But the tempco of -2.0 mV/degree C only applies at 10 uA in this example. At any other current, the tempco will be different. More on this later....

What if we want to start from our initial conditions and move to a different current, such as 1.8 uA at +27 degrees C? For this case, where things are at a constant temperature, you can use the diode equation:

IC1 = Io x e $^{qVBE/kt}$, or its inverse:

VBE1 - VBE2 = kt/q ln(IC1)/(IC2)

The ratio of currents is 0.18, and the natural log of 0.18 is -1.7148. At +27 degrees C, the factor kt/q = 26.06 mV per factor of e, which is the same factor as 60.0 mV/decade.

Therefore, the delta VBE will be - 1. 7148 x 26.06 mV, or -44.7 mV. The VBE will decrease from 640 mV to (640 - 44.7) = 595.3 mV. This isn't a surprise. Any time the collector current of a transistor changes at a constant temperature, the VBE changes in a nice logarithmic way. But that 26.06 mV is only at that value at +27 degrees C. At all other temperatures, it's different, as a linear function of absolute temperature.

Another useful way to look at it, is that any time you change the current by a factor of 10 at room temp (about +27 degrees C), the VBE will shift by 60 mV, up or down, as appropriate. For many cases where decades of current are the important factor, the multiples of 60 mV make calculations simple. No computers or calculators are required.

Now, let's consider the case where you want to compute the VBE when both the current and the temperature are changed. There are two ways to compute this. And, both of these computations had better give the same answer.

Let's say we want to compute the VBE at 1.8 uA at 0 degrees C. You could first change the temperature of the 10-uA transistor to zero degrees at constant current, and then change the current at a constant temperature.

Let's do that: We just agreed that the VBE would be 694 mV at 10 UA at 0 degrees C. How much will VBE change if we then go to 1.8 UA? At 0 degrees C, kt/q isn't 26.06 mV, but 273/300 x 26.06 mV, or 23.712 mV, as the temperature has decreased by that factor. Therefore, as we decrease the current by a factor of 0. 18, the VBE changes by -1.7148 x 23.712 mV, or -40.7 mV, so the VBE decreases to 653.3 mV.

What if we arrive at this point by the other route of first decreasing the current, and THEN decreasing the temperature? We just computed that the VBE at +27 degrees C and at 1.8 UA was 595.3 mV. What is the tempco Of VBE at THIS current? It isn't -2.000 mV/degree C, as it is at 10 uA. And, and it isn't -2.200 mV/degree C like it is at 1 uA. It's at an intermediate value. These slopes are all Proportional To Absolute Temperature, as they intercept absolute zero at 1240 mV. So the slope of (1240 mV - 595.3 mV)/300 degrees C is 644.7 mV/300 degrees C, or -2.149 mV/degree C. If you multiply this tempco by a -27 degree C change, the shift will be 58.02 mV. When you add this to 595.3 mV, the answer is 653.32 mV. So, fortunately, we get the correct answer when we compute it either way.

If you need to know the tempco of VBE, it normally changes - 200 uV/degree C every time the current is reduced by a factor of 10. Thus while the transistor of this example had - 2.000 mV/ degree C at 10 uA, it has - 2.200 mV/ degree C at 1 uA, -2.400 mV/degree C at 0.1 uA, -2.6 mV/ degree C at 10 nA, and -3.0 mV/degree C at 100 PA. While most people don't bias transistors down there, that does NOT mean that the tempco isn't surprisingly well defined down there, and it's a LOT bigger than just -2.0 mV/degree C!

What other factors should we take into account when we want to compute VBE? With monolithic npn transistors, it's fairly safe to assume that the transistors' VBEs are fairly well matched and predictable. We need to only take into account a difference of about 5 or 10 mV, if the transistors are designed with similar geometries. That's even if no special care is taken to match them perfectly. With discrete transistors from the same batch, the matching may be similar, or it might be POOR if the transistors came from different batches. There could be a lot of deviations, but you can't count on that.

As mentioned earlier, the curvature of VBE versus temperature will cause the VBE to be 1 or 2 mV smaller, at 0 degrees C and also at + 70 degrees C, compared to the linear predictions. It could easily be 3 or 4 mV lower at -55 degrees C or

+150 degrees C -- it really is quite close to a parabolic eror.

Additionally, Earley Effect will normally cause a low-beta transistor (beta = 50 or 100) to run 1 or 2 mV lower in VBE, if the VCE is as high as 20 V, rather than 0.6 V. On high-beta transistors (beta = 200 or 400), the decrease in VBE may easily run 3 or 4 mV. (At another time, we can discuss the complete ramifications of this Earley Effect. Suffice it to say here, transistors with high beta might have smaller CURRENT errors, but they tend to have correspondingly poorer VOLTAGE errors.)

Of course, if you run the transistor at high currents where V = IE x RE is significant, that effect can be additive (approximately) and is usually fairly linear and predictable (not to mention self-heating). If the IC or IE are small, then the leakages may cause significant deviations. Also, if IE becomes quite small, some transistors may have a rapid fall-off of beta, so you cannot be sure the base current is negligible any more! And if you ever let the transistor saturate, the VBE can rise or fall considerably, depending on how the transistor was made. Still, these graphical techniques can do a pretty good job of helping you to estimate the VBE of a bipolar npn transistor--and of a discrete pnp, too.

Now, you could write a fancy equation to compute all this, but I prefer a graphical approach. That way, I get good insights into what's going on, and I don't get fooled by computational mistakes.

All for now. / Comments invited! RAP / Robert A. Pease / Engineer rap@galaxy.nsc.com -- or:

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P.S. If you really want to use a big unwieldy equation, be my guest:

$I_C\ (uA) = 99.8 \times 10^9 \times e^{(V_{BE} - I_E \times R_E - 1.240V) \times q/kt}$

where q/kt = (1/26.06 mV) x (300 degrees Kelvin/t) Of course, your transistor will surely have a scale factor different from 99.8. / rap

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THE BEST OF BOB PEASE

What's All This Widlar Stuff, Anyhow?

When we got the word that Bob Widlar had passed away on February 27, 1991, at the young age of 53, (heck, I'll be up there at 53 in a couple years, if I'm lucky ...), we all began to bring out stories about things Widlar had done. There are lots of good Widlar stories, and many of them have been printed recently. I will just try to tell here the ones that nobody else has told.

First of all, Widlar did not bring in a goat to chew down the unmowed lawns at National (when the money for gardeners was cut back). That would be absurd. Widlar would not do that. What he brought in was a sheep. I can prove it, because Fran Hoffart showed me a picture of the sheep.[1]

Widlar brought the sheep in the back seat of his Mercedes-Benz convertible. That would be nice to document with a photo, but Fran didn't get a photo of the sheep's arrival. However, Bob Dobkin told me that he drove up with Widlar and the sheep, after Widlar bought the sheep in Morgan Hill for $60. Dobkin said that after the sheep was tied up to a tree in front of National's headquarters, the news photographers only took 20 minutes to show up. At the end of the day, Widlar went over to a bar (Marchetti's) and took the sheep with him. He left the sheep with the bartender.

That leads to another story, about the time Bob made the gardeners unhappy. Nobody remembers exactly what he did to make them so unhappy, but it must have been pretty good. One person said maybe that was the time Widlar could not find a good parking place, so he parked his convertible on the lawn -- repeatedly. The gardeners retaliated by letting a sprinkler run into that area, and when he came out to go home, the car had several inches of water in it. Did Widlar retaliate after that? Nobody remembers, but even Widlar knew that sometimes, it's time to quit when you are overmatched.

Charlie Sporck, (who recently retired as the president of National) told me about the first time he met Bob. He was in the Fairchild hospitality suite during the IEEE show in New York City back in 1966. He was reading in Electronic News that Raytheon had just brought out an RM709 as a second source to the Fairchild UA709. Bob, who was not pleased at being second-sourced, came over and, uttering a generalized profanity, set fire to Charlie's newspaper. Charlie was astonished, and threw it into a metal wastebasket. Unfortunately the fire did not go out. As they tried to extinguish the fire, the smoke alarms went off and the fire department arrived. So much for first impressions....

When I first came out to National in February of 1976, I was in a good mood, and I set about my new work whistling cheerfully -- until Widlar came by. Bob reminded me that my whistling was bothering people. In fact, my whistling was annoying *him*.

I tried to stop whistling, and he kept reminding me, and each time I agreed that I was trying to stop whistling as well as I could, but the music (Mendelssohn's organ sonatas) was really circling around gloriously inside my head, trying to get out. Widlar was as good-natured as he could be, and I finally broke the habit -- after about a week of reminders. There were just certain kinds of annoying sounds that he felt he didn't have to put up with. And to a large extent he was fair about that.

- Hacksawing large pieces of metal? Take it outside.

- Drilling many holes in a chassis? Wait till everybody went to lunch.

- Print out a huge print-out on the new line printer? Well, if Widlar could not get this noise delayed until "lunch time," Widlar would just go out to lunch with Dobkin or Mineo, or both, right then. Whether it was 10 A.M. or 3 P.M., Widlar didn't need much aggravation to convince him it was "lunch time." Some days, he did indeed drink a lot of lunch. But that didn't prevent Bob from getting lots of good ideas done. It may have helped.

We still have a sign around our lab, "This is not a black-smith shop." But there were times when Bob would discover he had wasted a day or two, just because one bad part had screwed up his circuit. He would bring this bad part -- a capacitor, a pot, a transistor, an IC, or whatever -- over to the vise and lay it on the anvil part. Then he would calmly, methodically beat it with a hammer until the smallest remaining part was indistinguishable from the dust on the floor. Then he would go back to work and get the right answer. He explained that it makes you feel much better if you do this, and, you know that bad part will never come around again and goof you up. He was right. And I recommend that you join me in doing this "Widlarizing" when a bad component fools you. You will feel a lot better.

One time Bob was standing up on a lab stool in the hall outside his office, taping a large firecracker to the paging system loudspeaker, when Pierre Lamond happened by. Pierre was the vice president in charge of R&D, and Bob loved to give him a hard time. Pierre asked, "What are you doing, Bob?"

Bob replied, "I am going to blow out these damn speakers." Pierre used all of his Gallic aplomb and replied, "Oh," and turned and walked back out the door. Widlar lit off the fuse and hopped down. Then an M-84's blast ripped the cone out of the speaker. Bob had to repeat the blast to get the paging system to stop making noises in his lab. And poor Pierre must have been under great stress to realize Bob was setting such a bad example, but Pierre could not let on that it was bothering him. So, Widlar was not averse to fighting noise with noise.

One of the celebrated things Widlar did was to put a "hassler" in his office.[2] When a person came in to his office and spoke loudly, this circuit would detect the audio, convert the audio to a very high audio frequency, and play back this converted sound. The louder you talked, the lower the pitch would come down into the audio spectrum, and the louder it would play. So if you really hollered, it would make sort of a ringing in your ears. Of course, if you noticed this "ringing" in your ears, and stopped for a while to listen, the "hassler" circuitwould shut up. He gradually got people to stop yelling at him. I mean, Bob really was almost always a soft-spoken person. He didn't have to yell or shout to get his message across. When he did speak, and softly at that, people would soon realize that it was a good idea to listen to him.

The first serious test of the Hassler was planned when Bob invited Pierre Lamond to his office. Pierre was immediately suspicious, because Widlar never invited him over. When he got there, Bob made several statements that were calculated to get Pierre angry. Pierre raised his voice, and the Hassler went to work. Pierre figured out that Widlar was playing some trick on him, and shortly he departed, angrier than ever -- just as Bob had planned.

One night Bob left the "hassler" on. The next morning, his secretary tried to do some typing, and every time she hit a key, the "hassler" would chirp. It drove her nuts until Widlar came in and turned it off.

One thing that would have made Bob gripe was to see "consultant" in his obituaries. Bob never failed to point out that he was NOT a consultant. Consultants get paid for showing up. Bob was a contractor, and contractors get paid for making things that work. Bob did get paid because his circuits did work. Of course, sometimes it took several masksets, and several years, because Bob was doing tasks that weren't easy.

Let me correct another error in the obituaries. The first story we heard was that Bob died while jogging on the beach, a story that got into all of the papers. Apparently he had been jogging on a sidewalk, in a steep hilly section of Puerta Vallarta, and died of a sudden heart attack. He was not recognized for several days.**

Not just an easy jog along the beach. Bob was, in recent years, pretty much into fitness, and he worked hard at his running. Recently, he had apparently cut down a lot on his drinking, too. Maybe the alcohol had chased away the coronaries, and the lack of alcohol contributed to the heart attack? I'm no doctor. But he did not die drunk, which may have amazed a number of his colleagues.

One time Bob was out drinking beer with his friends and he told his friend Ken Craft that he could drink a mug of beer faster than Craft could throw a mug of beer over his shoulder. At the word GO, Ken flung his beer over his shoulder in about one second flat. Widlar just stood there and smiled, and then slowly raised his mug to his lips, saying, "you win."

What technical things did Bob accomplish? Well, in addition to the amazing innovations in opamps and bandgap references, which every other magazine has commented on throughly, Bob also brought out the industry's first high-power voltage regulator, the LM109. A couple of people reminded me that in the fall of 1967, there had been a big controvery about whether it would be possible for anybody to build a high-power regulator on one monolithic chip. There were little letters to the editor in several magazines, pro and con. Finally, Widlar settled the argument by writing an authoritative-sounding letter. It pointed out that the thermal gradients on a chip would make it impossible to make a high-power chip with good performance, and the features would be impossible, and the reliability would be impossible. That settled the argument. Everybody shut up, because obviously Widlar knew what he was talking about. Then two months later, Widlar introduced the 20-Watt LM109, and it included all those features that Widlar had said were impossible. All of the IC engineers realized Widlar had taken them for a ride, and that he had the last laugh. What a master of the art of playing games!

When the first LM109s were ready for testing, Widlar designed a tester, and Ken Craft built it up. Widlar came over to try it out. He griped, "It works OK, but the START pushbutton is on the left side, and it ought to be on the right side." The next day, Widlar came by the box and there was a big arrow, "PUSH to test," pointing at a blank area on the right side of the top of the box. Widlar, being a curious sort, decided to PUSH where it was indicated. Immediately the test sequence began and cycled through, with a green light going on. What the heck?? There was no pushbutton there, but every time Widlar pushed that spot on the panel, the test sequence occurred. Ken had cut away the copper foil at that place and installed a sensitive light-detector under the epoxy pc-board material. When you put your finger on that spot and blocked off the light, it would trigger the tester as a conventional pushbutton would do. Widlar was pleased that his guys would come up with a sneaky, ingenious scheme like that.

What other technical things did Widlar do? Even to the end of his career, Bob eschewed SPICE and similar computer simulations. He preferred to use breadboards, all sorts of breadboards, and also "the Mexican computer."

Namely, he used Teledeltos paper[3] to make resistive analogues and simulate the two-dimensional flow of current. How many of you guys have used it? I recall we used it in school, 32 years ago, and I still use it every other year. You sketch the shape of your resistive pattern onto this resistive paper, at about 400 ohms per square (give or take 4 or 5 dB). You cut out the outlines, and paint on silver conductive paint at the border where current comes and goes. Then, after the paint dries, you shove in some currents and read the voltages and see if the ratios seem right. If not, it's cut-and-paste time again. Bob used this technique a lot to get some measure of how currents would flow. He used this especially for nonlinear or curved or non-obvious geometries. I don't think he ever actually did any of this work in Mexico, but I guess he could have if he had to. He never did any bread-boarding or measuring down in Mexico; he would write in his notebooks and decide what circuits to try, and then come up to Santa Clara and try them. He kept very neat notebooks, and he also wrote neat script when it came to writing technical papers -- some day I intend to show that George Philbrick's penmanship and Widlar's were uncannily similar.

Of course, the stories about Widlar in a light mood were almost as bizarre as they were true. He would sometimes go to the airport, walk up to a ticket counter, and ask the clerk, "What time does your next plane leave?" The clerk would mention the time and the destination: "Our next departure is at 5:20 P.M., flight 772 to Vancouver." Then Widlar would haul out his wallet and peel off some bills and buy a round-trip ticket to this random place from the astonished clerk. In a few days, Widlar would return from his surprise vacation.

Sometimes, Widlar took one of his secretaries and picked her up by the ankles and lowered her head into a fountain. She seemed to like it. (Jim Dunkley told me this. He said her name was Nancy...)

I gave a paper at a conference in March of 1970 in Paris. Widlar also gave a paper. I recall that at the end of lunch, Widlar made sure that he got a full bottle of wine to bring back with him into the conference hall, in addition to the wine he had enjoyed with his lunch. When it was time for Bob to give his talk, he had knocked the level of the wine bottle down quite low. He always said he didn't find it easy to give a big lecture, unless he had some tranquilizer in his stomach.

At this conference, Bob was well tranquilized, and he was giving a good lecture about his new circuits. But the translator (English into French) was having difficulty keeping up with all of the obscure technical phrases that Widlar was tossing off so easily and rapidly. A couple times, the translator begged somebody to get Widlar to slow down. But nobody could slow him down. Finally, the translator gave an anguished cry of distress and walked out. Bob just kept on explaining his circuits, without slowing down or speeding up.

Afterwards, when conference chairman Jerry Eimbinder told Widlar he would have to speak more slowly the next time, Widlar responded, "The next time I talk here, you'd better get better interpreters..."

A year ago, Jim Williams was compiling the book "Analog Circuit Design: Art, Science and Personalities."[4] I asked Widlar if he would like to write a chapter or two. Bob gave a shrug of disinterest and kept on with what he was doing. I asked if he would like to just talk into a tape recorder and we could get it typed. No, not interested. I asked, well, surely there must be a story that ought to be told, shouldn't you tell it? He explained, with weary patience, that he really had no interest in telling any such stories. I knew better than to try to argue with a guy who obviously knew what he didn't want to do. Maybe I should have invented a trick -- taken a tape recorder down to a bar and let the tape run? Obviously, if you can predict when you're going to lose a legend like Widlar, you would resort to a trick like that. But, we just saved all of the good stories we could ...and the ones printed here are barely half of the good printable ones, not to mention all of the ones that could never be printed....

Obviously, there will never be another engineer like Widlar. He led the linear IC industry in many amazing new directions. I think every circuit designer has looked at one of Widlar's new circuits and said, "Good heavens. You can do THAT? If THAT works the way he says it does, then I could use some of these ideas to improve MY circuits..." I found several places where I could correct or improve some of Bob's applications circuits, where he added resistors and capacitors around the IC. But I never found places to improve his ICs. This fall there will be a technical paper published in the IEEE Journal of Solid State Circuits, on the topic of substrate current flow in ICs. Widlar's last technical paper. And everybody will read it and say, "But, of course he's right. Why didn't I think of that myself, first?" I'm not sure if Bob Widlar ever designed an obvious circuit in his life.[5]

Comments invited!

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** When this column was originally published, I stated what I had been told: "Widlar had been running up on a high ridge, and was apparently descending a steep trail down from this ridge when the heart attack hit him, and he fell in a dive and died." But apparently this was not true. I'm sorry I had the wrong story, and am glad to get this corrected. / rap

1. That sheep's photo is now on my website: or go to:
www.national.com/rap and click on Horrible Pictures.

2. This circuit was published in "What's All This Hassler Stuff, Anyhow?", Electronic Design, May 15, 1995.

3. "What's All This Teledeltos Stuff, Anyhow?" May 30, 1994, p.101.

4. Published June 1991 by Butterworth-Heinemann, Woburn, Mass.

5. Refer to my web site as listed above, and at Horrible, Mr. Widlar's picture can be found.

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THE BEST OF BOB PEASE

What's All This Fuzzy Logic Stuff, Anyhow? (Part II)

If you can think of an unlikely person to study Fuzzy Logic, it's RAP. While it's a dirty, nasty job, somebody must do it, and I've had lots of ecouragement from all you readers since I put out my first column on the subject.[1]Note, some people have characterized me as being a detractor of Fuzzy Logic (F.L.), but I think I have done more good for the field of F.L. than lots of other guys all put together. I think it's to nobody's benefit to have people bragging about advantages that are unreal.

I believe people who are making responsible, intelligent claims for F.L. will be glad to have me on their side, to cut down on irresponsible, unfair, preposterous claims. I consider myself, rather, a skeptic -- and here is a laundry list of ideas I have figured out or discovered so far:

1. Nobody has yet submitted to me any realistic task or control loop that they did with Fuzzy Logic which I could duplicate.
2. Isn't it strange that some Fuzzy Logic promoters want to quiet down Pease, but none of them has brought me a nice simple example to show how F.L. really is better than conventional systems (and, after we turn on the lights, we hear them scuttling under the cabinets). I didn't expect to get many, but zero is indeed a very interesting number.

However, as one person pointed out, the F.L. experts who really are good, are too busy to fool around with demonstrations, since they have lots of work to do -- that's a fair explanation.

1. Almost everybody agrees that the examples I gave of outrageous F.L. claims were indeed pretty incredible, and that some F.L. promoters do exaggerate a lot. Several people sent in additional examples of Fuzzy Logic hype, such as pumps that allegedly come up to speed 2 times faster than with a "conventional" controller, and fuzzy motor controllers with miraculous "advantages..."
2. I have seen several readers give the same opinion that F.L. will be a lot more useful and valuable than its detractors predict, but a lot less useful and valuable than its promoters have said. Some of the claims, for example, that 50% of all microprocessors will be used for F.L. by 1996 seem a bit far-out.
3. Some promoters of F.L. are quite young, and when they promote F.L. as superior to other kinds of controllers, they show fantastic advantages -- not out of malice, but just because they're not really familiar with the capabilities of other techniques. So they set up a straw man, which they then proceed to knock over easily. They do this because they don't know any better. Those of us who know better have an obligation to explain this to them.
4. Some F.L. guys aren't very good at explaining. Certain people think this may arise from their experiences in applying for research grants: If they clarify everything, and make it look too clear and easy, how can they apply for another grant to explain yet more? Even allowing for this, they aren't very good at explaining things. They love to use lots of jargon. They speak in terms that are suitable for "preaching to the converted," but don't make clear explanations to the rest of us. Then they bleat that the rest of the world is closed-minded and prejudiced against them. I wonder why that is....
5. For example, some of them like to talk about the ability of their math to handle "probability." When you check it out, you find

that they're talking about proportionality -- the analog parameters. But because many of their old mathematical tools are borrowed from the probability experts, they persist in using that phrase. It bugs the hell out of me!! And a lot of other people, too!

6. Many F.L. guys love to make rash, outrageous philosophical claims: "With Fuzzy Logic controllers, you don't need any models." "With F.L., you never have to worry about the Nyquist sample rate." "You do not need to know the characteristics of a plant to design a controller for it." "The major advantage in the use of a fuzzy loop is that it reacts much faster to a process disturbance (or to overshoot and undershoot) than does a standard PID loop."[3]After much debate and criticism from conventional control experts, they may concede their claims aren't entirely true, but only after they have succeeded in getting everybody mad at them.
7. F.L. is claimed to make a good servo for some kinds of systems where conventional controllers don't work well. WELL, let's assume that in some cases it's true. Then how do you prove that such an F.L. system has good dynamic stability in all cases? For conventional controllers, there are methods to prove that a controller has a good safety margin of dynamic stability. How can you demonstrate and prove adequate safety margins/safety factors for F.L. systems? Remember -- F.L. claims advantages because it can accommodate system nonlinearity by incorporating appropriate nonlinearity in the controller. How do you prove that this is safe? How much proof is necessary? That sounds like a real problem to me. If your new F.L. washing machine blows up, how can the manufacturer prove to the jury that he used the best available tests to ensure customer safety? As with any nonlinear controller system, extensive testing is needed to prove that no regions of instability will jeopardize proper system operation.
8. Some people pointed out that a Fuzzy Logic system is a kind of Expert System -- a form of Artificial Intelligence. Now, the F. L. people may not like to talk about this because of the disappointments with Expert Systems in the past. But, are these not some of the same people who worked with Expert Systems and Artificial Intelligence in the past?? You tell me. Still, despite old disappointments, this seems to be a place where the Expert System, under the name of Fuzzy Logic, finally begins to fulfill its promise. MEANWHILE, some Artificial Intelligence experts are the most adamant detractors of F.L., because they have their math, and do not like to see F.L. people using "linguistic variables." Personally, if I hear "If the input is small, the output is little," one more time, I will vomit.
9. Let's assume that F.L. really can help make vacuum cleaners and washing machines work better. If that's the case, they do so because of the SENSORS. Which is more important, the better sensors or the F.L.?? Maybe those smart, aggressive, and problem-solving F.L. guys will use the sensors very thoughtfully. Which is the chicken, which the egg? I can't say.
10. Fuzzy Logic doesn't really generate a control law. It maps an existing control law from one set of rules into a logic set.[4] If the rules permit this to be done efficiently, it may be able to accomplish the computing function just by remapping. That's a well-known way to get your computation done quickly. But the programmer or rule-maker has to provide the mapping functions -- the rules. However, writing those rules isn't a trivial exercise. Even if you want to let Neural Networks write the rules for you, as with NeuFuz4[5], that can be quite a piece of work.
11. F.L. guys universally ignore the role of their input sensors, their analog-to-digital converters, and the format of the (digital) interface to their Fuzzy Processors. I've heard people say that in some cases, F.L. works just fine with a single input bit stream. In other cases, the controller obviously requires an 8-bit, 10-bit, 12-bit, or higher-resolution parallel data bus. But (just about) every Fuzzy Experimenter makes ZERO mention of the input data. One person admitted about F.L. designers: "Of course they need good input data, and they just assume that the data will be made available to them in a suitable format."

    ... Well now, what format is that? It certainly isn't the same for every case, and, therefore, it should certainly be discussed. Every time I've looked at an "example" of a real Fuzzy Logic system or controller, the data inputs were left completely unmentioned. This frustrates the hell out of me because I know that in the real world, in a real system, this is quite important. Caution -- don't be fooled into thinking, as one of my friends did, that a F.L. system only needs a 3-bit ADC at its input, because there are only 3 or 4 "rules." These few rules will take in and process the 8 or more bits of data (1 part in 256 resolution), which they then map into an output with full 8-bit (or more) resolution.

Also, don't think that the F.L. process is fuzzy or imprecise, or isn't "deterministic". I have been informed to point out that when the input moves a small amount, the output will move an appropriate amount, with no real uncertainty or doubt. A F.L. controller is, normally, just as "deterministic" as a conventional controller, whether analog or digital. It just uses different internal processes. The "fuzziness" in F.L. just refers to the way that an object is in a set. In classical set theory, an object is either in a set or it is not. There's no "in-between," no grading. In the real world, of course, objects can be in a set "partially." F.L. extends classical set theory by assigning degrees of membership (typically, fractional amounts) to objects in such a way as to not conflict with classical set theory.[6] Thus, F.L. can serve as a generalization and as an extension of existing set theory to help solve real-world problems in cases where traditional methods fail, or where nonlinearities cause poor results in price or performance. Of course, many of us engineers use analog signals to represent that proportionality.

12. Note that in most real systems, whether F.L. or conventional, it's important for the system to be given good information, with good resolution and good accuracy. If adequate information isn't made available, it's unclear how either one will do a good job. Specifically, when F.L. guys say that "You never have to worry about the Nyquist sample rate," that is true only if you have a big safety margin. If your F.L. system's sample rate is too low, and your system works badly, then of course you have to worry about it, just as everybody else does.[7]
13. In a conventional digital or analog controller, it is customary to provide a parameter, such as distance or rotation, to the controller. The controller then computes a derivative or difference signal, dx/dt. But in a F.L. system, you have to provide the x data and then a derivative, dx/dt. Apparently F.L. falls short when it comes to timing or counting, so the F.L. controller can't compute the derivative function -- you have to provide it that. Therefore it's not quite true that an F.L. system needs the same information as a conventional controller -- sometimes it needs *more* information.
14. LIKEWISE, Fuzzy guys uniformly ignore the output format of their systems. Is it serial or parallel? They're always too shy to mention this. I did hear that for the Inverted Pendulum experiment, the F.L. approach is so greatly superior to conventional controllers that it puts out just a serial pulse train (the signal is the duty cycle) which controls the loop without any trouble. Yet in other cases, it's obvious that the output must comprise parallel bits to a conventional DAC. But they never make any reference to this, either. How many bits, 8, 12, or 16? Nobody talks about this; it's "academic" and is left as an exercise to the reader.
15. Not only do the F.L. guys never talk about their input interface or their outputs, they also avoid talking about the actual computer or microprocessor they use. They rarely mention the number of bits, or the clock rate, or the software. They always try to keep things "academic" -- and they don't tell you what they really did.

NOW, let's talk about cases where F.L. may have advantages:

16. Fuzzy Logic is generally admitted -- even by RAP -- to have real advantages where the system is nonlinear. One simple example, again, is the Inverted Pendulum, where the base of a stick on a pivot is moved along a track by a little motor. The angular acceleration of the pendulum is NOT a linear function of its angle away from vertical, but a sort of third-power law. If you try to approximate this with a linear function, it's hard to get the gain right. It's either too low at the ends or too high in the middle. Or else you have to compute the function precisely, which may take a LOT of computation. But with F.L. you can get the gain approximately right with just a few segments of F.L. coding -- perhaps just 5 rules. These rules now are so simple, that the F.L. computing processors can compute this with good speed, and a cheap computer, faster and cheaper than a conventional computer can do when it computes EXACTLY the equations of motion for that Inverted Pendulum. Consequently, if the computer can go faster, it may be able to do a superior job of controlling, because although its math is crude, it's plenty accurate enough, and it's fast. NOW, when you compound the problem by stacking two inverted pendulums on top of each other, F.L. can (allegedly) still do it easily. For the triple inverted pendulum, F.L. can still do it,[7,5] whereas conventional controllers apparently can't do all of the complicated math fast enough. Maybe if you made some simplifying assumptions, some approximations, the conventional controller could then go fast enough, but this is generally ignored. F.L. can make certain assumptions, approximations, and simplifications, but other controllers aren't supposed to be able to do this.

17. F.L. is supposed to have real advantages where an approximate system solution is adequate. For example, I read a statement by a F.L. promoter[8] that said if you want a computer to park your car for you, you should exploit imprecision. If you don't need the car at exactly 6.00 ±0.02 inches from the curb, but something like 6 ±2 inches, then F.L. may be able to do a superior job, especially since you can use a cheap computer. When I read this, I was struck by its wisdom. But who would dare to admit that F.L. is not only not always better, but sometimes, inferior in accuracy, yet it's still plenty good enough? I looked, and it was Lotfi Zadeh himself, the creator of Fuzzy Logic. He was wise enough to say that, and I'm delighted to say I agree that when a solution is good enough, don't worry about perfection. I'm absolutely in favor of pragmatism, and of good-enough engineering. Perfectionism is the bane of cost-effective engineering. Anybody who knows when to do a good-enough job and stop is a friend of mine.
18. Let me insert an esaeP's fable here: One time I was bicycling down Massachusetts Avenue in Cambridge, Mass. on a quiet Sunday morning, and a dog started chasing me. Because I was on a downgrade I accelerated well, and the dog fell a few yards behind me. He could not gain on me, and I was going fast enough, so I did not bother to pull further away from him. At a split in the road, I continued on down Mass Ave. The dog veered off onto Mt. Auburn Street, barking all the way, as if to say that he was not really chasing me at all, so he did not care if he had not caught me. WELL, when I make a few convincing arguments to rebut the F.L. claim that "F.L. is always better", the F.L. experts often veer away, saying, "Even if it is not always more precise, it is less expensive." NOW, F.L. is alleged to be a less expensive way to run a controller. In some cases, it may be able to use a cheap computer. It may use fewer lines of code or a smaller ROM. The F.L. guys love to claim this. But I don't automatically trust them when they say "it's cheaper." After all, what would you expect them to say?? I am still skeptical about these guys. Other experienced engineers find that for some cases, conventional controllers can be more compact, cheaper, and easier to program than F.L. So, if in a given system the F.L. experts claim that F.L. is cheaper, you had better check their data. Make your own cost comparisons. Don't let them just set up straw comparisons. Stay tuned for more Fuzzy Logic stuff in the next issue...

All for now. / Comments invited!
RAP / Robert A. Pease / Engineer

Address:
Mail Stop D2597A
National Semiconductor
P.O. Box 58090
Santa Clara, CA 95052-8090

- References:

1. "What's All This Fuzzy Logic Stuff, Anyhow?," R. A. Pease, Electronic Design, May 13,1993, pp. 77-79.

2. One reader sent a report on a design involving a focusing system for a laser's lenses, but I couldn't very well duplicate that. Another person promised to send me more info about a motor speed controller, but never sent anything. One writer said that "all of the arguments of the above writer are not right," but gave no specific example of anything in my writing he thought was wrong....

3. "Fuzzy Logic: A Clear Choice For Temperature Control", Haubold vom Berg, Instruments and Control Systems, June 1993, pp. 39-41.

4. Private correspondence with Daniel Abramovitch, Hewlett-Packard Labs, Palo Alto, CA. June 30, 1993.

5. NeuFuz4 from NSC, combining Neural Networks and Fuzzy Logic. The Neural Network part can learn from recorded data, then generate fuzzy rules and membership functions. Thus, it can learn the best way to control the system. Call (800) 272-9959 for XXX Obsoleted.XXX details.

6. "Fuzzy Models - What Are They, And Why?" J. Bezdek, IEEE Transactions on Fuzzy Systems. Feb. 1993, pp. 1-6. A good introduction to Fuzzy Sets and concepts.

7. Private correspondence with Daniel Abramovitch, Hewlett-Packard Labs, Palo Alto, CA. June 30, 1993.

7.5 I heard later that the F.L. TRIPLE Inverted Pendulum controller was not actually done, in the real world, but only in simulation. Obviously, the practical limitations of sensors would make it quite hard, but it's still fairly impressive.

8. "On The Fuzzy Edge Of Technology", Tom Williams (quote of Lotfi Zadeh), Computer Design, April 1993, p. 14.

RAP's comments in 2002:

- Yes, some of my skeptical observations have been confirmed. A lot of places where F.L. claimed to be superior, did turn out to be INFERIOR. See also at Fuzzy Logic Part III, Fuzzy Logic Part IV, and Fuzzy Logic Part V, and at Refrigerator Stuff, and Acceleration Stuff...
/ rap

signetics FULLY ENCODED, 9046 x N, RANDOM ACCESS WRITE-ONLY-MEMORY

25120

FINAL SPECIFICATION[10]

DESCRIPTION

The Signetics 25000 Series 9046XN Random Access Write-Only-Memory employs both enhancement and depletion mode P-Channel, N-Channel, and neu[1] channel MOS devices. Although a static device, a single TTL level clock phase is required to drive the on-board multi-port clock generator. Data refresh is accomplished during CB and LH periods[11]. Quadri-state outputs (when applicable) allow expansion in many directions, depending on organization.

The static memory cells are operated dynamically to yield extremely low power dissipation. All inputs and outputs are directly TTL compatible when proper interfacing circuitry is employed.

Device construction is more or less S.O.S.[2].

FEATURES

- FULLY ENCODED MULTI-PORT ADDRESSING
- WRITE CYCLE TIME 80nS (MAX. TYPICAL)
- WRITE ACCESS TIME [3]
- POWER DISSIPATION 10uW/BIT TYPICAL
- CELL REFRESH TIME 2mS (MIN. TYPICAL)
- TTL/DTL COMPATIBLE INPUTS[4]
- AVAILABLE OUTPUTS "n"
- CLOCK LINE CAPACITANCE 2pF MAX.[5]
- $V_{CC} = +10V$
- $V_{DD} = 0V \pm 2\%$
- $V_{FF} = 6.3V_{ac}$ [6]

APPLICATIONS

DON'T CARE BUFFER STORES
LEAST SIGNIFICANT CONTROL MEMORIES
POST MORTEM MEMORIES (WEAPON SYSTEMS)
ARTIFICIAL MEMORY SYSTEMS
NON-INTELLIGENT MICRO CONTROLLERS
FIRST-IN NEVER-OUT (FINO) ASYNCHRONOUS BUFFERS
OVERFLOW REGISTER (BIT BUCKET)

PROCESS TECHNOLOGY

The use of Signetics unique SEX[7] process yields Vth (var.) and allows the design[8] and production[9] of higher performance MOS circuits than can be obtained by competitor's techniques.

BIPOLAR COMPATIBILITY

All data and clock inputs plus applicable outputs will interface directly or nearly directly with bipolar circuits of suitable characteristics. In any event use 1 amp fuses in all power supply and data lines.

INPUT PROTECTION

All terminals are provided with slip-on latex protectors for the prevention of Voltage Destruction. (PILL packaged devices do not require protection.)

SILICON PACKAGING

Low cost silicon DIP packaging is implemented and reliability is assured by the use of a non-hermetic sealing technique which prevents the entrapment of harmful ions, but which allows the free exchange of friendly ions.

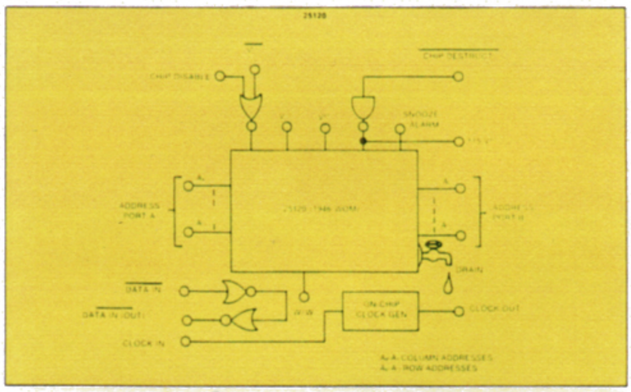
SPECIAL FEATURES

Because of the employment of the Signetics' proprietary Sanderson-Rabbet Channel the 25120 will provide 50% higher speed than you will obtain.

COOLING

The 25120 is easily cooled by employment of a six-foot fan, ½″ from the package. If the device fails, you have exceeded the ratings. In such cases, more air is recommended.

BLCCK DIAGRAM

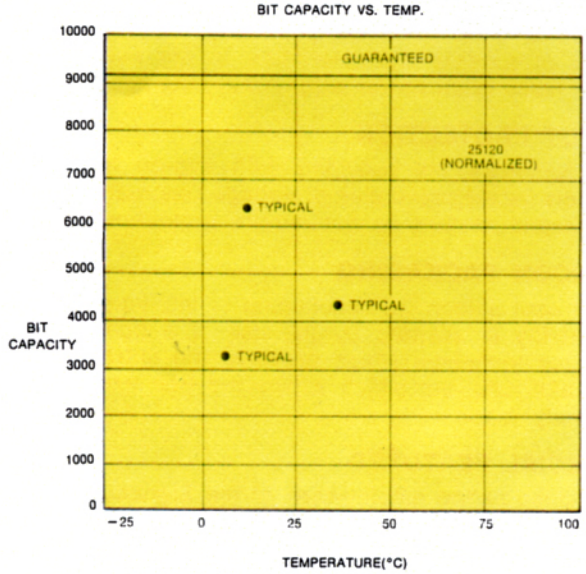


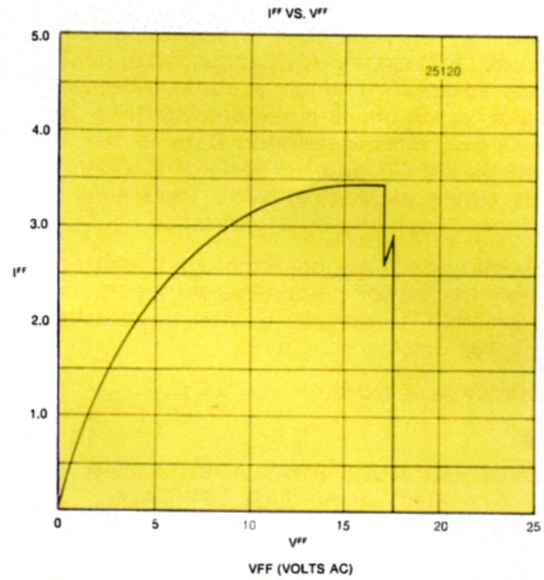
PART IDENTIFICATION

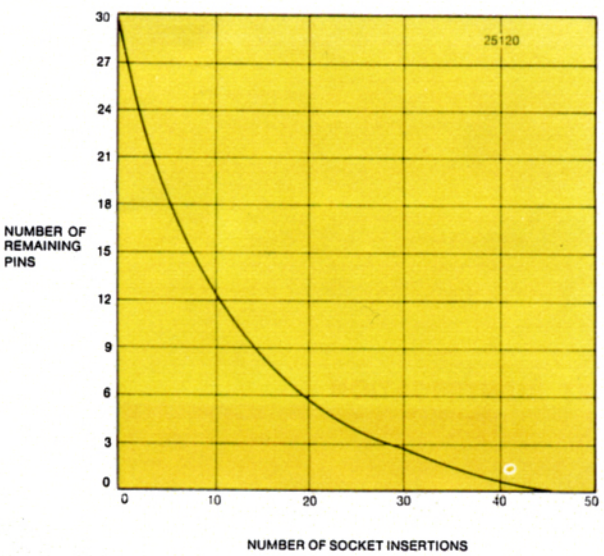
TYPE	"n"	TEMP. RANGE	PACKAGE
25120	0	0 to −70°C	Whatever's Right

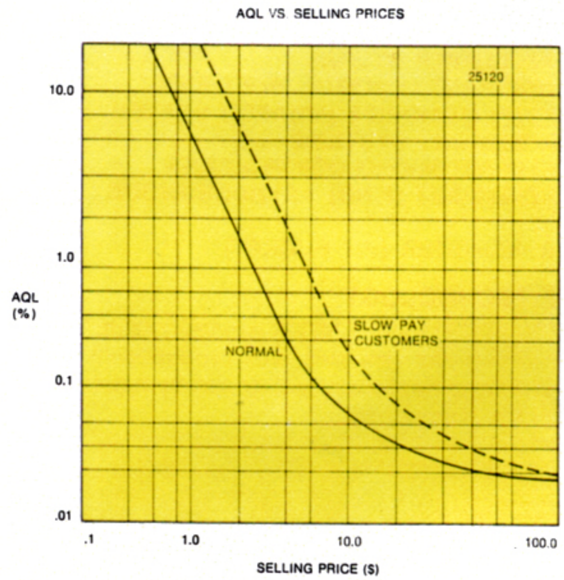
1. "Neu" channel devices enhance or deplete regardless of gate polarity, either simultaneously or randomly. Sometimes not at all.
2. "S.O.S." copyrighted U.S. Army Commissary, 1940.
3. Not applicable.
4. You can somehow drive these inputs from TTL, the method is obvious.
5. Measure at 1MHz, 25mVac. 1.9pF in series.
6. For the filaments, what else!
7. You have a dirty mind. S.E.X. is Signetics EXtra Secret process. "One Shovel Full to One Shovel Full", patented by Yagura, Kashkooli, Converse and Al. Circa 1921.
8. J. Kane calls it design (we humor him).
9. See "Modern Production Techniques" by T. Arrieta (not yet written).
10. Final until we got a look at some actual parts.
11. Coffee breaks and lunch hours.
12. Due credit to EIMA[illegible]r inspiration.

TYPICAL CHARACTERISTIC CURVES









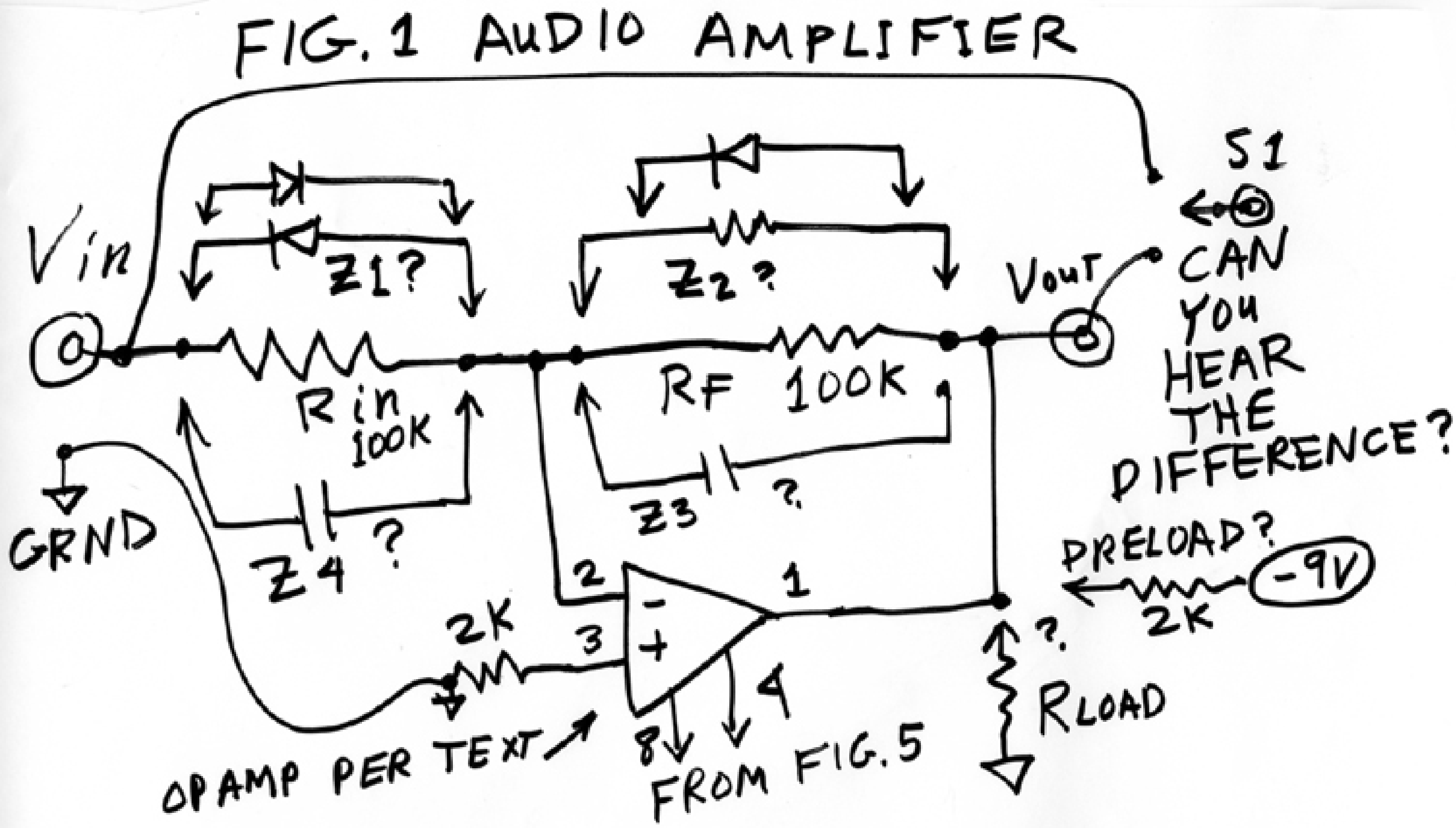
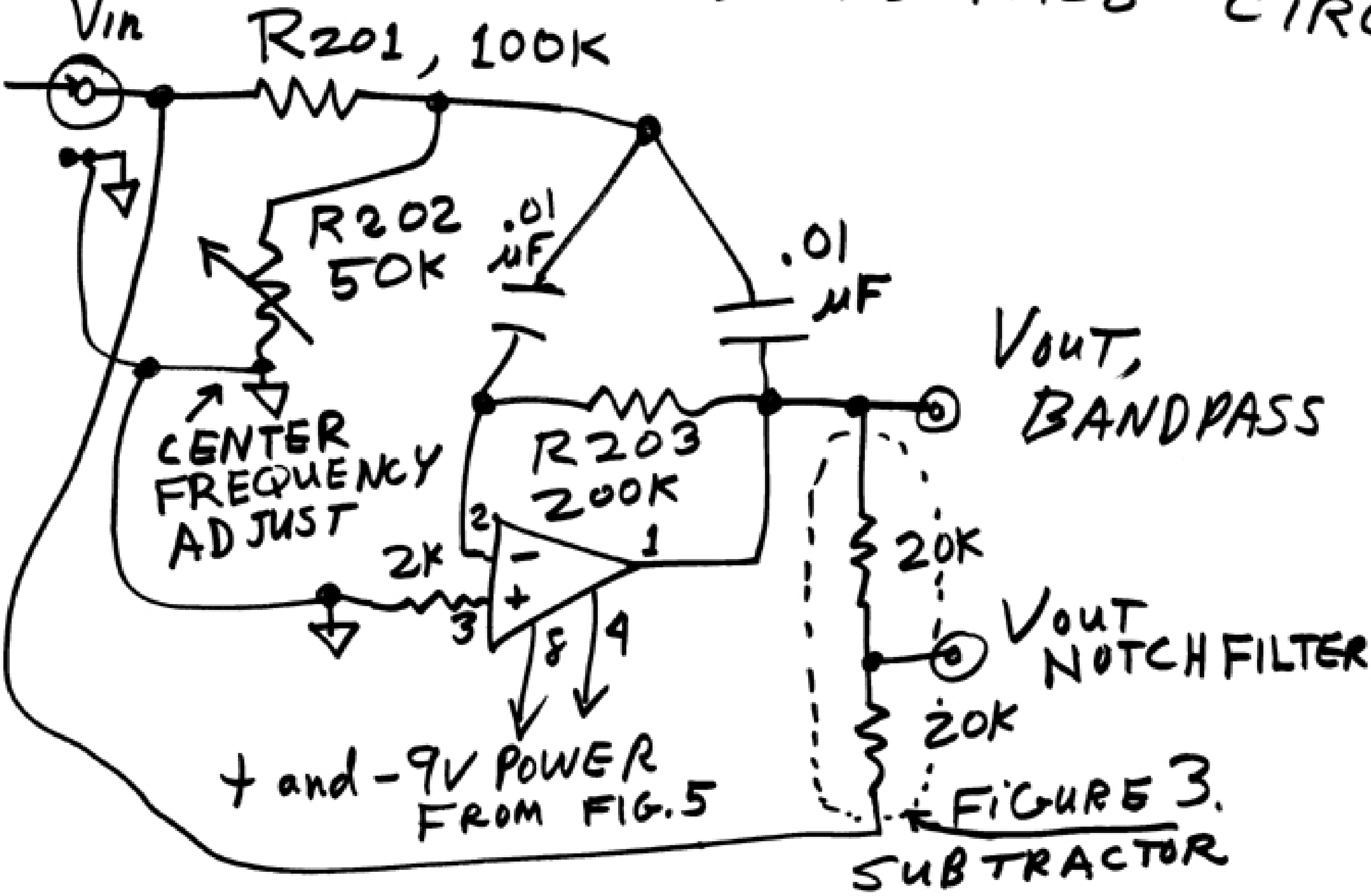


FIG. 1 AUDIO AMPLIFIER
S1
Vin
Z1?
Z2?
Vout
CAN YOU HEAR THE DIFFERENCE?
Rin 100K
RF 100K
GRND
Z4 ?
Z3 ?
PRELOAD?
-9V
2K
2
1
3
2K
4
?
RLOAD
OPAMP PER TEXT
8
FROM FIG.5

FIGURE 2, BAND-PASS CIRCUIT



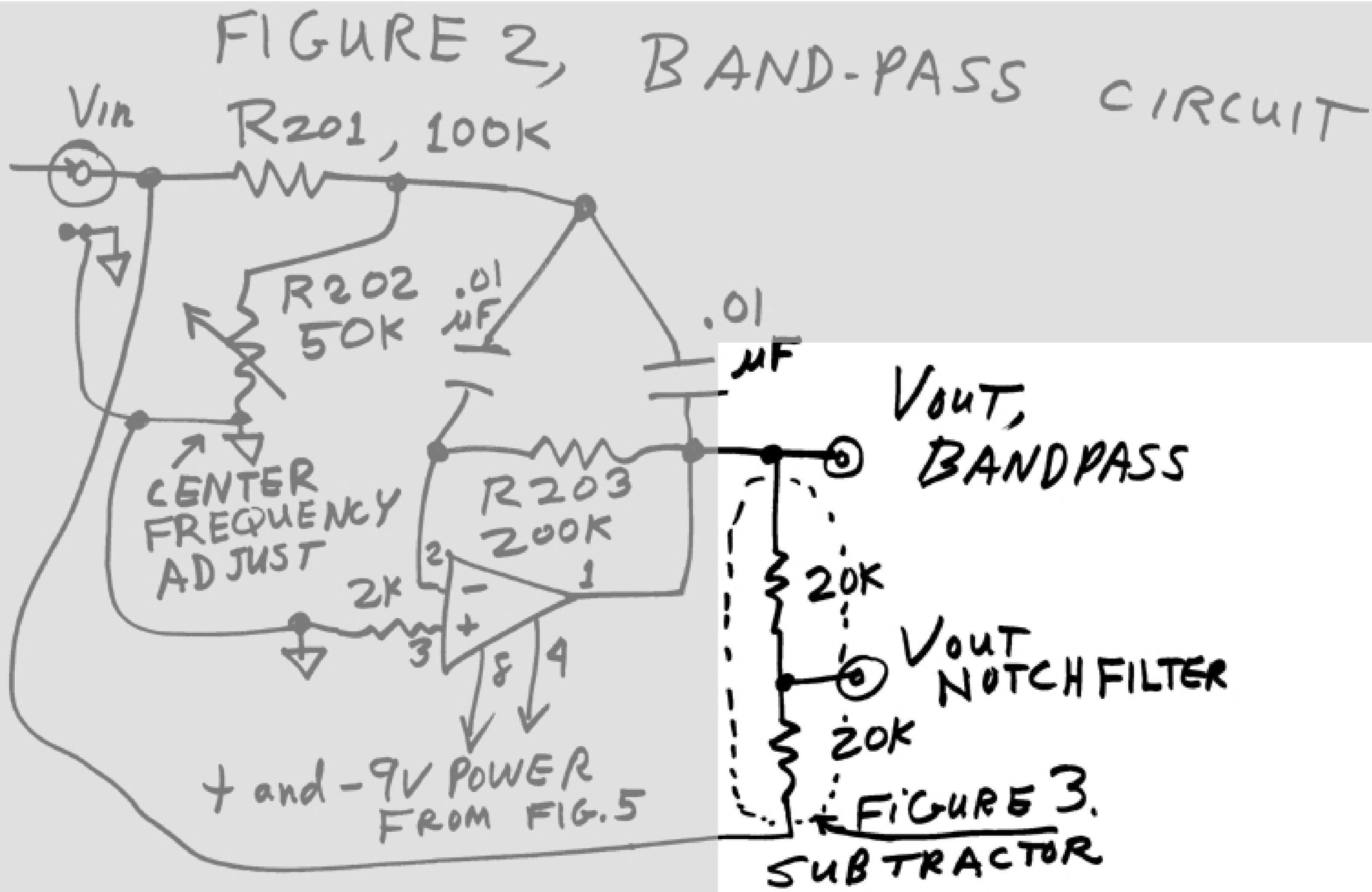


FIGURE 2, BAND-PASS CIRCUIT
Vin
R201, 100K
R202
50K
.01
µF
.01
µF
VOUT,
BANDPASS
CENTER
FREQUENCY
ADJUST
R203
200K
2
1
2K
3
8
4
20K
VOUT
NOTCH FILTER
20K
+ and -9V POWER
FROM FIG. 5
FIGURE 3.
SUBTRACTOR

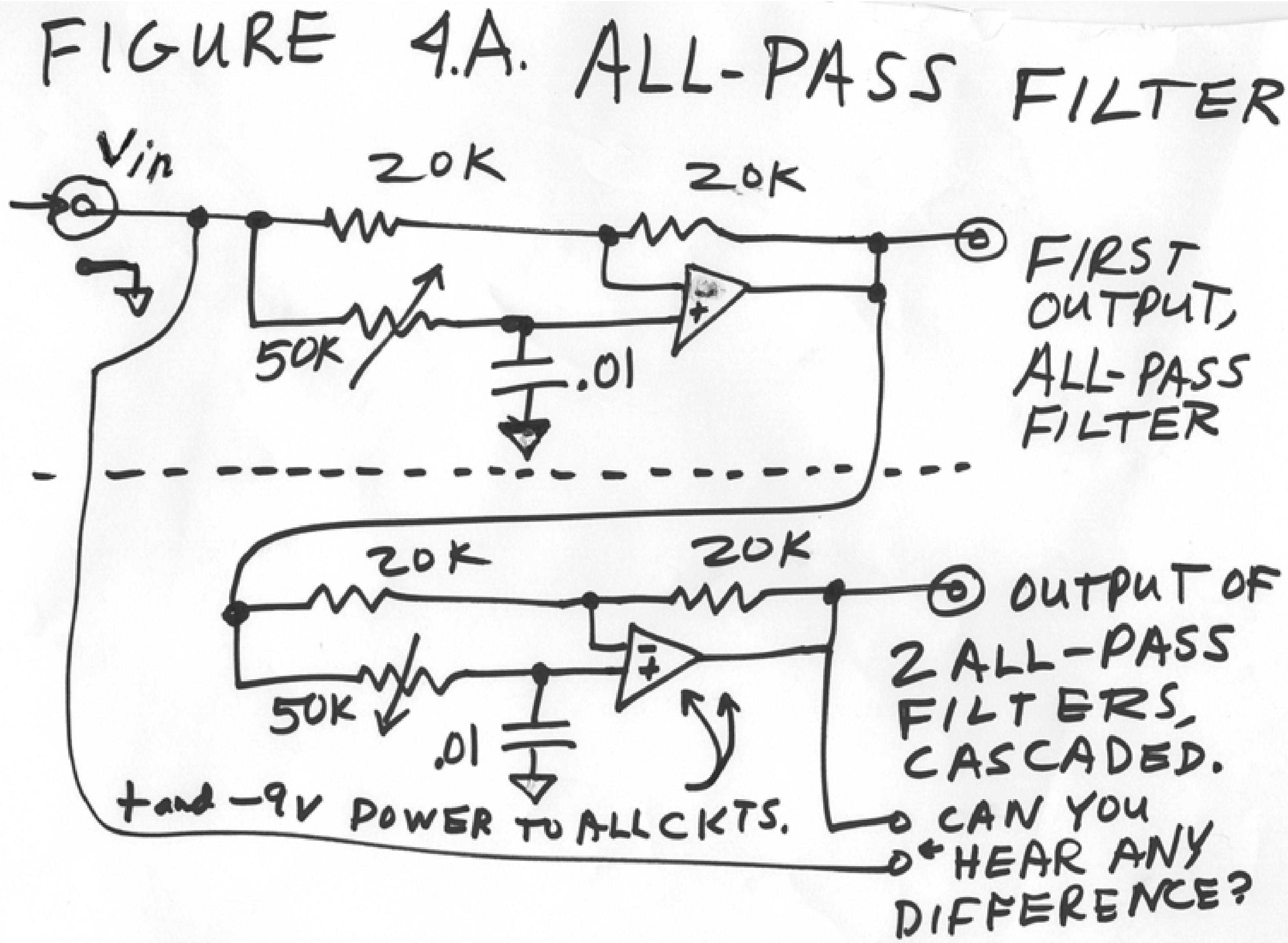


FIGURE 4.A. ALL-PASS FILTER
Vin
20K
20K
50K
.01
FIRST OUTPUT, ALL-PASS FILTER
20K
20K
50K
.01
OUTPUT OF 2 ALL-PASS FILTERS, CASCADED.
+ and -9V POWER TO ALL CKTS.
CAN YOU HEAR ANY DIFFERENCE?

FIGURE 4.B, ALL-PASS FILTER

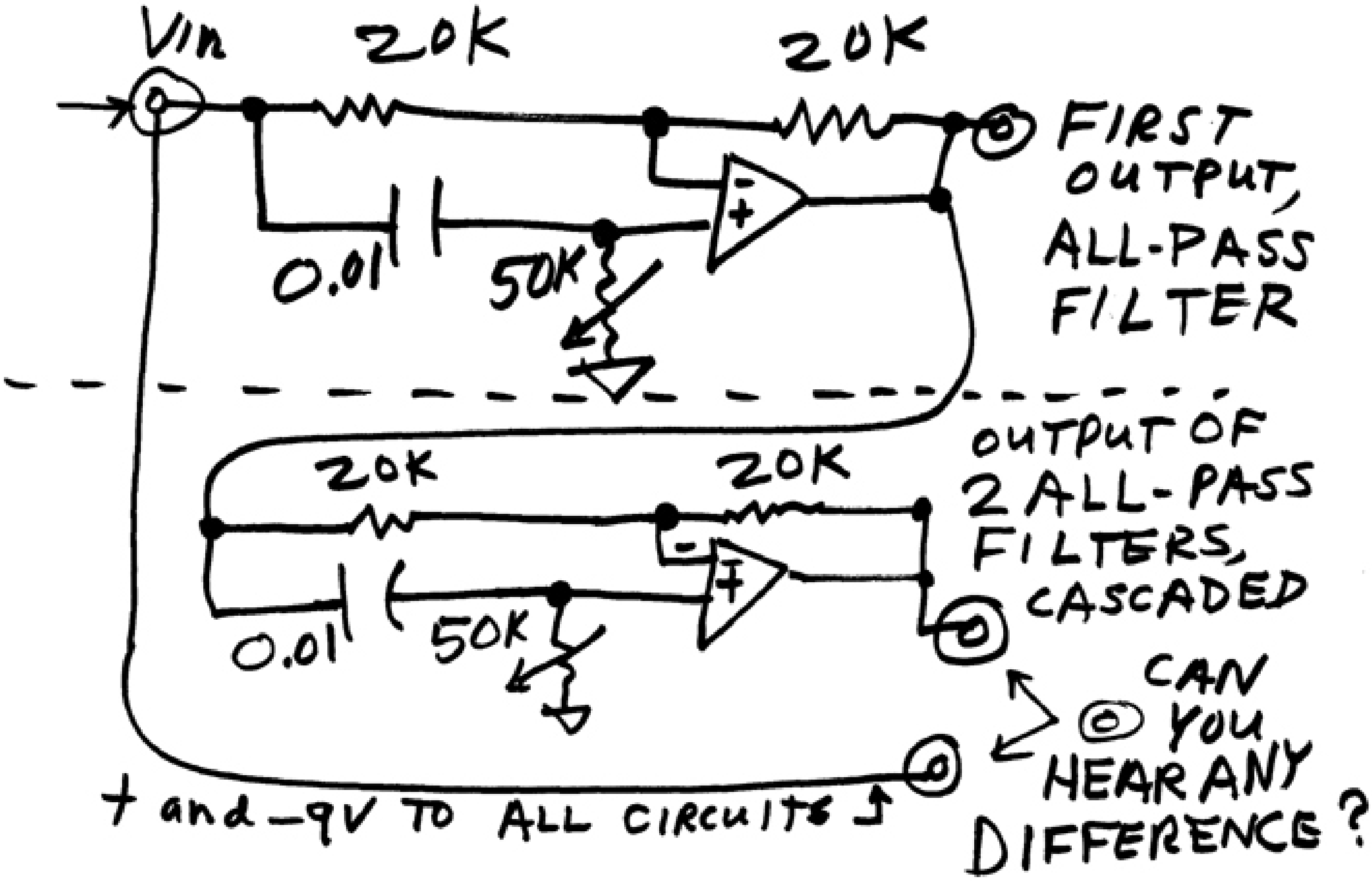
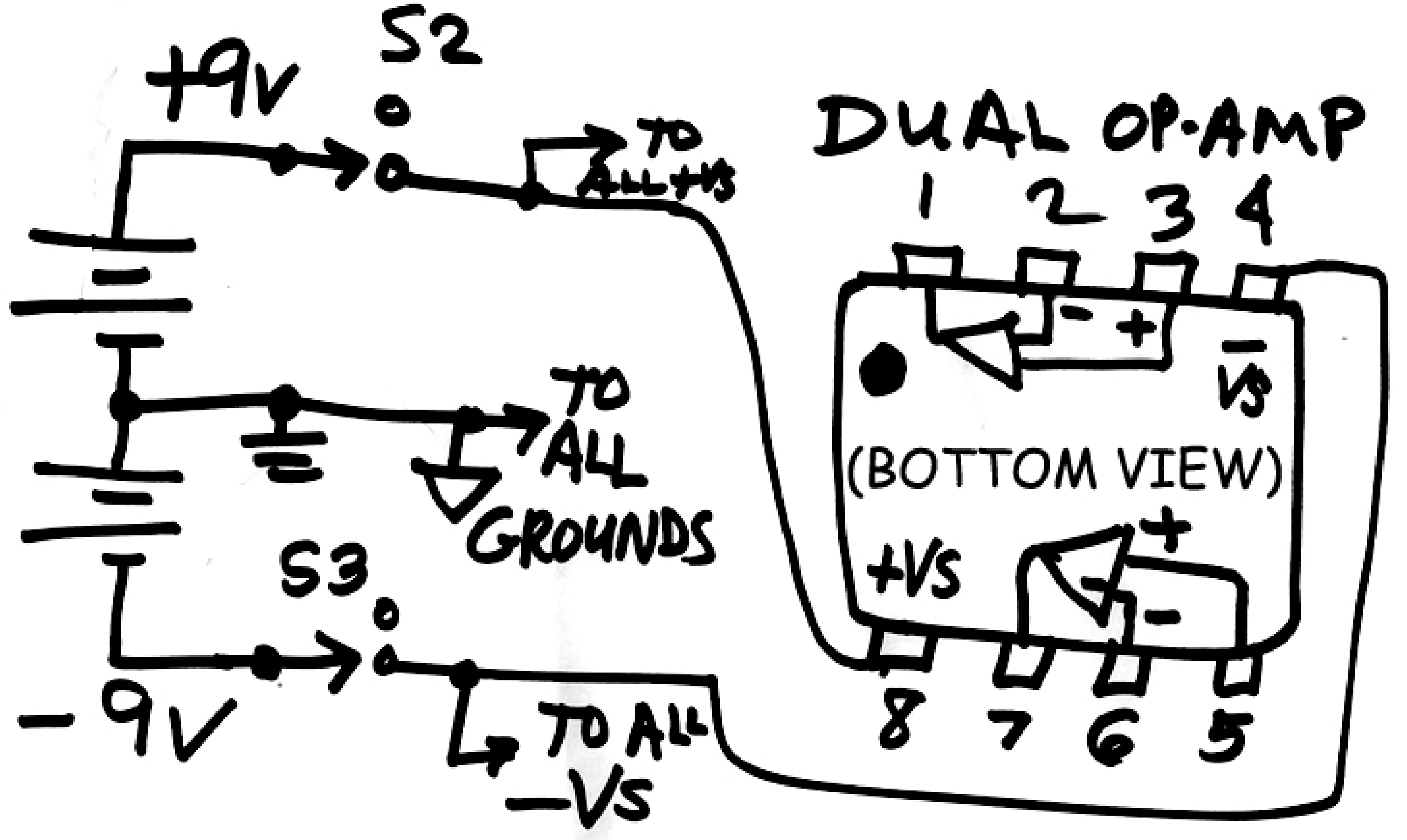
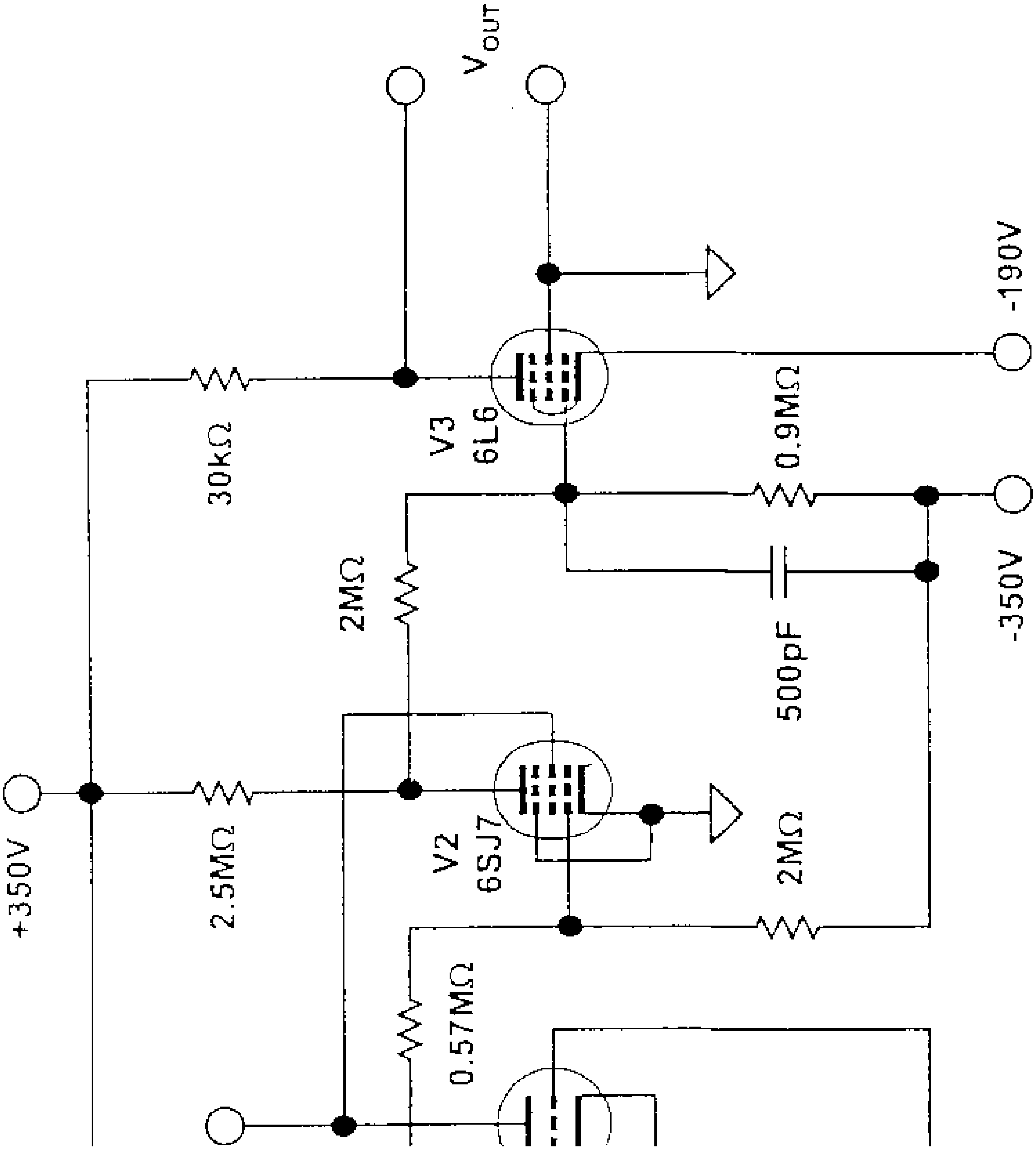


FIGURE 5, POWER WIRING





am of late M9 system op amp designed at Bell
ephone Laboratories

sy of Walter Jung

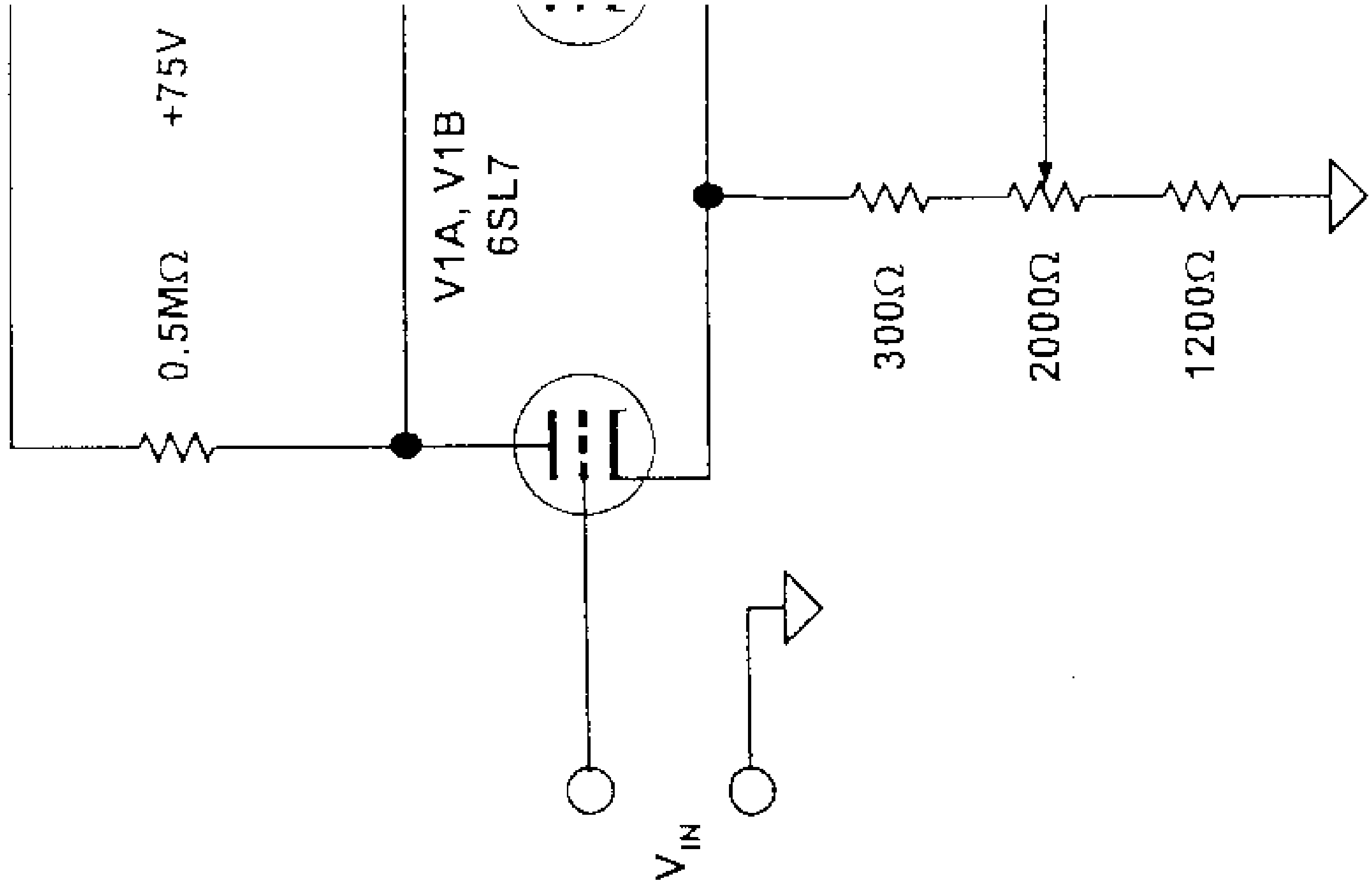
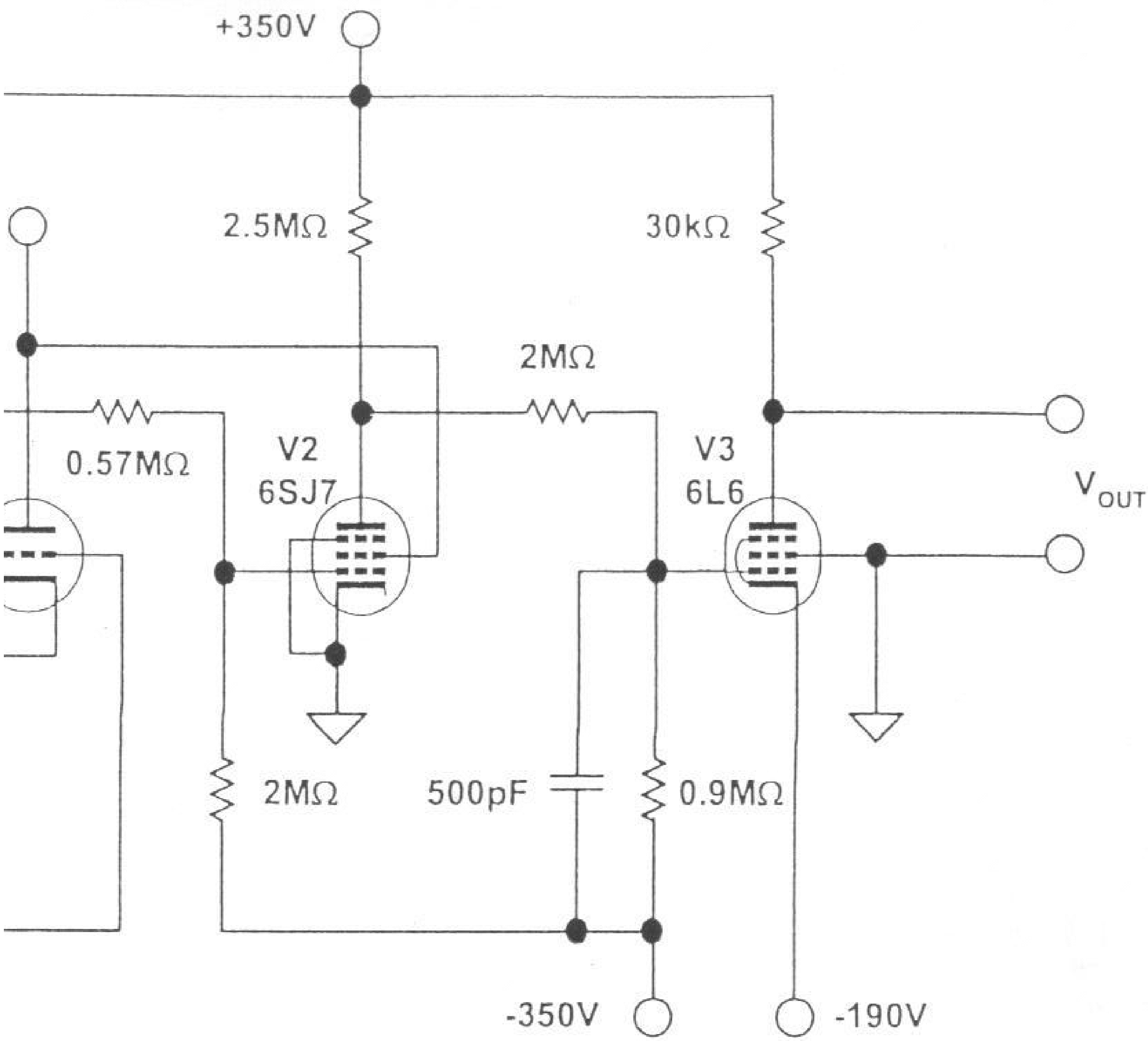


Figure H-4: Schematic diagra
Tele
Courte



am of late M9 system op amp designed at Bell
ephone Laboratories

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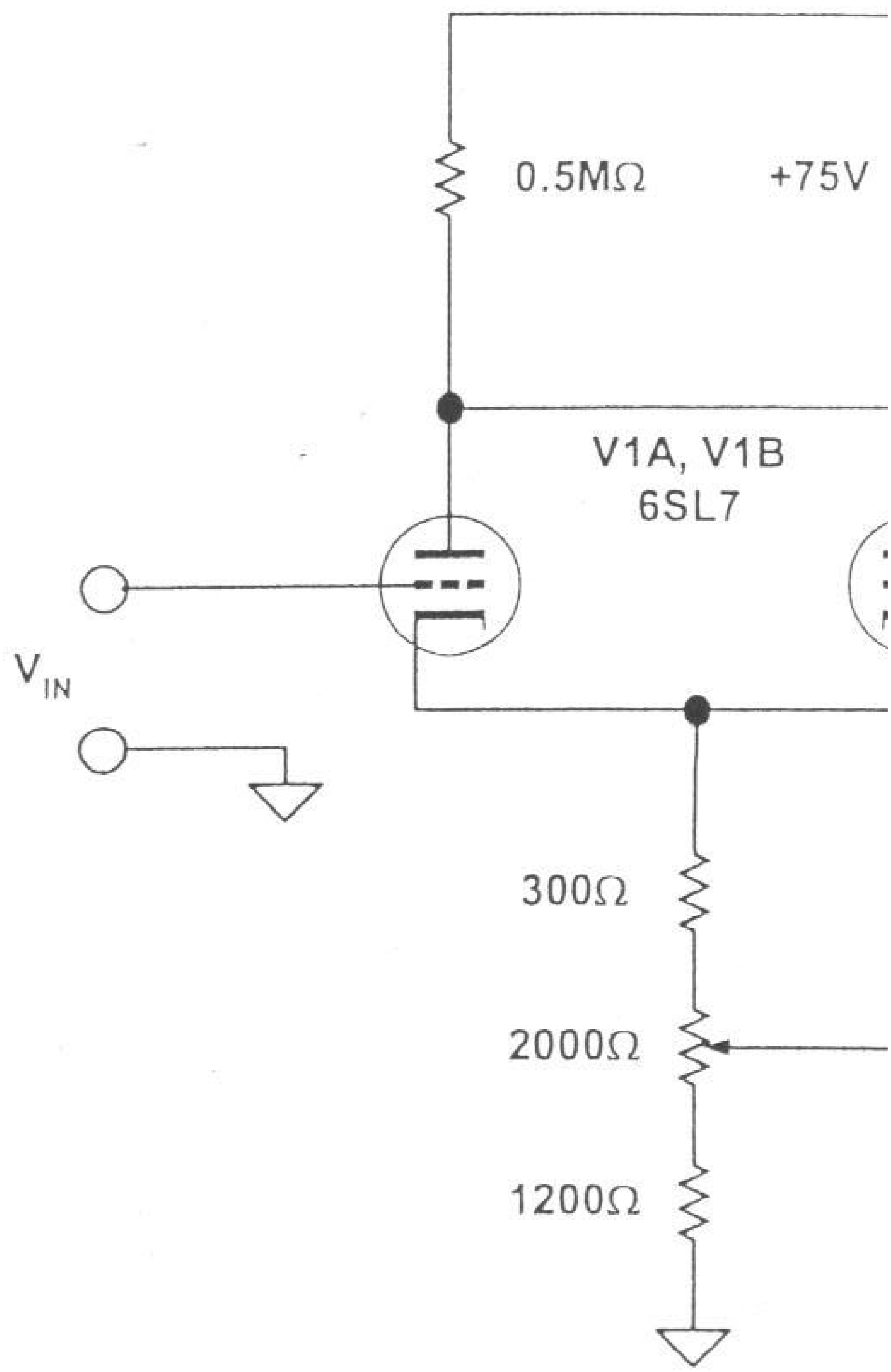
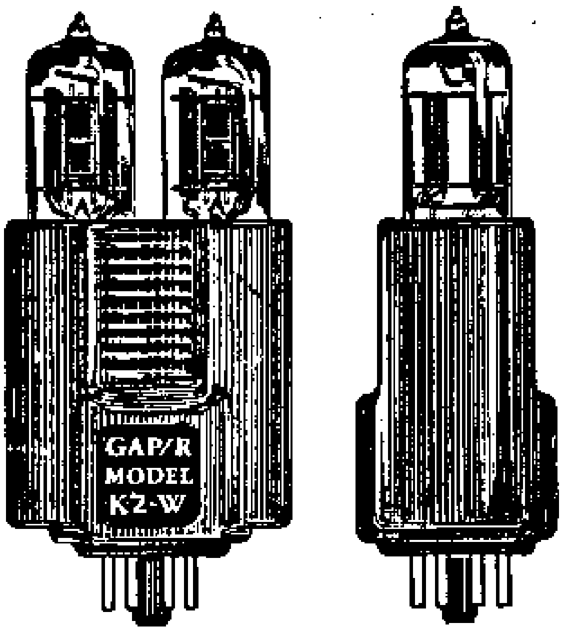


Figure H-4: Schematic diagra
Tele

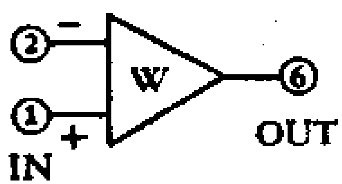
Courte

GEORGE A.
PHILBRICK
RESEARCHES, INC.,
127 CLARENDON STREET, BOSTON, MASS.

Model K2-W Operational Amplifier



OPERATIONAL SYMBOL

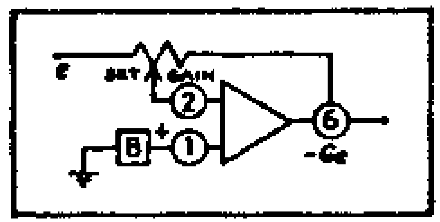


APPLICATIONS

In general terms, the field of application of the K2-W is in measurements and active transformations in the range from d-c to over 100 kc. It is primarily intended for use in feedback operations, fidelity of output depending upon the choice of external circuit components and arrangements.

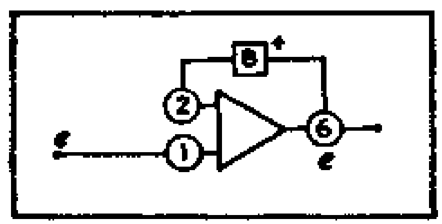
The K2-W is especially useful for the construction of electronic analog computor circuits, such as the GAP/R Analog Components, and for the assembly of operating control circuitry. With appropriate external circuitry, it will readily perform such feedback operations as addition, subtraction, integration, differentiation, multiplication, division, inversion, impedance-conversion, and the injection of current.

A few typical examples of fundamental applications are illustrated in figure 2.



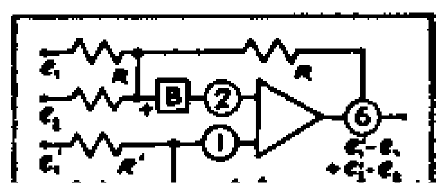
WIDE-RANGE AMPLIFIER

The usual feedback and feed-forward resistors are here embodied in a single potentiometer. A voltage gain of minus one is given by the central setting.



VOLTAGE REPRODUCER

This exceedingly simple arrangement supplies the need for a "follower" without attenuation or distortion, and with an output impedance well below one ohm.



ADDER-SUBTRACTOR

A number of simpler and possibly more familiar circuits are special cases of this one. By using unequal resistors, a more general form of

ELECTRICAL CHARACTERISTICS

Gain:
15,000 dc open loop

Response:
2 μsec rise time with bandwidth over 100 kc when used as an inverter

Drift Rate:
±5 mv per day referred to the input

Differential Input Levels:

Voltage (Inputs together):
−50 to +50 volts

Current:
Either input less than 10^{-7} amp. (Insulation leakage and grid current)

Impedance (either input):

Output Capabilities:

Output Current (Steady State)

Output Voltage	*Design Center*	*Min.*
+50V	+2.0 ma	+1.0 ma
0V	+1.8 ma −2.4 ma	
−50V	−1.8 ma	−1.0 ma

Impedance:
Open loop — below 1K

Max. Power Required (worst case):

Load	*Supply Voltage*	*Output +50V*	*Output −50V*

Above 100 M (open grid)

Capacitance (Pin 1 grounded):
7 $\mu\mu$f

Bias Required for Balance:
Adjustable from 0.9 to 1.7 volts between Pin 1 and 2 (Pin 1 positive with respect to Pin 2).

	vdc	*ma*	*ma*
No load	+300	+5.4	+4.1
	−300	−4.7	−3.8
Full load	+300	+6.4	+3.1
(50K)	−300	−4.7	−3.8
	6.3*	0.6	0.6
*6.3 vac or vdc		amp	amp

GENERAL CHARACTERISTICS

Temperature:
Max. allowable case temp. (hot spot) +65°C(149°F)

Tube Complement:
2 12AX7A or 7025

Casing:
Molded plastic, sealed unit

Base:
Octal Plug

Dimensions: (Above socket)
1 13/64" x 2 9/64" x 4 7/64" h (max)

Weight:
Installed: 3.0 oz.
Packed: 5.6 oz.

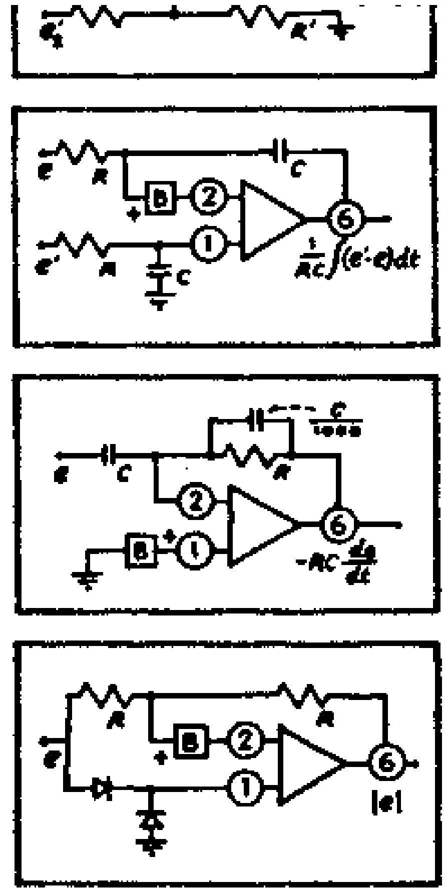
GENERAL DESCRIPTION

The Model K2-W Operational Amplifier is a high gain plug-in unit designed and constructed for use as a basic subassembly. With these units, feedback computing devices of all speeds can be assembled with a minimum of external circuitry. A schematic diagram of the K2-W is shown in figure 4.

The K2-W features balanced differential inputs for low drift, high input impedance, low output impedance, high performance, and economy of operation. Its range of operation is from d-c to above 100 kc.

With appropriate feedback connections, the K2-W maintains the two inputs at nearly equal potentials. The residual offset can readily be biased out. (See BIASING METHODS.)

linear combination is made possible.



SUBTRACTING INTEGRATOR

A positive or negative integral may be obtained by grounding one input. Unless an integrator is in a stable loop it must be subjected to some sort of "clamping".

STABLE DIFFERENTIATOR

The smaller shunt capacitor will prevent ringing or singing, and introduces very little error. In certain difficult cases one might also add a small resistor in series with the input capacitor.

ABSOLUTE-VALUE CIRCUIT

Reversing both diodes will reverse the sign of the output. To the a-c power engineer this is simply a "full wave rectifier", but as a computing device it is useful in a much wider sense.

Figure 2. Typical Applications of the K2-W Operational Amplifier

The values of the various resistance and capacitance elements shown in the above connections may be selected over an extremely wide range. It is suggested that resistors be kept between 50 K and 2 megohms. As for capacitance, a realistic range would be from 100 $\mu\mu$f to 10 μf.

BIASING METHODS

The box symbol B used in figure 2 denotes some source of dc voltage and its polarity. For most applications, a bias adjustment is necessary and may be applied in any of several ways. Some recommended methods of biasing are illustrated in figure 3.

When using any of these methods, set the potentiometer for zero d-c error under feedback.

When setting the potentiometer, ground the input of the computing network if possible.

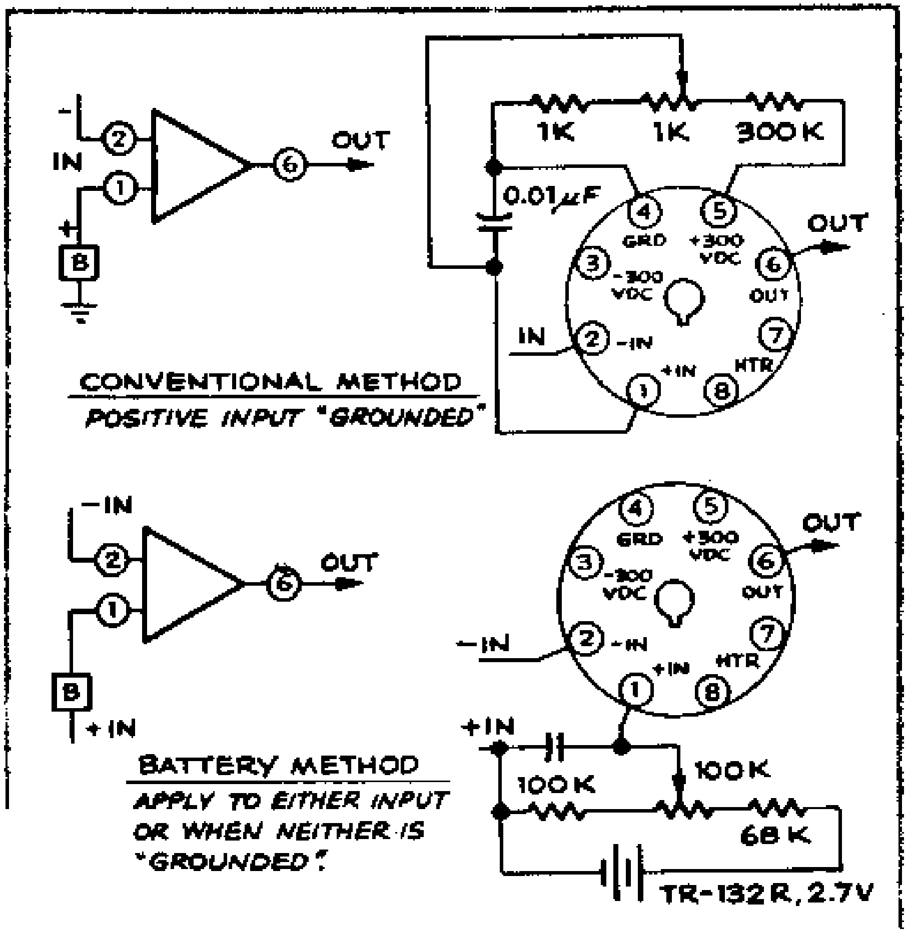


Figure 3. Biasing Methods

CAUTION

MAINTENANCE

Preventive Maintenance

1. During operation:
   a. Make sure that tubes are firmly seated.
   b. Make sure that the K2-W is firmly seated.

Trouble Shooting

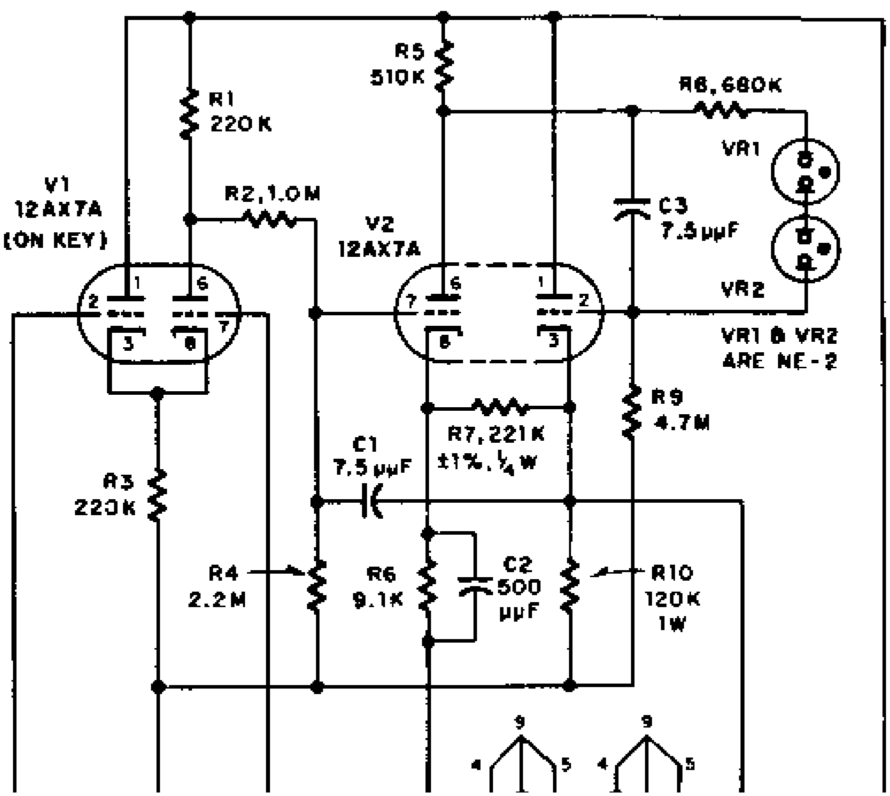
If trouble in the K2-W is suspected:

1. Check for loose connections, grounds, and/or shorts in the associated circuitry.
2. Check the tubes by substitution.
3. Check the plug-in by substitution.

Corrective Maintenance

1. Replace defective parts.
2. Do NOT open the sealed case.

Opening the case voids the guarantee. The unit should be returned to the factory for repair.



Avoid prolonged short-circuiting of the output. The K2-W is designed to tolerate temporary overloads such as output shorted to ground. However, such fault currents, if prolonged, can overheat and thereby shorten the life of K2-W and cause relatively large drifts.

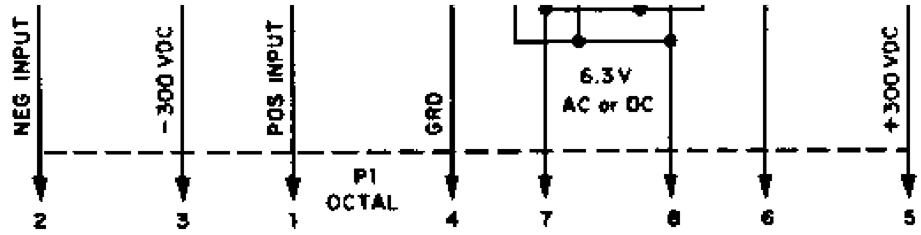
The K2-W and its load may dissipate 8 watts. Unless there is plenty of free air under 30°C (86°F) around the unit, forced ventilation will probably be necessary. The K2-W is not recommended for those applications where either the ventilation is poor or the ambient temperature high. For such applications the MIL equivalent K2-WJ is recommended.

CAUTION

Do NOT allow the temperature of any part of the case to exceed 65°C (149°F). Avoid severe overloading.

INSTALLATION

Wire the desired external circuitry to an octal socket or GAP/R Manifold. Plug the K2-W into the socket or Manifold. (Information about GAP/R Manifolds is available upon request.)



NOTE UNLESS OTHERWISE STATED RES. ARE ±5%, 1/2 W

Figure 4. Schematic Diagram

NOTE: For further information on the utility of Philbrick Plug-ins, refer to the "Applications Manual" available upon request.

GEORGE A.
PHILBRICK
RESEARCHES, INC.,
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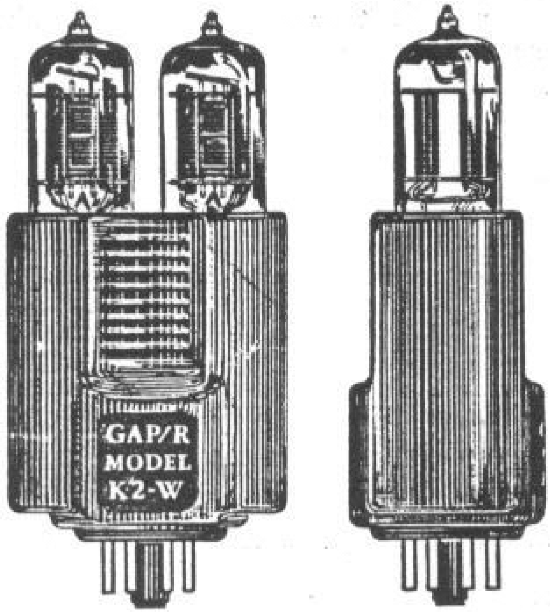
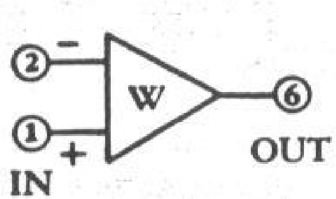
Model K2-W Operational Amplifier



OPERATIONAL SYMBOL



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−50V	−1.8 ma	−1.0 ma

Impedance:
Open loop — below 1K

Max. Power Required (worst case):

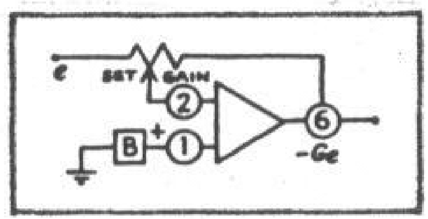
Load	*Supply Voltage vdc*	*Output +50V ma*	*Output −50V ma*

APPLICATIONS

In general terms, the field of application of the K2-W is in measurements and active transformations in the range from d-c to over 100 kc. It is primarily intended for use in feedback operations, fidelity of output depending upon the choice of external circuit components and arrangements.

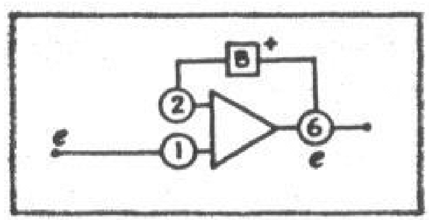
The K2-W is especially useful for the construction of electronic analog computor circuits, such as the GAP/R Analog Components, and for the assembly of operating control circuitry. With appropriate external circuitry, it will readily perform such feedback operations as addition, subtraction, integration, differentiation, multiplication, division, inversion, impedance-conversion, and the injection of current.

A few typical examples of fundamental applications are illustrated in figure 2.



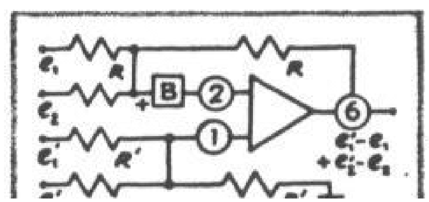
WIDE-RANGE AMPLIFIER

The usual feedback and feed-forward resistors are here embodied in a single potentiometer. A voltage gain of minus one is given by the central setting.



VOLTAGE REPRODUCER

This exceedingly simple arrangement supplies the need for a "follower" without attenuation or distortion, and with an output impedance well below one ohm.



ADDER-SUBTRACTOR

A number of simpler and possibly more familiar circuits are special cases of this one. By using unequal resistors, a more general form of linear combination is made possible.

Capacitance (Pin 1 grounded):
7 μμf
Bias Required for Balance:
Adjustable from 0.9 to 1.7 volts between Pin 1 and 2 (Pin 1 positive with respect to Pin 2).

No load	+300	+5.4	+4.1
	−300	−4.7	−3.8
Full load	+300	+6.4	+3.1
(50K)	−300	−4.7	−3.8
	6.3*	0.6	0.6
*6.3 vac or vdc		amp	amp

GENERAL CHARACTERISTICS

Temperature:
Max. allowable case temp. (hot spot) +65°C(149°F)
Tube Complement:
2 12AX7A or 7025
Casing:
Molded plastic, sealed unit
Base:
Octal Plug

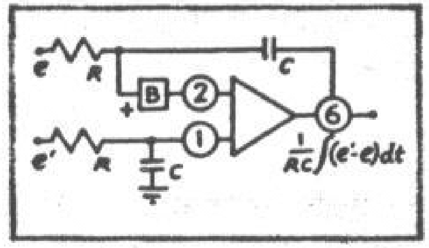
Dimensions: (Above socket)
1 33/64" x 2 9/64" x 4 7/64" h (max)
Weight:
Installed: 3.0 oz.
Packed: 5.6 oz.

GENERAL DESCRIPTION

The Model K2-W Operational Amplifier is a high gain plug-in unit designed and constructed for use as a basic subassembly. With these units, feedback computing devices of all speeds can be assembled with a minimum of external circuitry. A schematic diagram of the K2-W is shown in figure 4.

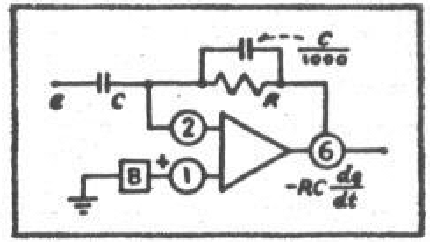
The K2-W features balanced differential inputs for low drift, high input impedance, low output impedance, high performance, and economy of operation. Its range of operation is from d-c to above 100 kc.

With appropriate feedback connections, the K2-W maintains the two inputs at nearly equal potentials. The residual offset can readily be biased out. (See BIASING METHODS.)



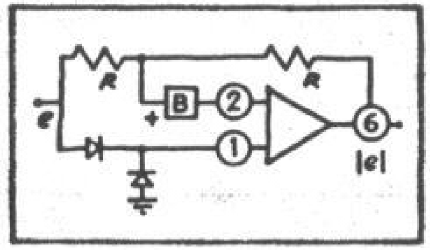
SUBTRACTING INTEGRATOR

A positive or negative integral may be obtained by grounding one input. Unless an integrator is in a stable loop it must be subjected to some sort of "clamping".



STABLE DIFFERENTIATOR

The smaller shunt capacitor will prevent ringing or singing, and introduces very little error. In certain difficult cases one might also add a small resistor in series with the input capacitor.



ABSOLUTE-VALUE CIRCUIT

Reversing both diodes will reverse the sign of the output. To the a-c power engineer this is simply a "full wave rectifier", but as a computing device it is useful in a much wider sense.

Figure 2. Typical Applications of the K2-W Operational Amplifier

The values of the various resistance and capacitance elements shown in the above connections may be selected over an extremely wide range. It is suggested that resistors be kept between 50 K and 2 megohms. As for capacitance, a realistic range would be from 100 μμf to 10 μf.

BIASING METHODS

The box symbol B used in figure 2 denotes some source of dc voltage and its polarity. For most applications, a bias adjustment is necessary and may be applied in any of several ways. Some recommended methods of biasing are illustrated in figure 3.

When using any of these methods, set the potentiometer for zero d-c error under feedback.

When setting the potentiometer, ground the input of the computing network if possible.

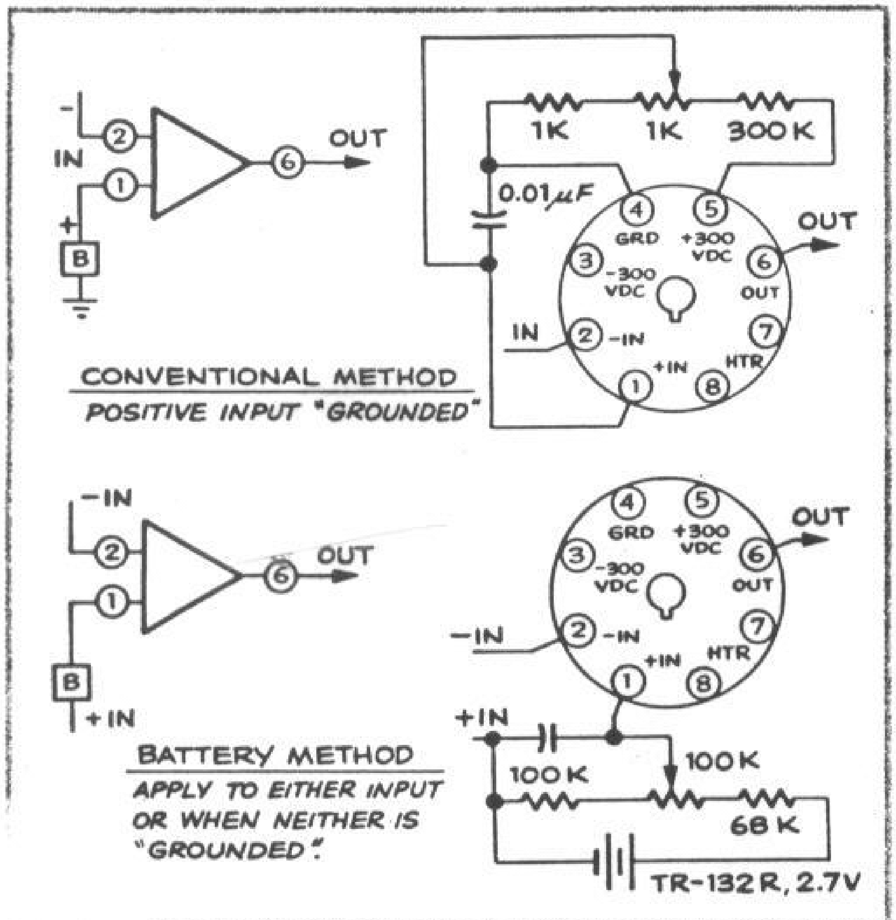


Figure 3. Biasing Methods

CAUTION

MAINTENANCE

Preventive Maintenance

1. During operation:
   a. Make sure that tubes are firmly seated.
   b. Make sure that the K2-W is firmly seated.

Trouble Shooting

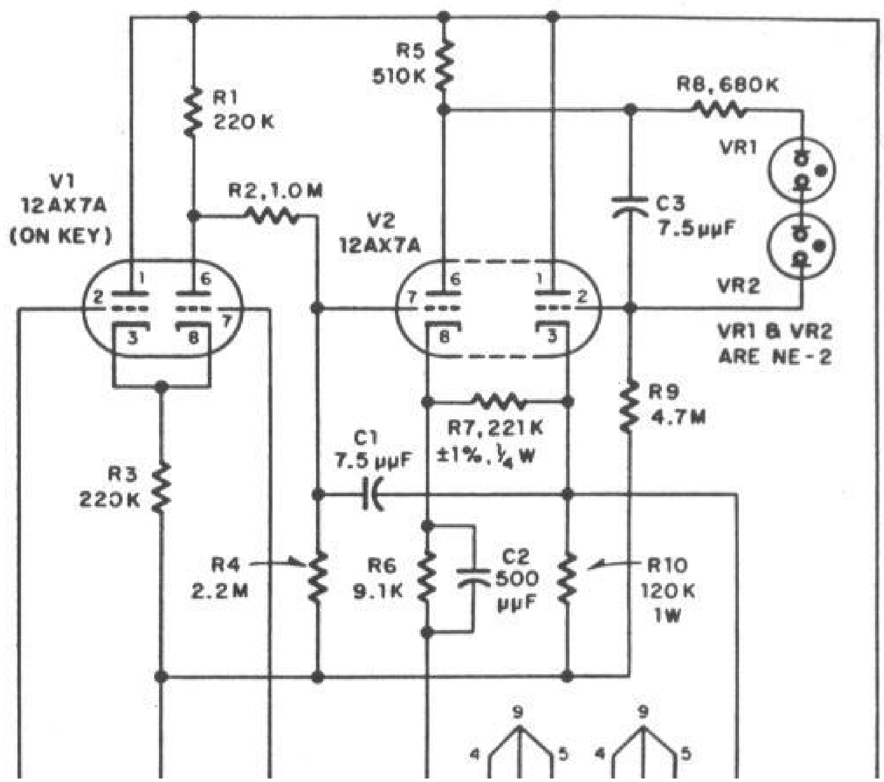
If trouble in the K2-W is suspected:

1. Check for loose connections, grounds, and/or shorts in the associated circuitry.
2. Check the tubes by substitution.
3. Check the plug-in by substitution.

Corrective Maintenance

1. Replace defective parts.
2. Do NOT open the sealed case.

Opening the case voids the guarantee. The unit should be returned to the factory for repair.



Avoid prolonged short-circuiting of the output. The K2-W is designed to tolerate temporary overloads such as output shorted to ground. However, such fault currents, if prolonged, can overheat and thereby shorten the life of K2-W and cause relatively large drifts.

The K2-W and its load may dissipate 8 watts. Unless there is plenty of free air under 30°C (86°F) around the unit, forced ventilation will probably be necessary. The K2-W is not recommended for those applications where either the ventilation is poor or the ambient temperature high. For such applications the MIL equivalent K2-WJ is recommended.

CAUTION

Do NOT allow the temperature of any part of the case to exceed 65°C (149°F). Avoid severe overloading.

INSTALLATION

Wire the desired external circuitry to an octal socket or GAP/R Manifold. Plug the K2-W into the socket or Manifold. (Information about GAP/R Manifolds is available upon request.)

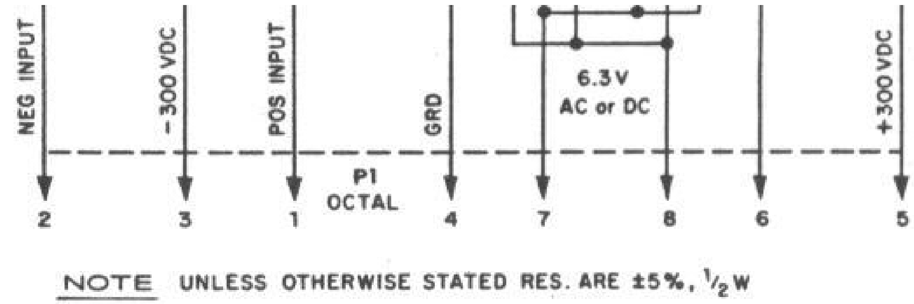
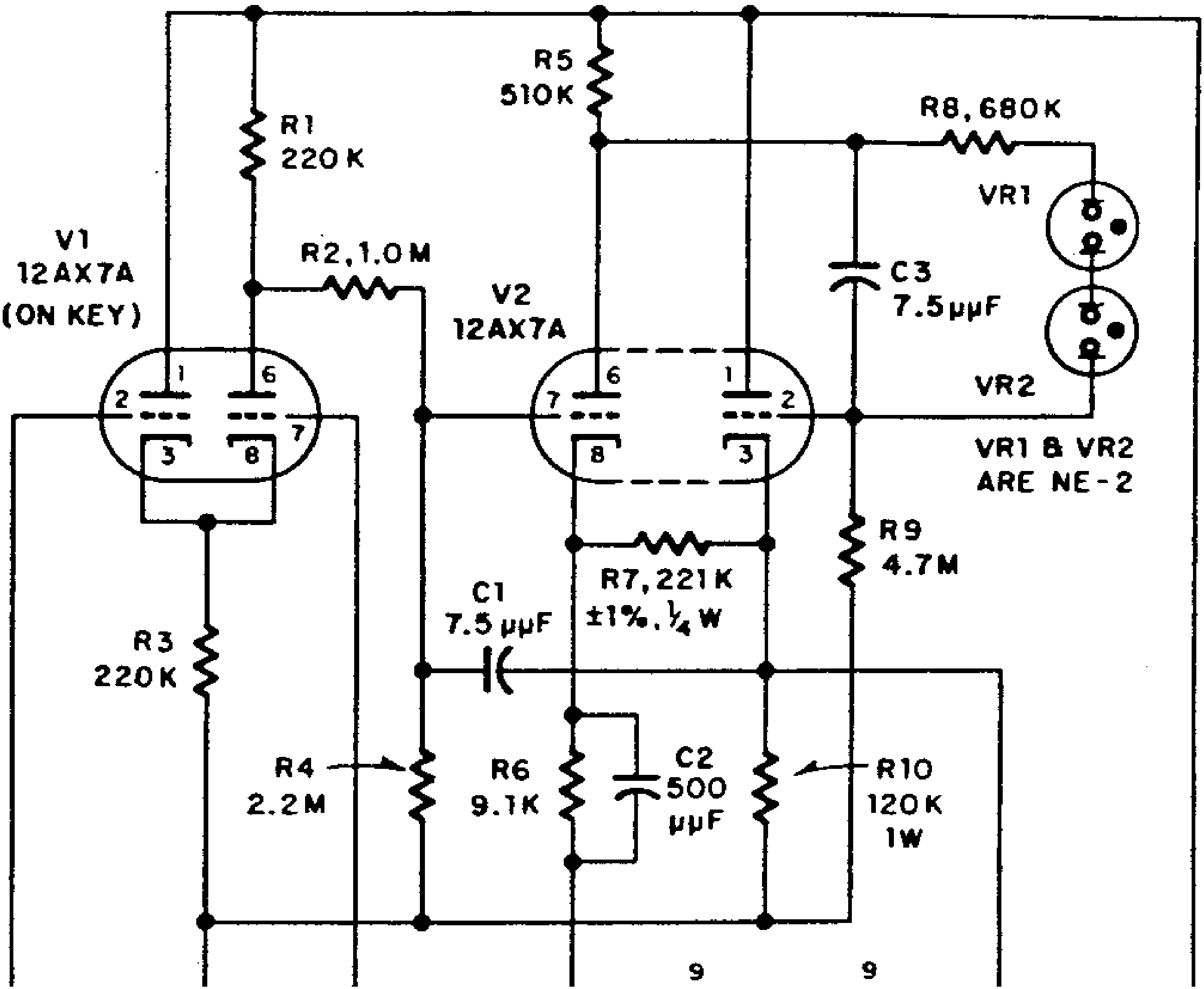
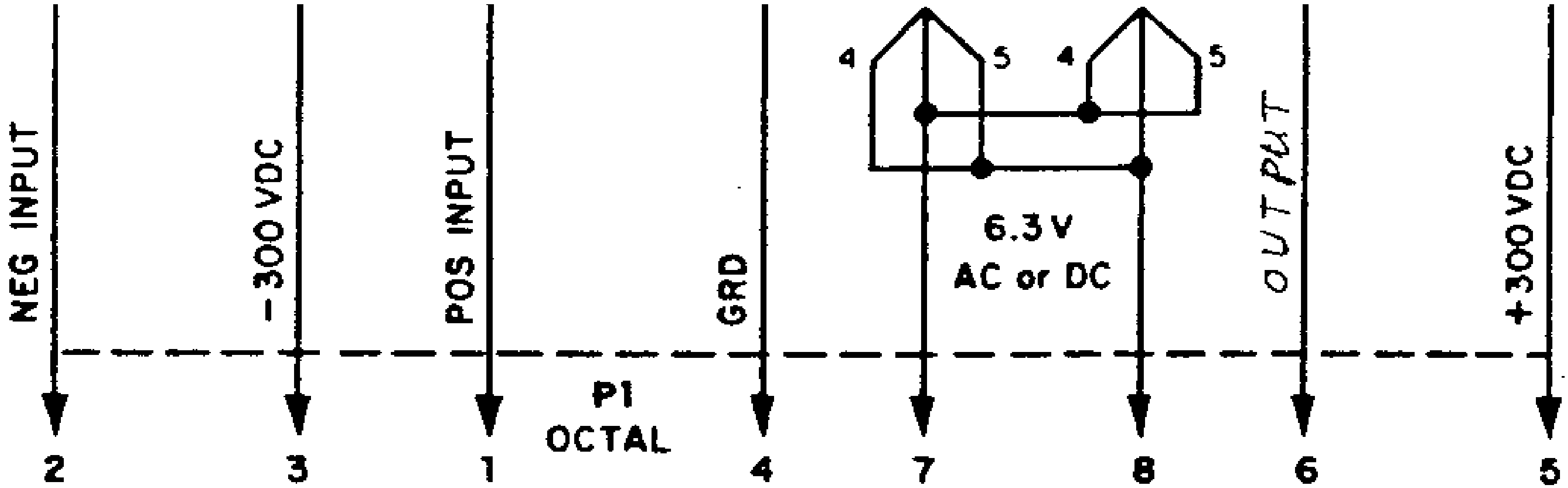


Figure 4. Schematic Diagram

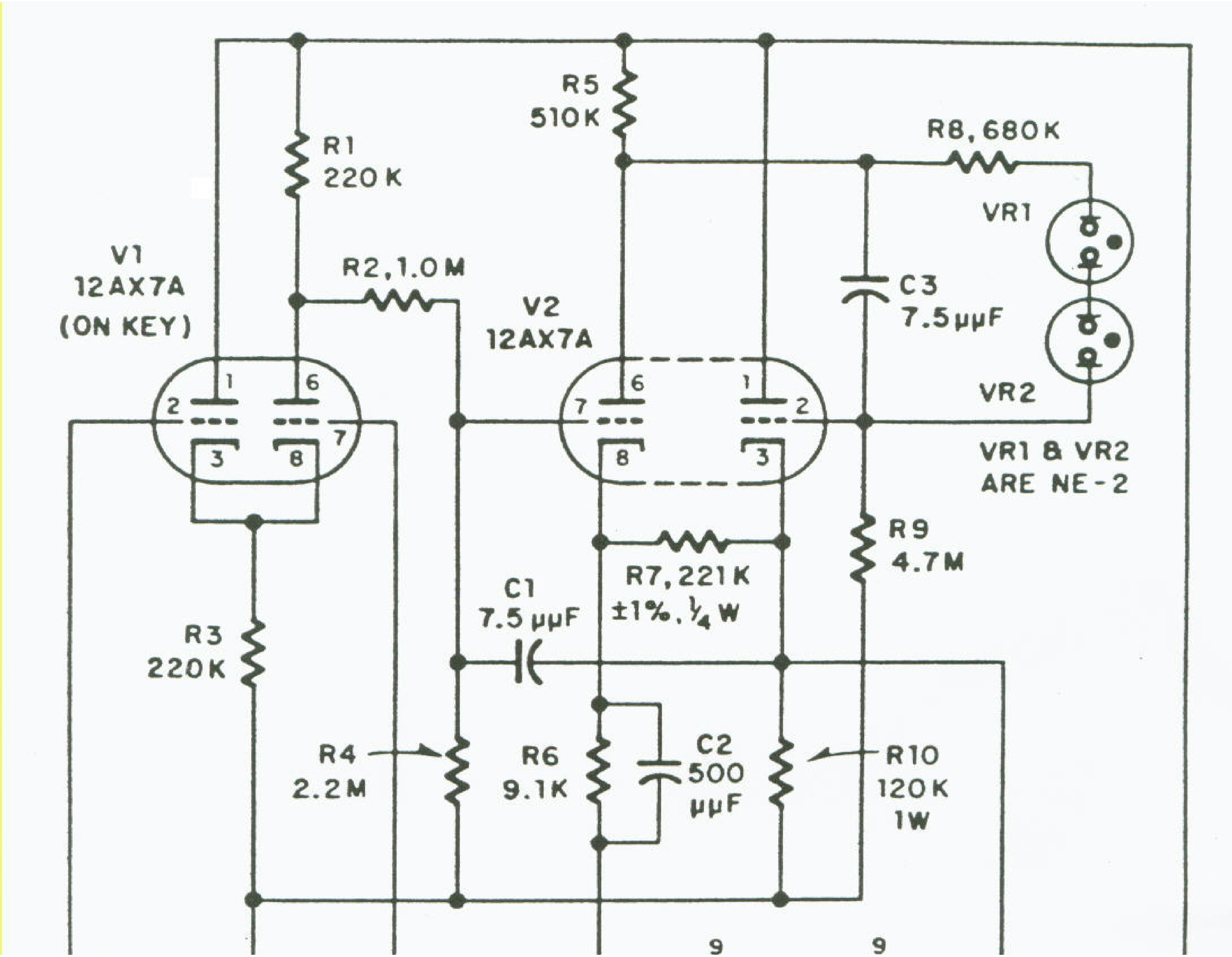
NOTE: For further information on the utility of Philbrick Plug-ins, refer to the "Applications Manual" available upon request.


R5
510K
R8, 680K
R1
220K
VR1
V1
12AX7A
(ON KEY)
R2, 1.0M
C3
7.5 µµF
V2
12AX7A
1
6
2
7
3
8
VR2
VR1 & VR2
ARE NE-2
R9
4.7M
R7, 221K
±1%, ¼ W
C1
7.5 µµF
R3
220K
R4
2.2M
R6
9.1K
C2
500
µµF
R10
120K
1W
9
9



NOTE UNLESS OTHERWISE STATED RES. ARE ±5%, 1/2 W

Figure 4. Schematic Diagram K2-W


R5
510K
R8, 680K
R1
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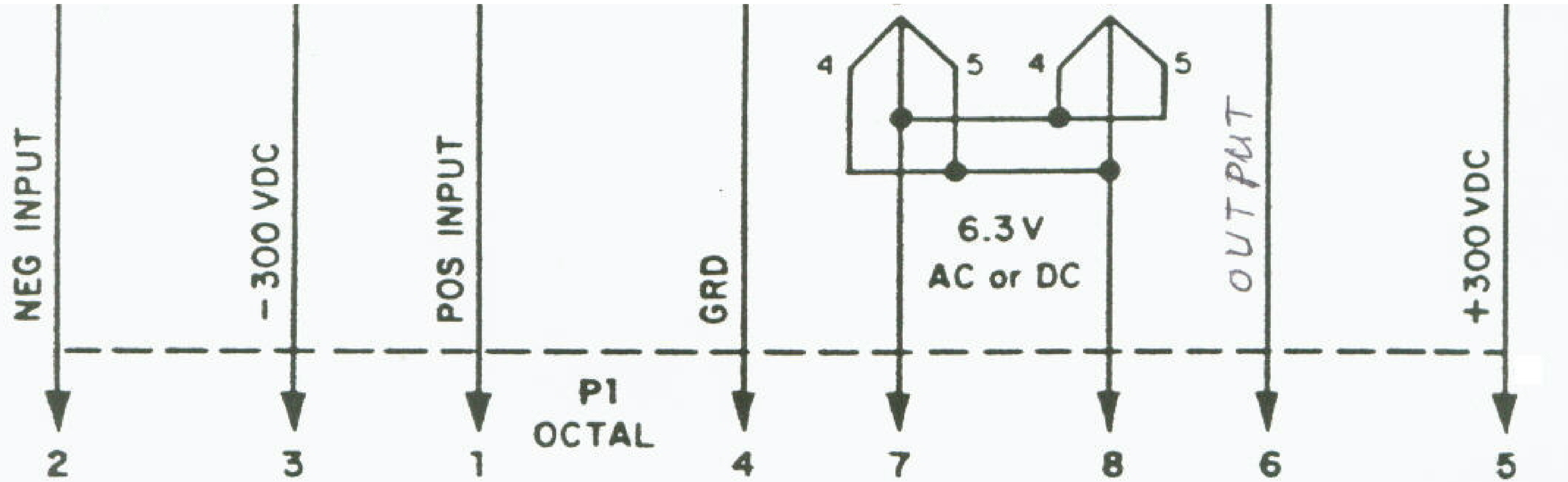
VR1
V1
12AX7A
(ON KEY)
R2, 1.0M
V2
12AX7A
C3
7.5 μμF
1
6
2
7
3
8
VR2
VR1 & VR2
ARE NE-2
R9
4.7M
R7, 221K
±1%, 1/4 W
C1
7.5 μμF
R3
220K
R4
2.2M
R6
9.1K
C2
500
μμF
R10
120K
1W
9
9



NOTE UNLESS OTHERWISE STATED RES. ARE ±5%, 1/2 W

Figure 4. Schematic Diagram K2-W

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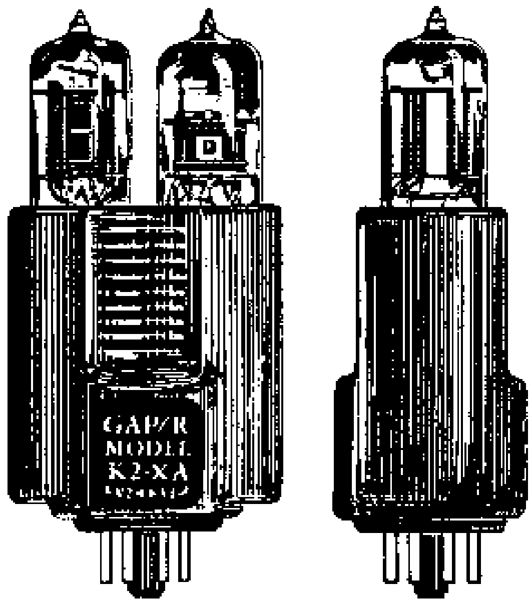
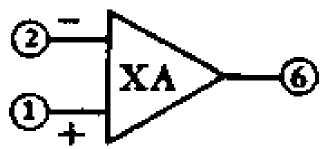
RESEARCHES, INC
127 CLARENDON STREET, BOSTON 16, MASS.

Model K2-XA Operational Amplifier



OPERATIONAL
SYMBOL



GENERAL CHARACTERISTICS
Design Center Electrical Characteristics

Gain:
30,000 dc open loop (depending upon the applications — see text)

Response: — Small signal:
1 μsec rise time with bandwidth over 250 kc when used as a unity-gain inverter under ideal circuit conditions

Drift Rate:
±8 mv per day referred to the input (See text — "DRIFT")

Differential Input Levels:
Impedance: — Either Input: typically above 100M (open grid)
Voltage Range:
Inputs together (common mode) −50 to +50 volts

Output Capabilities:

Output Voltage	Output Current (steady state) Normal	Case HP*
−100v	−2.8 ma	−4.1 ma
0v	+4.0 ma	+2.0 ma
	−5.0 ma	−7.0 ma
+100v	+6.1 ma	+4.8 ma

Maximum available transient output current is very much larger in the positive direction, but is the same in the negative direction.

Power Required: (for full output)
Normal Operation: (50K load)

Supply Voltage	At output +100v	At output −100v
+300	+10.4 ma	+3.4 ma

can readily be biased out. (See BIASING METHODS.)

Operationally, the K2-XA plugs into the same socket as the K2-W, and uses the same connections for power and for computing signals. Although momentary short circuiting of the output does no harm, its output must not be grounded for an extended period. Load capacitances in excess of 200 μμf usually require additional stabilization networks.

APPLICATIONS

The K2-XA Operational Amplifier can be used for analog computation in feedback systems of any complexity. It is entirely compatible with the K2-W and the two can be used in the same assemblages, each being used to exploit its own special characteristics. The K2-XA permits steeper wave fronts and greater signal excursions. Also, its greater output power allows the use of computing networks that require higher voltages and currents than are possible with the K2-W. However, be sure to provide ample ventilation.

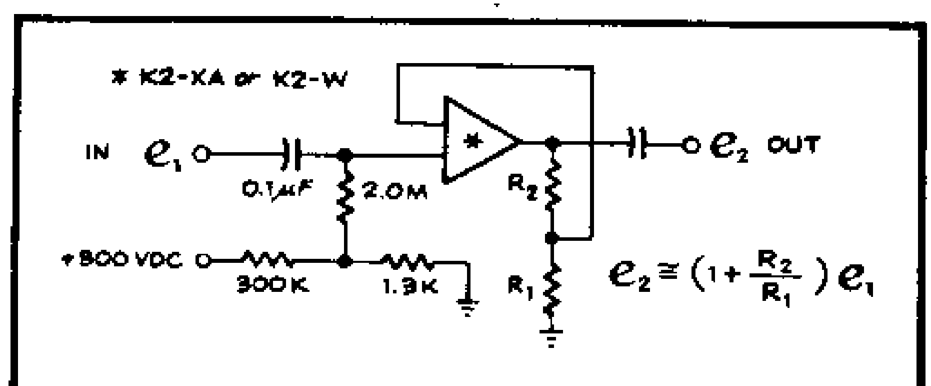


Figure 2 As an Ac Amplifier

Current: — Either input:

Typically less than 10^{-7} amp (insulation leakage and grid current)

Bias Required for Balance:

Adjustable from 1.1 to 2.0 volt between pins 1 and 2 (pin 1 positive with respect to pin 2) (See figure 3.)

−300	−11.4 ma	−7.9 ma
6.3 vac or vdc	0.75 amp	0.75 amp

*Case HP (with 33K load)

+300	+14.1 ma	+8.7 ma
−300	−14.1 ma	−9.2 ma
6.3 vac or vdc	0.75 amp	0.75 amp

*With a 150K, 2-watt resistor connected between pin 6 (output) and pin 3 (−300v).

PHYSICAL CHARACTERISTICS

Tube Complement:

1 12AX7A or 7025
1 6BR8A or 6CL8A

Casing:

Molded plastic, sealed unit

Dimensions:

Overall: 4 11/16 in. h (max.)
Above Socket: 1½ w x 2⅛ lg. × 4⅛ in. h (max.)

Base: Octal plug

Temperature:

Maximum allowable case temperature (hot spot) +65°C (149°F) (See text)

Weight: Installed: 3¼ oz.
Packed: 6½ oz.

GENERAL DESCRIPTION

The Model K2-XA is a high gain, wide band, plug-in, dc operational amplifier, designed and constructed for use as a basic subassembly for analog computor and instrument applications. It is primarily useful in feedback circuits where a high open loop gain and an output voltage range of from minus to plus 100 volts are required. The open loop dc gain for normal operation with a ±60 volt swing and a 50K load is 30,000. With a ±110 volt swing, the dc gain may decrease to 10,000. With these units, computing devices of nearly all speeds can be assembled with a minimum of external circuitry.

Like K2-W the Model K2-XA features balanced differential inputs. Its range of operation is from DC to above 250KC when connected as a unity-gain inverter.

With appropriate circuitry, the K2-XA maintains the two inputs at nearly equal potentials. The residual offset

Figure 2. As an AC Amplifier

The K2-XA, although inherently a dc operational amplifier, may suitably be used as an ac amplifier. The arrangement shown in figure 2 is typical of such application. The ratio e_2 to e_1 is given by $(1 + R_2/R_1)$ for all frequencies for which $RC >> 1/(2\pi f)$. For the examples shown, amplitude is "flat" and phase shift less than 6 degrees at 8 cps. Note that the network represented by R_{12}, R_2 may be complex or even non-linear. If required, narrow bandwidth may be obtained by shunting R_2 with a capacitance. This will obviously attain a very low noise figure. The K2-XA in figure 2 has a high input impedance which may be connected to a low impedance source. Unlike the conventional "operational" case, the mid-band gain of such a circuit is virtually independent of the input impedance.

INSTALLATION

Connect the desired external circuitry to a mica-filled or ceramic octal socket or a GAP/R Manifold and plug in the K2-XA (Information about GAP/R Manifolds is available upon request.)

NOTE

Operation of tubes for long periods with the cathodes heated and without plate voltage has been known to deactivate the cathodes. Therefore, if equipment is not to be used within a few hours, open the heater circuit.

All K2's made after Nov. 1, 1961 are housed in gray Lexan. The new case can withstand a much higher temperature than the 65°C. recommended max. for the yellow cases. However, longer component life will result, if the case hot-spot temperature can be kept below 45°C. Avoid severe overloading.

CAUTION

Although momentary shorting of the output to ground will not harm the K2-XA, prolonged operation under these conditions will cause over-heating and subsequent damage. The K2-XA and its load may dissipate 14 watts. Unless there is plenty of free air under 30°C (86°F) around the unit, forced ventilation will probably be necessary. The K2-XA is not recommended for those applications where either the ventilation is poor or the ambient temperature high. For such applications the MIL equivalent K2-YJ is recommended.

DRIFT

The K2-XA needs a seasoning period of about 100 hours of operation. Then, under optimum conditions typically found in analog computor installations, and after temperatures have become equalized, the drift rate of the typical K2-XA will average about ±8 millivolts per day. The optimum conditions include heater voltage regulated to ±0.5%, the plate voltage regulated to 0.03%, the ambient temperature constant at about 86°F (30°C), adequate ventilation, and the heaters invariably warmed for at least one minute prior to the application of plate voltage.

In applications where optimum conditions do not prevail, the drift rate may be ten to twenty times as much as under optimum conditions.

If bias is derived from resistive networks (figure 3) or 300v sources than can shift 1%, for example, such shift will manifest itself as "drift" of 15 millivolts. Wirewound resistors and Philbrick tracking type power supplies are recommended (viz. R-100B).

If the amplifier is overloaded the drift rate may be ten to twenty times as much as under optimum conditions.

The introduction of the GAP/R K2-P Stabilizing Amplifier is recommended for those applications in which drift must be kept well under 1 mv long term. (See the K2-P Data Sheet, available upon request.)

BIASING METHODS

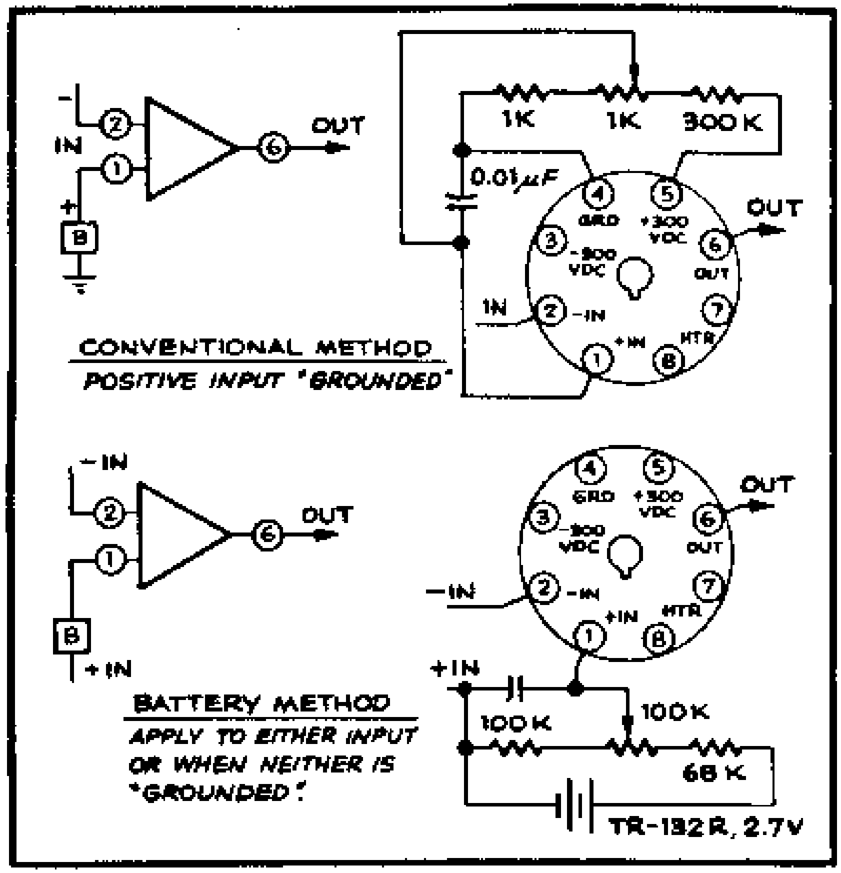


Figure 3. Biasing Methods

When using any of these methods, set the potentiometer for zero dc error under feedback. When setting the potentiometer, ground the input of the computing network for most accurate balancing.

AUGMENTED POWER — CASE HP

When substituted for a K2-W, a K2-XA will handle most computing networks with the higher performance already described. For still greater speeds and output, connect a 150K 2-watt resistor externally between pins 3 (−300 vdc) and 6 (output). (See figure 4.) The K2-XA (Case HP) will supply a load of 33K with a voltage swing from −100 to +100 volts.
This necessarily operates the 6BR8A near its maximum plate dissipation and shortens tube life.

The K2-XA is a higher output (±100v at 3 ma)

For most applications, a bias adjustment is necessary, and may be applied in any of several ways. Two arrangements are illustrated in figure 3. Variations of one of these arrangements have been found to be quite effective for cases involving differential inputs, as shown in figure 2. For further illustration ask for the Application Manual for Philbrick Octal Plug-in Computing Amplifiers.

version of the familiar octal plug-in Model K2-W Utility Differential Amplifier. It provides up to six times the output of the K2-W but ventilation sufficient to carry away a maximum of 12.1 watts must be provided. Gain and bandwidth are about one octave better than the corresponding quantities for K2-W over the ±50 volt output range.

MAINTENANCE

Preventive Maintenance

1. During operation:
   a. Make sure that tubes are firmly seated.
   b. Make sure that K2-XA is firmly seated.

Trouble Shooting

If trouble in the K2-XA is suspected:

1. Check the tubes by substitution.
2. Check for loose connections, ground, and/or shorts in the associated circuitry.
3. Check the plug-in by substitution.

Corrective Maintenance

1. Replace defective tubes.
2. Do NOT open the sealed case.

Opening the case voids guarantee. The unit should be returned to the factory for repair.

NOTE: For Quality Control Data and other general characteristics for circuit design use, ask for K2-XA Specification Control Data No. 6041-A-02.

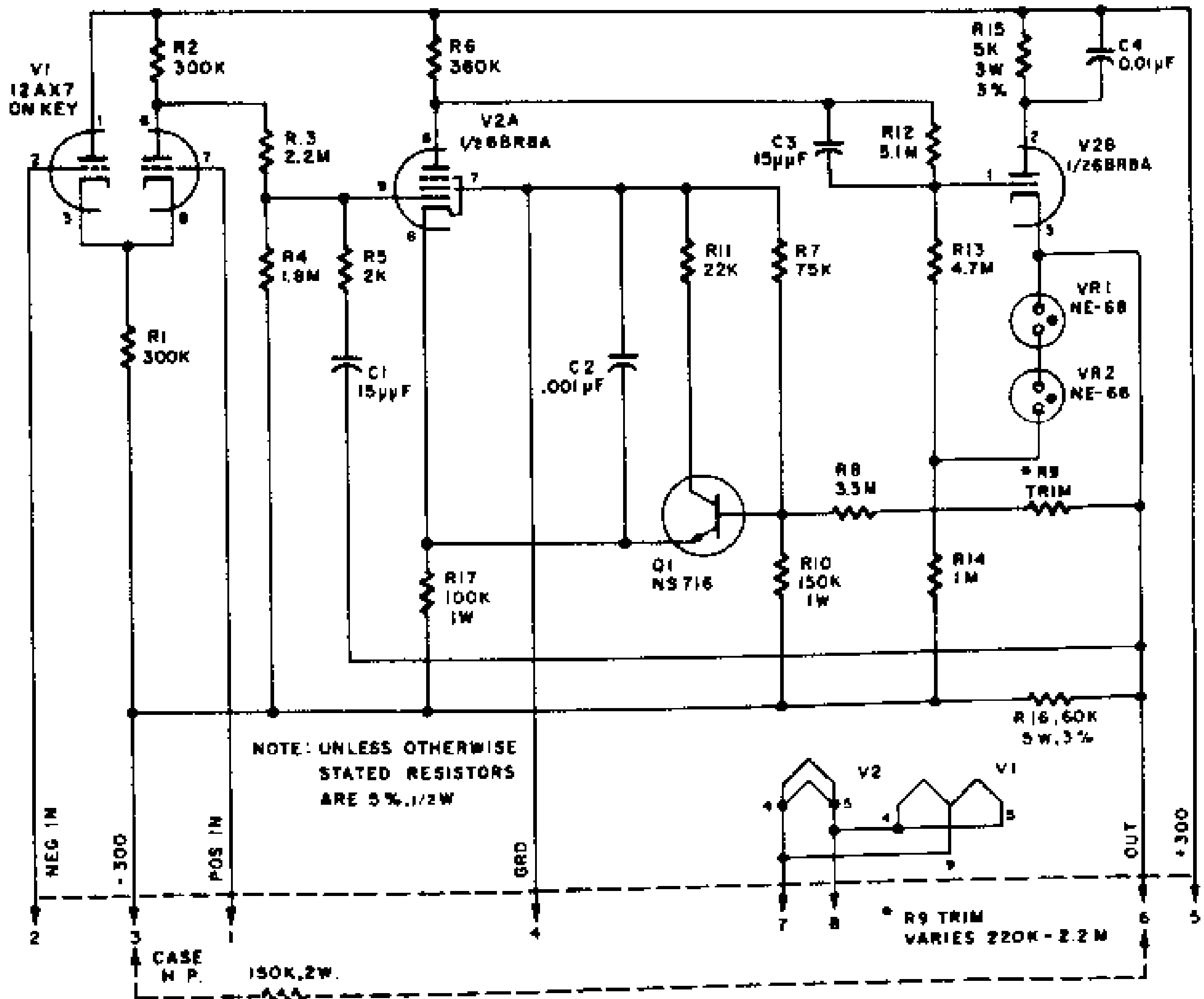


Figure 4. K2-XA, Schematic Diagram

AND/3M/1161/REV-2

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RESEARCHES, INC.
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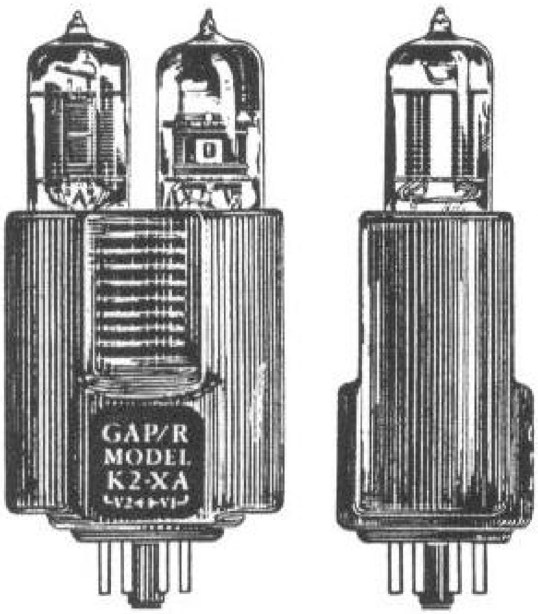
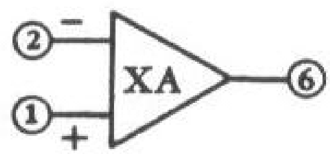
Model K2-XA Operational Amplifier



OPERATIONAL SYMBOL



GENERAL CHARACTERISTICS

Design Center Electrical Characteristics

Gain:

30,000 dc open loop (depending upon the applications — see text)

Response: — Small signal:

1 μsec rise time with bandwidth over 250 kc when used as a unity-gain inverter under ideal circuit conditions

Drift Rate:

±8 mv per day referred to the input (See text — "DRIFT")

Differential Input Levels:

Impedance: — Either input: typically above 100M (open grid)
Voltage Range:
Inputs together (common mode)

Output Capabilities:

Output Voltage	Output Current (steady state) Normal	Case HP*
−100v	−2.8 ma	−4.1 ma
0v	+4.0 ma	+2.0 ma
	−5.0 ma	−7.0 ma
+100v	+6.1 ma	+4.3 ma

Maximum available transient output current is very much larger in the positive direction, but is the same in the negative direction.

Power Required: (for full output)
Normal Operation: (50K load)

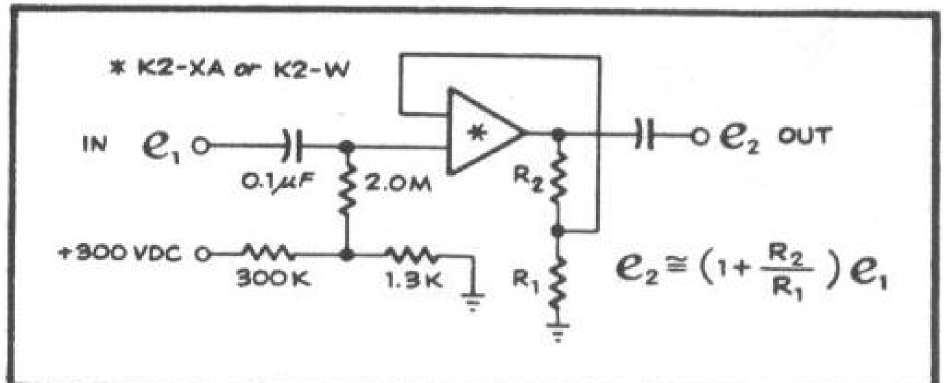
Supply Voltage	At output +100v	At output −100v

can readily be biased out. (See BIASING METHODS.)

Operationally, the K2-XA plugs into the same socket as the K2-W, and uses the same connections for power and for computing signals. Although momentary short circuiting of the output does no harm, its output must not be grounded for an extended period. Load capacitances in excess of 200 μμf usually require additional stabilization networks.

APPLICATIONS

The K2-XA Operational Amplifier can be used for analog computation in feedback systems of any complexity. It is entirely compatible with the K2-W and the two can be used in the same assemblages, each being used to exploit its own special characteristics. The K2-XA permits steeper wave fronts and greater signal excursions. Also, its greater output power allows the use of computing networks that require higher voltages and currents than are possible with the K2-W. However, be sure to provide ample ventilation.



−50 to +50 volts

Current: — Either input:

Typically less than 10^{-7} amp (insulation leakage and grid current)

Bias Required for Balance:

Adjustable from 1.1 to 2.0 volt between pins 1 and 2 (pin 1 positive with respect to pin 2) (See figure 3.)

+300	+10.4 ma	+3.4 ma
−300	−11.4 ma	−7.9 ma
6.3 vac or vdc	0.75 amp	0.75 amp

*Case HP (with 33K load)

+300	+14.1 ma	+3.7 ma
−300	−14.1 ma	−9.2 ma
6.3 vac or vdc	0.75 amp	0.75 amp

*With a 150K, 2-watt resistor connected between pin 6 (output) and pin 3 (−300v).

PHYSICAL CHARACTERISTICS

Tube Complement:

1 12AX7A or 7025
1 6BR8A or 6CL8A

Casing:

Molded plastic, sealed unit

Dimensions:

Overall: 4$^{11}/_{16}$ in. h (max.)
Above Socket: 1½ w x 2⅛ lg. × 4⅛ in. h (max.)

Base: Octal plug

Temperature:

Maximum allowable case temperature (hot spot) +65°C (149°F) (See text)

Weight: Installed: 3¼ oz.
Packed: 6½ oz.

GENERAL DESCRIPTION

The Model K2-XA is a high gain, wide band, plug-in, dc operational amplifier, designed and constructed for use as a basic subassembly for analog computor and instrument applications. It is primarily useful in feedback circuits where a high open loop gain and an output voltage range of from minus to plus 100 volts are required. The open loop dc gain for normal operation with a ±60 volt swing and a 50K load is 30,000. With a ±110 volt swing, the dc gain may decrease to 10,000. With these units, computing devices of nearly all speeds can be assembled with a minimum of external circuitry.

Like K2-W the Model K2-XA features balanced differential inputs. Its range of operation is from DC to above 250KC when connected as a unity-gain inverter.

With appropriate circuitry, the K2-XA maintains the two inputs at nearly equal potentials. The residual offset

Figure 2. As an Ac Amplifier

The K2-XA, although inherently a dc operational amplifier, may suitably be used as an ac amplifier. The arrangement shown in figure 2 is typical of such application. The ratio e_2 to e_1 is given by $(1 + R_2/R_1)$ for all frequencies for which $RC >> 1/(2\pi f)$. For the examples shown, amplitude is "flat" and phase shift less than 6 degrees at 8 cps. Note that the network represented by R_{12}, R_2 may be complex or even non-linear. If required, narrow bandwidth may be obtained by shunting R_2 with a capacitance. This will obviously attain a very low noise figure. The K2-XA in figure 2 has a high input impedance which may be connected to a low impedance source. Unlike the conventional "operational" case, the mid-band gain of such a circuit is virtually independent of the input impedance.

INSTALLATION

Connect the desired external circuitry to a mica-filled or ceramic octal socket or a GAP/R Manifold and plug in the K2-XA (Information about GAP/R Manifolds is available upon request.)

NOTE

Operation of tubes for long periods with the cathodes heated and without plate voltage has been known to deactivate the cathodes. Therefore, if equipment is not to be used within a few hours, open the heater circuit.

All K2's made after Nov. 1, 1961 are housed in gray Lexan. The new case can withstand a much higher temperature than the 65°C. recommended max. for the yellow cases. However, longer component life will result, if the case hot-spot temperature can be kept below 45°C. Avoid severe overloading.

CAUTION

Although momentary shorting of the output to ground will not harm the K2-XA, prolonged operation under these conditions will cause overheating and subsequent damage. The K2-XA and its load may dissipate 14 watts. Unless there is plenty of free air under 30°C (86°F) around the unit, forced ventilation will probably be necessary. The K2-XA is not recommended for those applications where either the ventilation is poor or the ambient temperature high. For such applications the MIL equivalent K2-YJ is recommended.

DRIFT

The K2-XA needs a seasoning period of about 100 hours of operation. Then, under optimum conditions typically found in analog computor installations, and after temperatures have become equalized, the drift rate of the typical K2-XA will average about ±8 millivolts per day. The optimum conditions include heater voltage regulated to ±0.5%, the plate voltage regulated to 0.03%, the ambient temperature constant at about 86°F (30°C), adequate ventilation, and the heaters invariably warmed for at least one minute prior to the application of plate voltage.

In applications where optimum conditions do not prevail, the drift rate may be ten to twenty times as much as under optimum conditions.

If bias is derived from resistive networks (figure 3) or 300v sources than can shift 1%, for example, such shift will manifest itself as "drift" of 15 millivolts. Wirewound resistors and Philbrick tracking type power supplies are recommended (viz. R-100B).

If the amplifier is overloaded the drift rate may be ten to twenty times as much as under optimum conditions.

The introduction of the GAP/R K2-P Stabilizing Amplifier is recommended for those applications in which drift must be kept well under 1 mv long term. (See the K2-P Data Sheet, available upon request.)

BIASING METHODS

For most applications a bias adjustment is necessary.

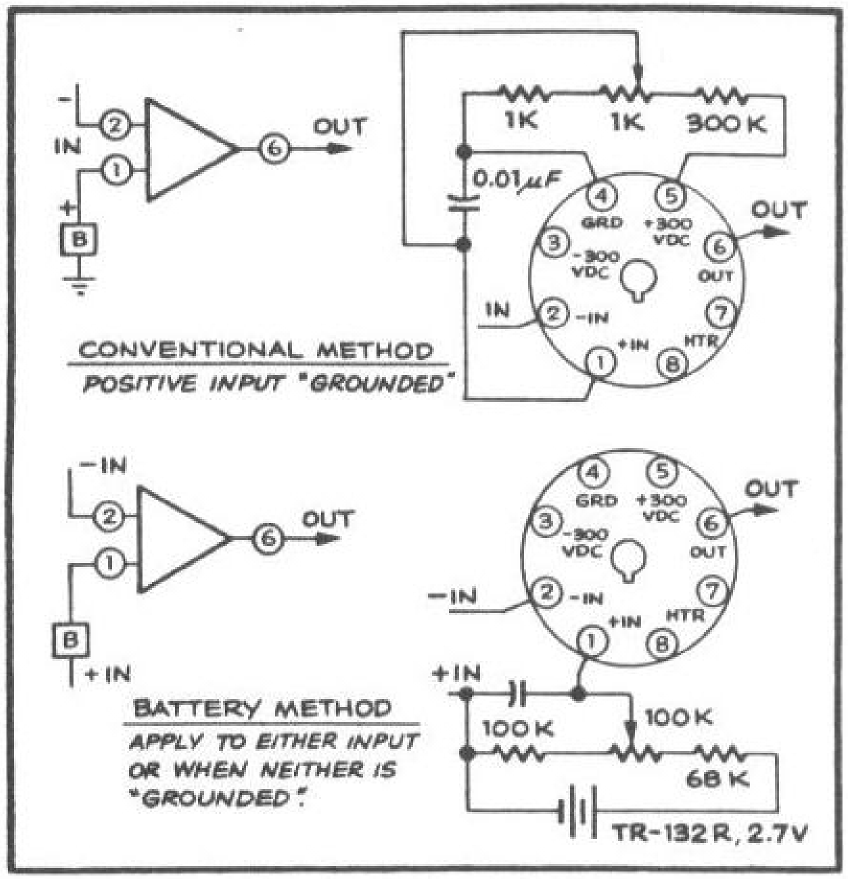


Figure 3. Biasing Methods

When using any of these methods, set the potentiometer for zero dc error under feedback. When setting the potentiometer, ground the input of the computing network for most accurate balancing.

AUGMENTED POWER — CASE HP

When substituted for a K2-W, a K2-XA will handle most computing networks with the higher performance already described. For still greater speeds and output, connect a 150K 2-watt resistor externally between pins 3 (−300 vdc) and 6 (output). (See figure 4.) The K2-XA (Case HP) will supply a load of 33K with a voltage swing from −100 to +100 volts.

This necessarily operates the 6BR8A near its maximum plate dissipation and shortens tube life.

The K2-XA is a higher output (±100v at 3 ma) version of the familiar octal plug-in Model K2-W Utility

For most applications, a bias adjustment is necessary, and may be applied in any of several ways. Two arrangements are illustrated in figure 3. Variations of one of these arrangements have been found to be quite effective for cases involving differential inputs, as shown in figure 2. For further illustration ask for the Application Manual for Philbrick Octal Plug-in Computing Amplifiers.

Differential Amplifier. It provides up to six times the output of the K2-W but ventilation sufficient to carry away a maximum of 12.1 watts must be provided. Gain and bandwidth are about one octave better than the corresponding quantities for K2-W over the ±50 volt output range.

MAINTENANCE

Preventive Maintenance

1. During operation:
   a. Make sure that tubes are firmly seated.
   b. Make sure that K2-XA is firmly seated.

Trouble Shooting

If trouble in the K2-XA is suspected:

1. Check the tubes by substitution.
2. Check for loose connections, ground, and/or shorts in the associated circuitry.
3. Check the plug-in by substitution.

Corrective Maintenance

1. Replace defective tubes.
2. Do NOT open the sealed case.

Opening the case voids guarantee. The unit should be returned to the factory for repair.

NOTE: For Quality Control Data and other general characteristics for circuit design use, ask for K2-XA Specification Control Data No. 6041-A-02.

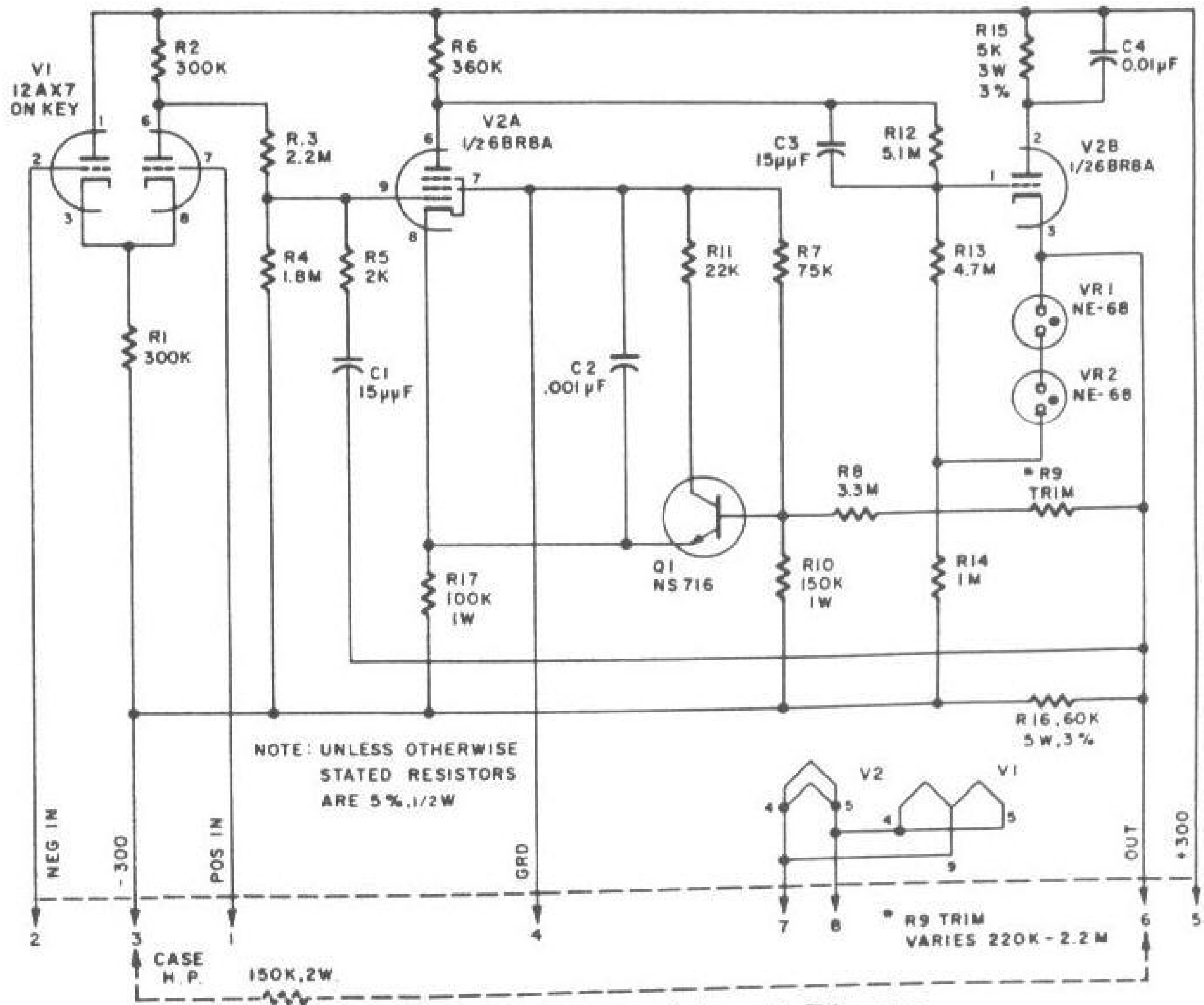


Figure 4. K2-XA, Schematic Diagram

AND/3M/1161/REV-2

Printed in U.S.A.

THE BEST OF BOB PEASE

What's All this Trekking Stuff, Anyhow? - Maxi-Report

[Directory] [Next-Equipment & Photography]

Who, US? US trekkers?

Who were we? On this trek, we filled it up to the limit of 15 trekkers. We had a few people aged 22, 33, 39, but most of us were in our 50's and 60's. But the best thing was, we were all pretty compatible, agreeable. We all were good hikers, and we were all in pretty good shape. (Well, some of us were in VERY good shape.) We all got along pretty well on the trail, and got along well when shopping or lunching or taking photos of the views - and of each other.

There were about 6 people who signed up because RAP decided to promote this trek, and the other 9 had never heard of me nor my stories in Electronic Design. There were 8 women and 7 men, plus Peter, so we had a pretty good gender balance.

We had some people who had been on 3 or 5 or 7 treks, but about 5 were first-timers. So that's a good mix, too.

I expected a broad assortment of interesting people - and we sure got that. We had hikers from Massachusetts, NY, New Jersey, Florida, New Mexico, Minnesota, and 6 from California. We soon learned to recognize the voices that rattled across camp. And the hats and the britches and the parkas. To this day, I can look at some ankles going up the trail, and say, "Oh, that's Carol with her boots", or, "That's Debbie in that skirt...." We got to know each other. If you go on a trek, I wish YOU to have such a very nice interesting assortment of interesting people. We could walk along the trail by pairs, or by threes, or any number. Often a good little discussion would start up. And then taper off, and stop, and later start again. "Look at that great waterfall over there" "...yeah, but I already took too many pictures of waterfalls...." "Hey, that is a nice bird up there..." "Peter, what kind of tree is THAT?" - Never a dull moment.

Scope of Trek

Several people said, "Tell me about your trek. Because most reports from Nepal are about 'How we survived the Death Zone'". This trek was definitely NOT about the Death Zone (above 25,000 ft.), though we did get high enough to scratch at a zone of concern. Any time you start going above 14,000 feet, there is always the chance of altitude sickness. But Peter got us acclimatized slowly, and none of us had any serious problems pushing up to 15,000 ft and then to 17,771 ft.

Peter's trip description was quite accurate: this was a moderate trek for 20 days, going up as high as 15,000 ft - and just one long hard, high day. Many days were quite easy. We had several short days, and a couple half days when the weather was wet and we stayed in camp until lunch. If we had had to wait a day or two for good weather, at Phedi, then that cushion would have left us walking a little faster. But most days were just right. Our long day was from Jharkot down to Marpha, a full 10.5 miles as the crow flies, per GPS. That must have been a full 12 or 13 miles of trail, but most of it was nice, easy downgrade. Even on that day, we had plenty of time to goof off, and take lots of pictures, and have a leisurely lunch, and we still got to camp early. Other days had fewer miles, but there was rough trail or slow descents, and they still came out right. We almost never got to camp later than 4 PM.

There are many other treks in Nepal that are no harder than this (if the one hard day over Thorong La were left out). Our treks to Dhorpatan and Langtang were just about as hard: not extremely. They had a comparable mix of a few long days, lots of medium days, and lots of short days, too. So if you want a good trek and are not confident about hiking above 14,000 feet, there are many good choices.

Conditioning

A couple readers wrote to me, "We could never do a trek like that, 165 miles". I told them they were probably wrong about that. Most people can walk 5 miles. If they hike every day, they can easily get in shape to do 8 or 10 miles, even with some hills added. If you are able to hike 6 or 8 or 10 miles, day after day, you could pretty easily do a hike like this. One of our trekkers had been a couch potato for years. He decided he wanted to go on this trek, and he started hiking 4, then 6, then 8 and more miles, with some good hills thrown in. He had no trouble hiking this trek, and he got a big kick out of this trek, because he had no trouble hiking - and because the trek was fun.

I took a couple "calibration hikes" with this guy, and we convinced ourselves that we had done enough hiking and enough conditioning that we were SURE we could do all the hiking and have enough reserve energy to make most days really easy. We wanted to have enough strength that we would not get very tired out, and the hiking would be FUN. And that's what we did.

On the other hand, one of the trekkers was a marathon runner, with a time of about 3:30. My wife said she had heard that sometimes marathon runners do not do well on treks - perhaps because they think it should be easy, or because they do so much running, they are not good at hiking. This guy got along fine, had no troubles with the hiking and the altitude. So you can't always believe rumors.

Trails on the Annapurna Circuit

There sure were a lot of different kinds of trails on the Annapurna circuit. Most were quite good. Some were excellent, some were glorious. A few were tough, steep, rough, bitchy. I included some views of trail in my video, to show how trail conditions were. Mostly, hey, very nice. Some of the walking on the Kali Gandaki River bed was a bit rough and slow because of all the loose rocks. But, that was not really bad. The rough parts only went on for perhaps a half hour at a time. In some towns, the trail was paved with rough rocks pointing up at sharp angles. I am not sure why they did that. Maybe for better traction for pack animals. In many towns, the trail was nicely paved with smooth stones. In many places, you could tell the steeper sections had been paved with rocks, but the relentless abuse by pack trains had worn the trail down, and the rocks were falling away. I guess that can't be helped when there is heavy use. It was not usually a big deal. Most of the walking was on good dirt or good gravel. There were a few places where there had been slides, and the new trail was cut into the dirt. Most of these were not any problem or worry, even if the trail was a bit narrow or a bit rough. Hey, the trail has to be wide enough for horses and pack trains.

High-Altitude Hiking Stuff??

When I was hiking in Nepal in 1989, we hiked up to 14,600 feet at Gosainkund Lakes. It was 3 PM. I wanted to go up to Laurabina Pass. None of the other hikers was interested, but Salaam Sing, one of the sherpas, was agreeable to take a hike before supper. Up we went, and I was hiking at a rate of about 1 full breath per step. It took a full 2 hours to get up to 15,100 feet at the pass. After taking some photos, we hurried back down to supper. But I knew I was in pretty good shape to get up to 15,000 feet. Would I have any trouble getting higher?? Maybe - maybe not.

As we started ascending seriously past 10,000 feet on this trek, I began to do serious breathing through my nose. REAL hard breathing, to storm up any steep upgrade. I was going at about the rate of 2 steps per one full breath. My wife said I was making too much noise. But, what's new? (Note, to keep your nose clear at these altitudes takes a lot of handkerchief work. Some people would say it's nasal mucus, but I say it' snot.)

As we kept on ascending to 14,000 and 15,000 feet, I kept on breathing hard through my nose.

When we actually set up our high camp at Thorong Phedi (15,100 feet), I went for a half-hour hike up the hill, to check out the next day's climb. As we had not had much trouble getting up TO 15,000 feet, I did not expect much trouble ABOVE that, and I was right. When the trail was shallow, I could continue on - NOT at 1 full in/out breath per step, but almost at 2 steps per full breath. If I just took shorter steps when the grade was steeper, I could keep going at about that pace, but every few minutes, a 10-second break did feel good.

As we started out from Phedi the next morning, the grade of the trail was fairly moderate, but as we went higher, the grade got shallower, so all the way up to 17,700 feet, it did not feel much different. I was NOT gasping for breath. Listening to my videotapes, I can hear that my voice was not very different. I did not seem very much out of breath. It didn't feel weird. I did not feel terrible or light-headed; I did NOT feel like I was gonna die. It was just good hard work, good exercise, like a lot of other good hard hills (which were a lot steeper, but at lower altitudes).

Of course, a lot of this was related to how we got acclimatized. We took 4 days to travel about 16 miles, from 11,000 feet up to 15,100 feet. Could we have done those miles in 2 days? Of course - but that would have been WRONG. It's wise to put on no more than 1000 feet of elevation per day, for best acclimatization. Peter Owens herded us up the hill, nice and SLOW, so we would have our best conditioning for the pass. And it worked, because all 15 of us made it over the hill. So, "slow and easy wins the day".

Why did we camp at 15,100 feet? Because the camping down at 14,600 feet was all full up. Thorong Phedi is listed at the elevation of 14,600 feet, but there are 3 levels, and we camped at the higher level, and it was fine. And it saved us about 20 minutes of climbing, when we had to start up. None of us had any complaint about that. When we got up to about 16,000 feet, Nancy was feeling crummy, because she could not breathe hard enough to get in enough oxygen. She was getting a cold, and her nose was clogging up. When she tried breathing hard through her mouth, her lungs felt bad, as if "frosted". So at 16,500 feet, I took her pack away, and put it on my front. My pack was about 15 lb., including my solar panel, and hers was about 10, as we had put on most of the clothes in our packs.

This barely slowed me down. I just walked on up the hill. It's true, when I took off the packs, it did feel a little lighter. No trouble on the easy grades up to the pass.

After a few minutes of rest, we started down, and all the effects of altitude just went away. Descending the shallow (and also the steep) grades to the west felt no different than any other descent at low altitude. We were slow in places, because the trail was steep and slippery, but that had nothing to do with altitude.

After I had been down in Kathmandu at 4000 feet for a week, I took a motor vehicle to the top of Pulchowki, a hill at 9000 feet. I started up a few little trails. My feet felt very heavy, and my legs soon got tired, and my lungs ran out of breath quickly. So acclimatization can disappear surprisingly fast, when you go down to low altitudes! / rap

P.S. I found an old memo I got by Internet, back in August. One correspondent claimed that "you have every reason in the world to be excited about going to Annapurna. It's an experience like no other. At the top of Thorung La, your head will be pounding, your stomach will be in knots, you will be dizzy, thirsty, aching, and nauseous."

ACTUALLY I felt none of the above. My head and belly and lungs and legs all felt fine. I didn't even feel tired. Of course, I did take a few sips of water on the way up. If you didn't do THAT, you might feel lousy. And as I said, when I hiked briskly up the hill to a little knoll 100 yards south, I was STILL not out of breath.

If I had kept on ascending above 18,000 feet that day, I do not know where I would have run out of steam. But I'd have to guess I would be able to get to 20k. Maybe some day I'll find out. Of course, you need GOOD slow acclimatization. / rap

P.S. I did take the recommended Diamox pills, to minimize the effects of high altitude. They seemed to do no harm, maybe some good....

Stone Steps

When we started up from Tatopaani to ascend to Ghorepaani, about 4 days from the end of our trek, I decided to count the stone steps. That was because there was an alleged number of 3319 steps from Ulleri down to the next bridge at Tirkedhunga, over the Bhurungdi Khola, descending east toward Birethanti. I suspected that there were a lot of stone steps ascending up TO Ghorepaani. That's a big hill, too! At least 5500 feet of rise.

I counted 1850 stone steps up to the first Deorali at Santosh Hill, and 1752 more up to lunch at Sikha, and 1902 more up to our camp at Chitre. Total of 5504 for that day. (Additionally, there were 219 DESCENDING steps.)

Then I counted about 1520 more, the next day, up to the pass at 9700 feet at Ghorepaani. So that was about 7024 stone steps. NOT just 7000 stone steps that you COULD walk on, but 7000 stone steps in sequences or rows. Not just baby steps, or flat steps, or steps ramping up, but real steps, 4 inches or more. Most were 6 or 7 inches; some were more. That was my standard for, "what makes a step?" I just counted the real steps. Sometimes when there were lots of 3-inch steps, I would count each as "half". Jerry didn't believe I was really counting the steps. But I sure was counting them.

Then when we went up to the top of Poon hill, that was another 1280 steps. Descending from the pass at Ghorepaani to Ulleri took 2636 descending steps, (plus 409 steps UP).

The next day, from the middle of Ulleri down to the first bridge at Tirkhedhunga was alleged to be 3319 stone steps, according to Carol's book. I was suspicious that maybe they were counting baby steps, or flat steps. So I counted, and I got 3267, which is barely one percent different from their count. So 3300 or 3319 is a pretty good estimate. The total number of stone steps of descent at that point was about 5903. Below that bridge, I counted about 500 steps up, and 500 down, and then the steps petered out. I gave up counting them. Still, while the books say there are many thousands of stone steps on the east side of Ghorepani, it is also correct to say that there are many thousands of steps on the WEST side of Ghorepani, coming up from Tatopaani. On each side of the hill, it is fair to say there are at least 7000 steps. That's a lot of stone steps to hike over in a few days. Mostly, that makes very nice hiking. / rap

Steep, rough, bitchy trails
Most of the trails on the Annapurna Circuit were really quite OK. I'll mention the few that weren't.

The trail that descended by switchbacks to the last bridge below Thorong Phedi was tough, as a little stream had flowed over the trail and frozen overnight. Fortunately, the sherpas took an ice axe and gouged steps into it, and it was not bad. But this was only 50 yards of trail. Not a bad deal.

When we started to descend from Thorong La, the first couple miles of trail were really quite good. Mostly a lot of gravel, some snow. Not steep. Good hiking, and we made pretty good time.

But the next couple miles were really quite steep, and covered with hard-packed snow. 180 people had been over the trail in the last 2 days, and it showed. It was really tough to get any traction, and in our group, Peter and Nancy and I had to walk off the side of the trail, to get decent traction. Sometimes we had to go on goat- trails 10 or 20 feet below the real trail, and dig in our heels hard. This was slow and bitchy, but after the waste of a couple hours, we got down to Thorong Phedi (west) and then we made good time. It took us from about noon to about 4:45 to get from the pass down to Phedi. Slow progress. It took barely an hour to cover the next couple miles to Muktinath, no problem. The steep stretches would have been OK if it were not for the hard-packed snow. Some people said that even if they were not snowy, the trail there is steep and slippery, but I think it would have been a lot less bad.

Cold-Weather Camping
When we started at BesiSahar, the temperature was pretty warm. Perhaps 50 degrees with clear skies, the next morning. The first 3 nights were not very cool; we barely had to put our sleeping bags over us. Then it started cooling off. At Koto, Peter told us that the temperature had hit 23 degrees F, just 10 miles up. Sure enough, from there on in, the temperature in the morning kept dropping from 35 degrees F to 25 and later to 15. If the air was clear, we would get a lot of radiational cooling and the air would get down to 15 degrees F. Fortunately, the air in our tent was about 15 degrees warmer than outside, but we still had to start zipping up our sleeping bags. Some of us had flannel liners or sheet-sacks to go inside our sleeping bags, to help keep us warm. (They also helped keep the sleeping bag a little cleaner.) When we got up to Yak Kharka and Thorong Phedi, it got down to about 8 degrees F. We had our pajamas, and long-johns to keep us warm. I had one hat to wear in the day, and a softer one to wear at night. When it got cold, I just kept on whatever hat I had on.

If it had ever gotten REALLY cold, I had extra pants and foul- weather pants; extra jackets and shirts; and extra hats and mitts. I could have bundled up out in the snow, and almost as much, if needed, to get warm in the tent. I sure was glad it did not get down below zero, as most other people - porters and trekkers, too - were not prepared for that. Fortunately, when it DID get cold, it did NOT get very windy, but rather calm. Still, camping at 10 degrees F above 14,000 feet is just like REAL cold-weather camping, because your body cannot run its metabolism very hot, with so little oxygen. Two nights of that were PLENTY. (I've done a little camping at 20 and 30 degrees below zero, and it's not much different.)

We normally had 40 minutes to drink our morning tea and cookies, and stow our sleeping bags, and get everything we needed for the day. We soon learned to get everything we needed for the morning, ready at night, because there were often good scenes to photograph at daybreak. So I would get the new roll of film, and the next shirt and socks, and stuff them into my day pack, so I could easily grab them in the morning. Much better than fishing around in the dark.

Note: some people said - why bother with a watch on a trek? You don't need a watch - or an alarm... WRONG! I kept my alarm set for 5:40 AM. Then I could get up and pull on my clothes, and go to the john before 5:55, and avoid the 6:02 rush to the toilet tent. I thought an alarm watch was VERY useful.

Other than that, our camping was not that much different when it got cold. We just simplified our routines.

One detail was that Nancy and I decided to wash some clothes after about 5 days on the trail, as we had enough dirty socks, shirts, and underwear to make it worth the effort. Unfortunately, the next 3 days were cool and damp and not sunny, and we had a heck of a time getting the shirts dry. Finally we just tied them on our packs. After a couple more days, they were dry enough to wear. But it was a big pain in the neck.

So we easily re-learned the routines of camping in cold weather. But it sure is really nice, when somebody else puts up the tent, and takes down the tent, and somebody else CARRIES the tent. Much nicer than when you do it yourself, especially when the tent and poles are cold. / rap

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THE BEST OF BOB PEASE

Equipment & Photography

[Previous-Start the Adventure] [Directory] [Next-The Head Cook- Buddi]

Boots

I bought a good pair of Vasquez boots, about 5 years ago. They were good and comfortable and waterproof, using Goretex. For a couple years, they were very water-proof. But not recently. I poured some water into the boots, and it ran out at the seams. I put some ShoeGoo II on those places. It stayed on OK for a few weeks, but then a week into the trip, it started coming off. Still, the boots were very comfortable, as they have always been. I could put them on cold in the morning and they would come up to warm comfort shortly.

But when we got into some snow, they got cold and damp. When it got really cold, they tended to freeze up. They were still comfortable, but not very warm. So if I were going on another trek, I would not take my old leaky boots, even if they were comfortable. Also they did not grip on rock and snow as well as they used to. The vibram edges were not sharp. I did not get into trouble. But wearing comfortable old boots is not always a good idea. Time to retire them.

Other people did not have much trouble; most of them wore newer boots without so many miles on them. So I will get smart, too. Still, my feet were generally comfortable, and I had no blisters in 180 miles. / rap

Hats

When I was packing up, I weighed everything I carry. I brought everything I weighed. Since I never CARRY my sun hat, but just wear it, I did not weigh it. I forgot to bring it, so I had to buy a sun-hat in Kathmandu. Otherwise, John C. and I would have had identical hats. So much for planning and checklists. I was too busy to use my checklist, at the last minute. I did bring 3 good wool hats, for cold weather. I never had to wear 2 at a time, as it never got cold enough. Fortunately.

Peter Owens wears a different hat every day. Most of them are glorious and amazing, wonderful. If you see an amazing hat, at a sale, preferably in a very large size (size 8), you might want to buy one and give it to Peter, to add to his amazing collection.

Altimeter Stuff....

When we were preparing for this trek, Nancy decided that she wanted to buy an altimeter. Not just a dumb altimeter, but a recording altimeter, built into a watch, that would tell you how much you had ascended today. I didn't think it was a big deal, but she thought it was a good idea. We checked out an Avocet ($120) and it seemed to do the right things. So I bought her an early birthday present.

There were 2 other people on the trek who had electronic altimeters (Casios). They all seemed to work well, and all had pretty good accuracy. They all seemed to agree pretty well with each other, and when we came to a town, they agreed pretty well with the elevations shown on the maps, or listed in books. Except at Tatopaani; the books said 3800', but we all agreed it was 4200'.

So, what's the big deal? Is an altimeter as foolish and useless as a GPS receiver? No, it is actually fairly useful. When we were approaching Thorong La, one of the Sherpas told me, "90 minutes to the pass". So most of us were prepared to slog on for 90 minutes. We knew we could gut it out, slog along for over an hour. But the guys with altimeters could say, "17,400 feet, not much further to go". They were right, and the Sherpa was wrong. We arrived at the pass soon, about 25 minutes. So the altimeter was useful for ball-park indications or estimates of our progress.

Some hikers told my wife, "just a few minutes to the pass". That when she was down at 16,000 feet, and she knew THAT was wrong.

Secondly, on our third day, I hiked good and hard, but I was getting really tired, coming into Dharapaani. When I got to camp, Nancy told me that we had only made a net gain of 2140 feet that day - but we had ascended 4300 feet and descended 2160 feet. NO WONDER I was tired!! So, the altimeter can be a good sanity check.

Overall, the minimum amount of ascent on this hike was from our starting point of 2700 ft. at BesiSahar up to 17,770 ft, and also from 4200 ft. at Tatopaani to 9200 ft. at Ghorepaani. A total of 20,070 ft. rise and about 20,000 ft. of fall, too. But Nancy's recording altimeter recorded that we went up 38,000 feet, total, and about 38,000 feet of descent. That sounds like a lot, and it was, but it was spread over 21 days. Thus, about 1800 feet of rise and fall, each day. I didn't expect that much. So, I will not again scoff at my wife when she thinks an altimeter is a handy gadget to bring on a picnic. As usual, she has good guesses. / rap

- The following list of elevations at each camp is not a big deal, as that could be gotten off any map or good guide-book. It is the Ascent of each day, with the Net Rise subtracted, that indicates how many EXTRA feet of Rise AND Fall you hiked on a given day.

START at BesiSahar - 2640 ft. to Ngadi (top end of blue bridge) - (3080 ft.) Ascent: 1290 ft.; Net Rise, 440 ft. Extra R&F, 850 feet.

- Ngadi up to Jagat (4300 ft) Ascent: 2400 ft., Net rise, 1220 ft. Extra R&F, 1180 ft.

- Jagat up to Dharapani, (6440 ft.) Ascent: 4300 ft., Net rise, 2140 ft. Extra R&F, 2160. ft.

- Dharapani up to No-Name Camp, (1 hour below Koto) 8240 ft. Ascent: 2740 ft., Net rise, 1800 ft. Extra R&F, 940 ft.

- (Below Koto) to Tukhure Pokhara, Lower Pisang: (10370 ft.) Ascent: 3230 ft., Net Rise, 2130 ft. Extra R&F, 1100. ft.

- Tukhure to Hongde (11070 ft.) Ascent = ? Net rise: 700 ft. Extra R&F = ?

- Hongde to Braga, (11300 ft). Ascent = ? Net Rise: 230 ft. Extra R&F = ?

- Braga to Yak Kharka, (13,350 ft.) Ascent = ? Net Rise: 2050 ft. Extra R&F =

- Total from BesiSahar to Yak Kharka: Ascent: 19,600 ft. Net rise: 10,710 ft. Extra R&F: 8,990 ft.

- Yak Kharka to Phedi, (15,100 ft.) Ascent = ? Net Rise: 1750 ft. Extra = ?

- Phedi to Thorong La (17,770 ft.) Ascent = ? Net rise: 2670 ft. Extra = ?

- Thorong La to Muktinath (12,600 ft.) Descent = Net fall: 5170 ft. Extra = ?

- Note, below Muktinath, we did not keep good records, but there definitely was a little of UP and DOWN while travelling along a nominally flat area. Due to recent trail construction, we did not have to climb so much as in previous years, just to get down the valley.... / rap

Video in Nepal

As I mentioned, I really wanted to get some good video in Nepal, because last year, an audio connector fell off inside my Sony TR-51, and I got no audio at all, just 7 hours of silent movies. This year, I sure wanted to avoid that problem. So I brought along a little speaker, so I could hear that the audio connector had not fallen off. It did NOT fall off. No problems with that. I wanted to have more battery power, so I brought 3 batteries and a better charger. But the season was winter, and we had rather few hours of sunshine, and I STILL got more recording in than last year. So I can't gripe a lot.

Some people like to take pictures very slowly. Carefully posed, everything carefully composed. Sometimes I do that. But I have a monkey mind, and I like to be able to GRAB snippets of action, as they pop up. As you can see from my editted film, I often do that.

When TV advertisements are shown these days, they like to run a lot of segments, each about 3/4 seconds of splashy eye-ball-wrenching video, and then go to the next BITE. I really don't like that. I am cheerful to set up my video at 5 to 10 or 15 second snips. But some things last longer than that, and other things last shorter than that, and I'll throw in some of each. As you can see.

I like to tape random chunks of conversations, of people interacting, of places and things. I sure have a lot of fun, and it seems to work. Of course, I have to do a lot of editting. Not a big deal. - I think I lost too much good video because the camera went out of focus. On future treks, I may decide to leave the viewing in FIXED focus, and put my finger on AUTO focus in case that is needed.

Weather and Viewing

Even when a day starts out clear you tend to get increasing clouds over the peaks as the day goes on. Also, it tends to get cloudier, day after day, until you get a storm. We saw that. We got NO RAIN until well over the pass. We had just 5 inches of snow before we went over the pass. We had a lot of days when the clouds did not get heavy, and we had GLORIOUS views all day long. One day, when we were down in Tatopaani, we had blue skies and no clouds ALL DAY! If we had been in sight of Dhaulagiri that day, we would have seen it in the clear. But on this trip I never did see its summit in the clear, as it was always shrouded in a small veil of clouds. Otherwise, we had many hours of good viewing of the great peaks.

We had many great views of all the Annapurna peaks - Annapurna I, II, III, IV, and Gangapurna. The panorama also included, at various times, Tilichot Peak, Nilgiri, Hiunchuli, and the spectacular Machhapuchhare (often called Fishtail Peak). Also good views of Manaslu and Peak 29, off to the Northeast of the Annapurnas, early in the trip. Also, the huge walls of Dhaulagiri, just west of Annapurna, and Tukuche Peaks (a handsome triple pyramid just north of Dhaulagiri). And many other great mountains that would be famous if they were not overshadowed by the Annapurnas. By the way, I just found out that Annapurna is the name of a harvest goddess in Nepal.

Annapurna III and Manang

Click on Image to enlarge

So we had no rain, and very little snow, north of the Annapurnas. Yes, when they call that a "rain-shadow", they are not kidding! Now, what is the OPPOSITE of "rainshadow"? When we descended from Ghorepaani, we found out: Rainforest. That's what it was, and we got a lot of rain that morning.

That Calendar Picture?

I decided to look for those mountains that were in that inspiring picture of Thorong La, when I got up to the pass. But when I got up there, nothing looked like that. John said, "Oh, yes, back in the first hour, there were views that looked like that". I found some photos and some video that did get that general view, but nothing exactly like the view on the calendar. Next time I'll be more observant, and take some pictures down there.

Thorong La Scene

Click on Image to enlarge

Batteries and Charging

I had a few new ideas on how to improve my battery charging, for the nicads of my camcorder. I used good old connectors, and my solar arrray rated at 22 volts and 280 mA. I got 2 new nicad batteries, so I would have 3.

Even though I did have some suspicions that my 2nd battery was not holding a lot of charge, I brought it along.

Mistake! I put it on charge the first day on the trail, when it got low. It did not show any charge after 2 hours. I put it on John C.'s little charger. After a couple more hours, it STILL did not show any charge.

I put it on my Turbo circuit, (which doubles the current and halves the voltage, using a switched-capacitor circuit) and this did seem to show that it put more current into it. More than direct current from the solar array. It was DEFINITELY connected. After 2 hours of good sunlight, that lousy battery showed, still no charge. So I had to carry that battery 150 miles so I could get it replaced on warrantee. Quite annoying! Musta had a bad cell.

Then I put both my other batteries onto the Turbocharger circuit. One of them charged up just fine. But the larger one (Ambico) did not seem to want to accept any charge from the Turbo circuit. So I set that aside, and just ran the dc current directly into the battery.

One of my battery connectors croaked. Fortunately I had a couple spares. One of John's connectors croaked. It sure is good to have lots of spares, especially if they weigh only 1/2 ounce. Next year, I will have better connectors, and better batteries. I may even have a set of D-cells, to use on rainy days.

I had read that some of the villages on this trek had 220-volt power, but I forgot to bring my charger. Yes, a lot of them had wires, but about 1/2 of the power systems were not working. STILL, I should have brought my line-powered charger. If I split the 1.5 lb of weight between 2 people, it would have been very minor, and we could probably have gotten a lot of good charge on grey days when we could not get much charge from our solar arrays. Next time I'll be smarter.

Editting my Video

When I got home, I took each of my 5 video tapes, and, starting at 0:00:00, I noted the exact second when I wanted to transfer a section into the Master tape. When I was all done, I went out and rented a good VCR, to help the transfer. I went to the first snip. The wrong material was in place. When I found the right material, it was offset by 27 minutes. I corrected the 27 minutes; then the next snip was off by 6 MORE minutes, and the next one by 6:13. I could not put in any fixed correction. The TR-51 had blown its little digital mind. So all the dozen hours of preparation were lost. How annoying! I eventually got around to doing this ~right, with my TR-75 recorder.

When your (digital) camcorder is not able to keep its place, it is very annoying. No, the real time-base is accurate within much better than 0.1%. When I record, the time base is not grossly wrong. Each tape is still about 2:02:20, which is about right. It's just when I do a fast-forward (or fast rewind) (which you have to be able to do while editting) that it seems to be badly goofed up. When you look for a GOOD 10-second segment in the middle of a blurry, boring minute of stuff, you need a marker to tell you when to transfer it. When the markers or timers or counters are in error, you are OUT of business. But I finished the editting OK, if lumpy.

Note, I had about 68 minutes of good stuff (Part A); 90 minutes of stuff that was of interest primarily to trek Members (Part B); and few more minutes of STUFF, such as shopping and sight-seeing in Kathmandu, that might be fun to watch. Grade C, but fun. / More later. / rap

35mm Photography

We took a couple dozen rolls of 35 mm film, and got lots of good pictures, and lots of mediocre ones, too. I like to figure, if 1/2 of my photos are duds, I am doing something right. (If all of my pictures were perfect, then I am not being bold enough.)

One thing for sure, a zoom lens is a big advantage, as it lets you frame things well. When I first came to Nepal in 1989, I had a zoom lens, and it worked pretty well. However, my old Nikomat FTN had manual focus and exposure, and I botched some shots by not thinking. I am sure the good photographers in our group will show us how it was done right. AND, the Nikomat was much heavier and bulkier than my camcorder! So I did not bring that.

The camera I used was just a small Olympus that I kept in my pants pocket. By being able to rip out the camera at any time, and fire off a shot, sometimes you can get amazing things, on the spur of the moment. Of course, when you are doing things like that, in a hurry, you make mistakes and blur things. Tough. My primary objective was to get good video. Refer to Video. Still, I got a few good shots that other people did not. / rap

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THE BEST OF BOB PEASE

The Head Cook - Buddi

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One of the best attractions of a trek is the great food. When we first started on our 1989 trek, my wife was really impressed when she saw that Buddi had bought 2 kilograms of garlic, and over 8 kilos of onions, for a group of 10 people. She knew, this guy really knows how to cook. And she was right.

Buddi has a LOT of recipes; some are based on western supplies such as Knorr soups, or canned meats. Many are cooked up fresh with local ingredients. But Buddi has his own way to make them special. The kitchen boys do most of the cutting, chopping, and preparing the food, and then cooking it up. Budi manages the whole operation, and sets the tasks, checks the critical stages, and does the tasting and the adjusting of flavors. Obviously, Buddi is RESPONSIBLE for how the food tastes, and we really enjoyed it, almost all the time:

The Food

The proof of the pudding is, how did we like the food. I thought it was almost always excellent. Especially the fried foods. At least once a day, Buddi made something fried. Breakfast or lunch or dinner. We might have bacon puri and cheese puri for breakfast, or french-fried potatoes for lunch, or potato chops for supper. Or pizza. Everything was very delicately fried, not greasy. Even at the end of the trip, the fried foods were very tasty; the oil did not taste old or tired.

I have tried to keep lists of all the food - but I was not perfect at list-making. Still, we had some excellent taste treats.

At Jomosom we had spring rolls with our Goat McNuggets, for lunch.

At Tal we had baked beans with sausage and pancakes and cabbage salad. A couple places we had new boiled potatoes that we bought locally. Eggplant with veggies. Cauliflower. Spaghetti al Pesto. Lots of rice. DahlBhat with freeze-dried water-buffalo meat.

Breakfast always started with juice (hot juice when it was cold) and oatmeal or granola. Once we had choro, a local beaten rice cereal, fried and served with ham and onion. Excellent. Followed by breads or french toast or pancakes, or omelettes. Then tea and coffee, and hot water (so you could make hot chocolate, or herbal tea), and we were well fortified to hit the trail.

French toast. Omelettes with yak cheese, or with tomatoes, or with bacon, or plain omelettes. Of course, when you are out in the open air, and working hard, that makes food taste better. I ate with a big appetite, and still lost about 9 pounds. I've only gained a couple pounds back. Did I lose weight because I didn't like the food? Not at all! I think I lost weight because I was working hard, and because the tea-and-cookies we were served at 6 AM helped curb my appetite a little. But still I almost always ate seconds.

"Goat McNuggets"

Some of our members became vegetarians when they saw the cute white goat we bought in Jharkot. They petted it and patted it. When the goat stew was served for supper, they decided to eat vegetables. Actually, the goat stew was quite tasty; a little tough in spots, but very good flavor. Not gamy. But the idea of eating an animal that they had petted was just not acceptable. This was reinforced by the kitchen boys, who asked, "Would you like some Maa-aa-aa?" I think they did this because (over many treks) they had learned that if they described supper that way, fewer trekkers would eat the goat, and would leave more meat left over for them to eat. I guess that is what happpened. Good for them. I thought this was hilarious!

The next day in Jomosom, we did have "Goat McNuggets" for lunch, with spring rolls. Again, "Would you like some more Maa-aa-aa?" Some said "No-o-o"; others said "Ye-e-e-s". But they were very tasty. I had never actually eaten Chicken McNuggets, so after I got home, I went to a McDonalds and ordered some. They were very bland, not much flavor. Heck, the Goat McNuggets were better, more flavor.

Most trekkers did not want to see how the goat was killed and butchered up. But I wanted to see how they did it. The kitchen crew did an extremely professional, humane, neat, sanitary job of killing and cutting up the goat. I watched, I took video. They really knew how to do it. I wanted to learn how they did it, because I would certainly be willing to kill a goat if we were hungry and needed the food. But I didn't know how to do it, so I watched and learned. Most procedures made perfect sense. I did not realize that just pouring boiling water on the carcass would make the fur come off easily in just a few seconds. They used lots of boiling water, and were VERY clean. Then after they had scraped the skin very clean, they rubbed curry powder all over the skin - and shortly they washed it right off. Thanks to the pressure cooker, the stew was ready to eat, barely two hours after the goat was walking around.

So if you are carnivorous, but you wouldn't want to eat an animal that you petted - wouldn't want to see how the meat was prepared - but you'll eat it if you don't have to think about it - that's your choice. But when you see how carefully the meat was prepared, you have a lot of respect for the guys who have to work with the butchering - and they do it very carefully.

Likewise, the chickens we bought were handsome big birds. Some people were uncomfortable about eating a bird when they had heard it squawking. But the chickens sure were delicious. One item I recommend adding to your equipment: dental floss. Because little bits of the meat can get stuck in your teeth, even though it has been pressure-cooked.

Recipes

I can give you a couple of Buddi's good recipes. The first is just sort of a concept: any good cook can figure out how to execute this:

Potato Chops

Make patties out of mashed potatoes; dip in beaten egg, dip in bread crumbs, and fry. Buddi uses deep fat. Most of us do not have a lot of fat to use that way, but you could just fry them in a pan. I had never had them before. They were excellent. Obviously there are many variations you could make with different spices, garlic, etc, now that you have the basic concept.

Buddi's Ramen Soup

Buddi makes this up for lunch on cold days, such as at Ghora Tabela or Yak Kharka. It is a real warmer-upper. (He also serves a fairly bland chicken-noodle soup alongside this. I always sample that, but THIS is MUCH better.) Recipe for 2 people:

> Take 2 packages of ordinary cheap ramen noodle soup, any flavor. Start with 3.5 cups of cold water, or the amount

that the package specifies. Add diced or finely-chopped pieces of any raw vegetables available such as onions, peas or chinese peapods, carrots, broccoli, green pepper, whatever you like, whatever you have. Put veggies in the cold or warm water and bring to a boil. When water is boiling, add the noodles and cook per the instructions (just 2 or 3 minutes). The vegetables will not be really well cooked, but just par-boiled, a bit crunchy and al-dente. That is what I intend.

Open a can of tuna fish and break it up into small pieces. If you are working hard, on a cold day, you may even want to put in the oil from the tuna. When the noodles are cooked, add the tuna and the contents of the soup's flavor envelopes, and add hot pepper flakes to taste. I would recommend about 1/4 teaspoon, or more if you like it hot. Stir, serve. Excellent on a cold day. If you are really hungry, you might use 3 packages of Ramen for 2 hungry people. When Buddi makes it, I eat even more than that! Drinking a lot of salty soup is a good way to keep hydrated, on the trail. And the pepper really warms you up. Whenever you eat this soup, think nice thoughts about Buddi! / rap

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THE BEST OF BOB PEASE

GPS Stuff

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I like to bring my GPS receiver, a Garmin GP38, along with me. It does not provide any information that is essential or useful. But I take a set of readings every day. Even if useless. The data are provided here, even if not very accurate or useful. See notes at end.

GPS LIST
November
Date, Location at end of day, (Miles travelled to get there):

08th, San Francisco,
37 N 24.601', 122 W 07.733' (2 November, Waypoint 17)

11th, Kathmandu, Potala Guest House. (7300 + miles)
27 N 43.887', 085 E 18.620' (22:55 on 11 November, Wpt. 18)

12th, Besisahar, (travelled 66 miles)
28 N 13.625', 084 E 22.757' (14:13 on 12 November, Wpt. 19)

13th, Ngadi, (travelled 6.2 miles)
28 N 18.902, 084 E 24.112 (00:41 on 14 November, Wpt. 20)

14th, Jagat, (travelled 6.9 miles)
28 N 24.914, 084 E 24.375 (11:31 on 14 November, Wpt. 21)

15th, Dharapaani (travelled 8.4)
28 N 31.592, 084 E 21.152, (00:59 on 16 November, Wpt. 22)

16th, (Below Koto) (travelled 4.6)
28 N 33.092, 084 E 16.926, (00:42 on 17 November, Wpt. 23)

17th, Tukure Pokhara (travelled 7.2)
28 N 36.191', 084 E 10.753', (00:39 on 18 November, Wpt. 24)

18th, Hongde, camp (travelled 5.5)
28 N 38.138', 084 E 05.837', (00:12 on 19 November, Wpt. 25)

19th, Hongde, low end of runway (0.2)
28 N 38.557', 084 E 05.361', (03:18 on 19 November, Wpt. 26)

19th, Hongde, high end of runway (0.2)
28 N 38.602', 084 E 05.084', (03:36 on November 19, Wpt. 27)

19th, Braga (2.91)
28 N 39.479', 084 E 02.414', (11:38 on 19 November, Wpt. 28)

20th, Yak Kharka (6.11)
28 N 43.432', 083 E 58.410', (00:26 on November 21, Wpt. 29)

21st, Phedi (3.9)
28 N 46.850', 083 E 58.169', (11:01 on November 21, Wpt. 30)

22nd, (Thorong La) (Estimated)
28 N 47.8', 083 E 56' (Estimated)

22nd, Muktinath (6.58)
28 N 49.166', 083 E 52.216', (06:45 on 23 November, Wpt. 31)

23rd, Below Jharkot (1.8)
28 N 49.069', 083 E 50.434', (00:52 on 24 Nov, Wpt. 32)

24th, Marpha (10.5)
28 N 45.014', 083 E 41.144', (02:01 on 25 November, Wpt. 33)

25th, Kalopaani (9.2)
28 N 38.343', 083 E 36.119', (03:38 on 26 November, Wpt. 34)

26th, Ghasa (3.6)
28 N 36.124', 083 E 38.587', (01:21 on 27 November, Wpt. 35)

27th, Tatopaani (7.1)
28 N 29.951', 083 E 39.154', (10:25 on 27 November, Wpt. 36)

28th, Tatopaani (0)
28 N 29.951', 083 E 39.154', (10:25 on 27 November, Wpt. 36)

29th, Chitre (5.8)
28 N 25.424', 083 E 41.693', (01:21 on 30 November, Wpt 37)

30th, Ghorepaani (1.5) (estimated)
28 N 24', 083 E 42' (estimated.)

<u>December</u>
Date, Location at end of day, (Miles travelled to get there):
1st, Upper Ulleri, (4) (estimated)
28 N 21.588', 083 E 44.066', (10:50 on 01 Dec, Wpt. 38)

2nd, Birethanti (4.2)

28 N 18.521', 083 E 46.240', (01:14 on 3 December Wpt. 39)

3rd, Pokhara (13)
28 N 13.011', 083 E 57.307', (14:14 on December 3, Wpt. 40)

December 6, Nagarkot (102)
27 N 42.943', 085 E 31.404', (08:53 on 06 Dec, Wpt. 41)

December 6, Kathmandu, (13)
27 N 42.833', 085 E 18.591', (23:28 on Dec 6, Wpt. 42)

Kathmandu, (0.1)
27 N 42.785, 085 E 18.600', (01:30 on 07 Dec, Wpt. 43)

Kathmandu (0.1)
27 N 42.766', 085 E 18.689', (01:31 on 07 December, Wpt 44)

San Francisco (7380)
37 N 43.746', 122 W 27.398', (23:46 on 14 December, Wpt. 45)

- I thought I got a reading at each camp, but I guess I missed a reading at Ghorepaani. Not a big deal.

- Most of the GPS readings are within 100 or 200 yards of where my map says we were. HOWEVER, Jagat is on my map 1 mile west AND 1 mile north of where the GPS says it is. And this is on my nice German map that seems (usually) quite accurate, with crisp resolution. I checked this with the map Peter gave us. Its location of Jagat agrees with this list very well! So beware of fancy maps that look very impressive! I'd like to recommend that you buy the good map - but it does not have any publisher listed. This map is at 1:150,000, and is labelled "ROUND ANNAPURNA", and on its second title page, the photo of Machhapuchhare has a smaller photo of Muktinath set into it. A good, colorful, inexpensive map - with better accuracy than the crisp high-tech one!

- The time of the GPS reading is NOT referred to local time, but to Greenwich time. So I was NOT taking readings at midnight. Nepal's time zone is offset 9:15 west of San Francisco, and 17:15 west of Greenwich. (Or 6:45 East of Greenwich.) It is NOT offset an even number of hours. So a reading of 00:12 was actually taken at 6:57 AM. Sometimes I was able to get my readings from inside my tent, so long as it was not too wet. If I were in Tibet, I would be SURE to not take GPS readings outside my tent... or where anybody could see me.

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THE BEST OF BOB PEASE

More information about Trekking

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"Trekking in Nepal", by Stephen Bezruchka, is the definitive book on this subject. ISBN = 0-89886-535-2, SEVENTH Edition (1997). If you are interested in trekking, you just about have to buy this book. It gives excellent info on all aspects of trekking in Nepal, and similar places. For more details about any particular route, there may be further information. His equipment check-lists are almost as good as mine. I even spotted PATIENCE and ADAPTABILITY in one of his lists! Lovely!! (But he neglected to mention earplugs...)

Peter Owens' Treks

Peter Owens' description of this trek really WAS quite realistic. You can look up Peter's Web site at: http://www.InstantWeb.com/p/peterowens.

Or write to Peter's Agent: Govind Shahi, Himalayan Treasures and Travel, 3596 Ponderosa Trail, Pinole CA 94564.

Or telephone him at 800-223-1813, or 510-222-5307. Request info on any of Peter's treks that you are interested in - or curious about.

After you get the basic list of treks, you can see which ones sound interesting and suitable, for YOU, in terms of time, and how interesting and strenuous they are. Then you can ask (by email, which is very convenient) or by phone or mail, for info on any trip you are interested in.

Wilderness Travel?

If you are able to get on the Web, it is easy to look up Wilderness Travel at http://www.wildernesstravel.com. They have nice descriptions of their treks, excellent pictures and images, and their treks look very good. They are also expensive. They cost about twice as much, and cover about half as many miles, as Peter Owens' comparable treks do. So when in Nepal, I would not likely trek with anybody else beside Peter. But I like to look at the WT pages, and their colorful catalogs. If you are not a Web-oriented guy, write to them at: Wilderness Travel, 801 Allston way, Berkeley Ca 94710 or call: 800-368-2794, or 510-548-0420... - and they will cheerfully send you a catalog. I will definitely recommend their treks for places other than Nepal. I took one trek with them, several years ago, the tour around Mont Blanc, and it was a very good trek. Great leaders.

Sobek/ Mountain Travel

My sister took a trek with these guys, to Annapurna Sanctuary, and she thought they did it very well. She had nothing but good words to say about them, and their nice people. I don't know much about them, but I am sure they run good treks. Good, and expensive. Call 510-527-8100 or 1-888-MTSOBEK (888-687-6235) - Their Web Site is at http://www.mtsobek.com.

Himalayan High Treks

I do not know anybody who has gone on a trek with this new trekking outfit run by Effie Fletcher in San Francisco, but her literature says a lot of the "right" (environmentally- and culturally-sensitive) things. You might check them out at 800-455-8735 or at their web site: http://www.HimalayanHighTreks.com

Kayaks and Rafting?

Peter said that Ultimate Descents is the best raft trip group in Nepal. I dropped in to their office in Pokhara. They were running raft trips in two places: One of them was the Marsyangdi Khola, below Ngadi, which we hiked along. Other Rafters claimed to be running raft trips on a LARGE number of rivers. Maybe the Ultimate guys are more discriminating? We saw some guys kayaking on the Marsyangdi Khola, below Ngadi. They seemed to be having fun. I'll let other people do that.

Also I read about this trek in several books:
- - - - - Kev Reynolds wrote an excellent little book about the Annapurna Circuit, and if you are going trekking there, I'll recommend it. It is out of print in the USA, but in Kathmandu, if you go to the top of the hill in Thamel, the bookstores there may have it in stock for a while.

- - - - - Carol bought another good little book in Kathmandu, on the Annapurna Circuit. Title = ??

- - - - - The next two books are not ESSENTIAL or useful, if you are going on this trek, but if you happen to run into these books, they could give you a chance to compare different treks, hikes, and walks. They give you a chance to CALIBRATE this hike versus other hikes you may have been on, or other hikes you might want to do. Books like these are often found in libraries; it's worth a try.

- - - - - "Where Mountains Live: Twelve Great Treks of the World", 1987, by Leo LeBon, Aperture Books, ISBN : 0-89381-242-0. This tells about his treks on the Annapurna Circuit, in 1977 and 1986. A little old, but this still gives you a good picture about these regions. Info on 11 other treks.

- - - - - "Classic Walks of the World", 1985. Editted by Walt Unsworth. Trek report by Dennis Kemp. Also good text and a good overview of the hike and the regions. Info on 16 other treks.

Book Stores

Any of these books may be purchasable from here in the States. (Some of them might be out of print.) They may also be bought in Kathmandu, such as in Pilgrim's Bookstore, up in Thamel, adjacent to the Northfield Inn. When you get to Kathmandu, you should DEFINITELY check out this place. A GREAT bookstore. Don't ask their address, as these streets have no names or numbers, but if you go to Thamel, and ask "?? Pilgrim Book Store??", you could not fail to get good directions to there.

Teahouse Trekking

I have a friend, Brian Dipert, who has some web pages with some very good stories about travelling by the Teahouse Route, which means just carrying your sleeping bag, and staying in little inns, and eating at the local inns and restaurants ("Teahouses"). I do not at all doubt this is a very nice and interesting way to travel. I sure do want to try it, someday. If you have more time than money, this is definitely worth considering. Trekking around Nepal by this way would be fascinating, and inexpensive, and fun. But you have to be aware of the possibility that you could get sick with some gastro-intestinal problems, and have troubles completing your trek on schedule.

I have a preference for trekking with a good group, such as Peter Owens', because I have LESS time than money. But even if you go trekking with a group, you should look at Mr. Dipert's stories, and be aware of this mode of trekking. Visit

URLs below for the 1998 trek: http://www.geocities.com/Yosemite/Rapids/5902/nepaljrn.htm

with a nice gallery of (photos) at:

http://www.geocities.com/Yosemite/Rapids/5902/nepalpix.htm

Also click (here) for the 1999 trek:

http://www.geocities.com/Yosemite/Rapids/5902/nepal_journal_1999.htm

Brian tells many stories about trekking, and getting an appreciation for the people and places of Nepal. If you read a lot, you will learn a lot... and enjoy and appreciate your trek more, too.

High-altitude Stuff

I just read in a book, that the Rongbuk Monastery at 16,500 feet is the highest inhabited dwelling in the word. Maybe so, but some guy was running a tea-house at 16,500 feet, a couple miles east of Thorong La. And somebody was selling tea at the pass, at 17,772 feet. and I'm sure these people did not go down the hill every night, after the last trekkers left. So there are some inhabitted places that are pretty well up there. You can walk right up there and buy a cup of tea, for a few rupees.

Come to think of it, I know that the boiling point of water has dropped a lot at 10,000 feet. If somebody poured you a cup of boiling tea at 17,773 feet - could you drink it right down? How hot is that? - That would be about 192 degrees F, 20 degrees cooler than usual. If the tea were poured into a pre-heated glass, it would still be too hot for most people to drink, but if poured into a cup, might be just right.

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THE BEST OF BOB PEASE

Peter Owens' Staff

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Porters

When we went over the pass, we had 17 porters. But when we started from BesiSahar, there were about 23. As our food was eaten, and our loads shrank, we sent back more porters.

Some of the porters carried tents, others carried the trekkers' duffels, others carried food, and others carried miscellaneous camping equipment. They would pack up and start out of camp about 7 AM, just as we were starting to eat breakfast. (They would go down the road a mile or two, then cook their breakfast.) We would pass them, many times a day, and they would pass us back. These guys were all nice people. Peter introduced us to them, and we tried to remember their names. Some spoke a minimum of English, some spoke more. We got to know some of them pretty well. These were NICE guys. If WE spoke Nepali better, we would have gotten to know them and like them even better.

Here's another way to look at it: I work hard to earn the money to pay these guys. THEY work hard for me. I ENJOY working hard, to pay them. THEY seem to enjoy working hard for us. That's the kind of deal that's agreeable to me - everybody's happy, working hard. Would I pay them to hike up a hill with my duffel, if I would not work hard to go up the same hill?

Here's another way to look at it. These guys weigh 120 lb - and they carry 80 pounds up the hill. I weigh 200 lb - and carry 15 lb, or 215 lb. total. I carry more than they do! But I have a lot more muscles. It's just they are in much better TRAINING than I have ever been....

Note - these porters really do a great job of carrying. Some carried 75 or 85 lb. - others carried over 100 lb. I tried picking up some of these guys. The smallest of them, at 100 lb., were easy to lift, but the bigger guys at 140 lb had GREAT heavy strong LEGS.

I tried carrying a porter's load. I picked up a load, with two duffels and more, about 80 lb. This uses nothing more than a tump- line - a strap over the porter's forehead. I wobbled a little, but I got the pack on, and I stood up, and I carried it a few yards up the trail, and then 100 yards DOWN the trail, which was a nice idea, as we were going downhill that day. The weight did not bother me, as I can easily carry that much. The wobbly-ness was a concern. I have seen some porters with a waist-strap, to help steady the load, and I think that is a good idea. The lack of shoulder straps does not really bother me.

If I had to carry that 80 pound porter's load up 8 miles and a couple thousand feet in a day, I am sure I could do it. But it's a good thing I do not have to carry such a load DOWN that much, because I don't think my knees are good for that. Yes, there are a number of porters as old as I am. But they have been training better than I have...

We saw some of the professional porters carrying heavy loads on the trail. Some were carrying 160 lb. of pipes... others, 140 lb. of a wooden beam, or 120 lb. of Coca-cola bottles. That's kind of a tough job. I saw a group of 5 guys, carrying what looked like 500 lb of continuous steel cable, packaged as 5 100-pound coils, all linked together, destined for some high bridge or power cable. They moved along so fast I barely got my camera out! A great team.

When we hire a porter off the street, Peter and Jai (the Sirdar) make the arrangements to hire them for a certain duration. On the way up to our bus, from our hotel in Kathmandu, we hired a couple more porters, right off the street - to come on the bus with us for 80 miles, and then carry our stuff, for a week. Kind of a free-lance porter! Porters like these get paid a little over $3 a day, plus some tips.

When we got to our trail-head, we hired a couple MORE. These guys just went up the trail with us for a week, and then when the loads were lightened, they got paid off, and then they went back down. BUT most of Peter's porters are long-term employees. They carry for him on 'most every trek, for YEARS. They get extra benefits - some profit sharing - if they serve on 5 or 10 treks.

Singing and Dancing...

When the treks go to Mustang (pronounced Moostang), some trekking outfits bring horses or mules to carry their stuff. Peter does not. He says, "Horses don't sing and dance". Peter's Porters, and the Kitchen Boys and Sherpas, too, like to Sing and Dance. They sing all kinds of folk songs, and play on the drums, and dance. And they drag us trekkers to join in the dances. Peter has photocopied the words of some of the songs. Surely I should have learned them by now!

Kitchen Boys

Our Kitchen Boys we saw many times per day. Their job was to get up at 4 AM and light the big kerosine stoves, and start preparing breakfast. After it was ready, they would come around at 6:00 SHARP, and serve us tea and cookies. Then at 6:40 we would be all out of our tents, and they would serve us juice, and then breakfast, and then try to sell us on seconds. And then toast and jam, and tea and coffee. As soon as breakfast was done, they would wash all the dishes, and pack up the food and dishes, and hike briskly up the trail ahead of us. They carried LARGE packs, but maybe only 55 lb. By 10:40 AM they would have selected a good place for lunch, and start cooking lunch. When we came along at 11 AM and heard the roar of the kerosine stove, we knew we could sit down and take a break, to wait for lunch.

Thorong La Scene

Click on Image to enlarge

After lunch, the wash-dishes-and-pack-up routine was repeated, and they chased after us again, hiked ahead, and started planning supper. Fortunately, we often got to camp by 3 PM, so they did not have to panic and rush to make supper, too quickly.

Supper was usually served about 6 PM sharp, with soup, main course, and dessert, with tea. After supper, more dishwashing. Does the life of a Kitchen boy sound easy? No.

But these guys were so CHEERFUL about how they served the food, that we ALWAYS had good things to think about them. They all spoke pretty good English, a little. Peter and they were trying to teach us some Nepali. "Ali ali" means "just a little". "Adi" means "half" - such as a half cup of soup. These guys were so genuine and sincere about wanting us to eat, just as we were quite hungry. "More soup, Bob?" "More rice?" "More chicken?" It was so much fun working with them, because they really seemed to enjoy serving all this food, and selling their products. We always had a lot of fun at meals. (See also at Goat McNuggets).

SHERPAS

The sherpas, Ram, Mailla, Kalu, & Tertiman, were the people we interfaced with the most, because they hiked with us every day, and talked with us. We taught them a few new English words or phrases, and they taught us a few Nepali phrases. We asked them about the things we saw along the way - they explained what we were looking at.

One sherpa's job was to lead, at the head of the group, and mark the trail with an arrow if we came to a fork in the trail. One hiked at the end of the group, sort of as a SWEEP. He carried the first-aid kit, so if there was ever a problem, he would soon show up. At least one hiked around the middle of the group, randomly. The sherpas also took down and packed the tents in the morning - a nice thing to appreciate in the morning, when the tents were cold. They put up the tents in the afternoon when we got to camp. Even if it was raining, or snowing.

They kept track of all the things along the trail. They helped in case of any trouble, or potential trouble. And boy, they were nice people. Interesting guys. If you ever have a chance to hike with Peter, I'm sure you'll find it fun to interact with the sherpas. They were fun to talk to in camp, and they were always available for help or advice.

Nancy was talking with Ram Rai, one of the Sherpas. "What is this?" - "What is that?" - Then she asked, "What is that tree?" Ram replied, "that is a cow eating tree." Of course, this was a tree that was growing, for the purpose, for a cow to be eating - but the first couple times I thought about this, I kept seeing the image of the tree eating a cow... I still giggle about this. Language can be a great game. There is much room for us all to learn to communicate with the Nepalis. Peter has lived in Nepal for 20 years, and I bet he'll admit he has a few things to learn, about their language.

Employee Relations....
Of course, in any trek, every trek employee's job is to be nice to the guys who are paying the bill. Be agreeable. Peter's guys did a good job, and were almost always agreeable. Hey, is it easy to do that if your feet are cold because you have to bring in a tray of food when it is 9 degrees? I don't think it is easy. I don't think it would be easy for me. But these guys are dedicated - and I think they are good sports. When I am hiking with a bunch of tough little guys, who are nice, it is easier for ME to try to be nice, and be a good sport at all times. Even if I am momentarily disappointed, or the trail is not easy, or the weather is crappy, I have to be agreeable and cheerful, too. And just about everybody on our trek worked hard at being cheerful, agreeable, and a good sport. It's contagious.

Sirdar
The guy who is in charge of the whole expedition, our Sirdar, was Jai Rai. Jai has visited the USA, and speaks good English. He always did his job so well, that it SEEMED that we did not quite need him - everything went well without needing him. But that's how it seems on a well-organized trip, where the leadership has made almost everything run smoothly. It's just an illusion that we did not need such a great leader.

Jai's voice was distinctive; I didn't have to turn around when I heard his voice, to know who it was. Often he talked faster than anybody else - in English or in Nepali. If one wants to contrast the aspects of a guy who never got more than a 3rd-grade formal education, with a person who has learned how to get things done, never raising his voice, in 2 languages, Jai is a great example. If any sherpa wants to be an expert at everything, Jai is a great example.

Head Cook:
Don't forget Buddi. (Pronounced BOOdi) Never forget him! - see above at FOOD.

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THE BEST OF BOB PEASE

Diary - Nepal
November Stroll, 1997

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November 8 - Flew down to Los Angeles and met 6 more trekkers at LAX. Departed on Royal Thai flight, crossed International Date Line. November 9 - Refueled in Seoul; arrived in Bangkok and stayed overnight at Louis Tavern.

November 10 - Breakfast on 3rd floor of airport; flight to Kathmandu. Arrived 1 PM, and Peter Owens greeted us, and brought us to the Potala Guest House. Promptly we went to Bodhnath, and Pashupatinath, where we consorted with snake charmers. We all had supper with Peter at Nepali Kitchen near the hotel. Good video of Peter and John C. drinking flaming rakshi (brandy).

November 11 - Up early to walk to Monkey Temple. Return to breakfast at Northfield Inn. Tour down to Durbar Square. Lunch at Mike's. Many people went to Bhaktapur, but I went over to Lotus Energy to arrange my December lecture. Dinner at Chinese restaurant.

November 12 - Early start - tea in Peter's room; walk 1/2 mile to the bus, and a long ride to lunch at Mugling. A few good views of the distant Annapurnas from the bus as we came over the pass. The ride from Dumre to BesiSahar was rough and slow - we walked the last 1/2 mile into town, as the bus driver chickened out. Beer with friends. Walked up through town before Supper. Excellent mushrooms at supper. Porters were singing and dancing after supper, by moonlight.

November 13 - Nice view of distant snowy peaks at daybreak. Hiked for miles along the Marsyangde Khola - nice farms and terraces. Lunch at Bhulbhule. Camped on a field between the Ngadi Khola and the Marsyangde Khola. Warm, pleasant weather for sitting around. Sang old Outing Club folk songs such as Logger Lover, and Samuel Hall, from the 1950s.

November 14 - Hiked up to Bahundanda - then down, along great views with terraces and fields. Crossed the river and ascended over tough, steep ascents - partly on trails carved into old slides - then descended to Jagat. Nice camping behind a tea house.

November 15 - Great waterfalls. Steep countryside, cliffs. A lot of ascent today. Nancy told me the info from her barometer-watch, that we ascended 4300 feet and descended 2160 feet for a net gain of 2140. No wonder we were tired! Arrived at Dharapaani.

November 16 - Peter said it was said to be 20 degrees F at Pisang, 12 miles up. Good steep grades - narrow gorge, with great views of the river - too fierce for rafting. Arrived at Tal for lunch. Great waterfalls. Up to camp on the grounds of a small teahouse below Koto.

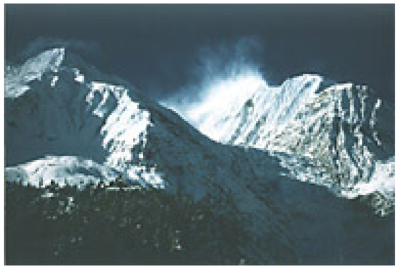
November 17. Cool this morning. Great hiking. Up to Bagarchap where we visited the (Buddhist) Gompa. Slow hike up to early lunch spot. Waiting in an orchard for the sun to come on us! Nice waterfalls and gorges. Went up to camp in a broad meadow at Tukure Pokhara below Pisang. Set up the Dining Tent for the first time. It really was warm vs. outside. Had popcorn and rum punch at "tea".

November 18 - A few nice views at daybreak - mountain peaks in the clear. It was about 25 degrees F. Nice cool hiking up to Upper Pisang - then we descended to Pisang, and saw how Rakshi is made. Ascended to the Deorali above Hongde. A Twin Otter came in from the east and landed there, and then took off and came back overhead. Bought a couple Mars bars. Then we descended to an early lunch at a small tea-house in the Middle of Nowhere. Continued through cool cloudy weather to Hongde. Camped in a lumber-yard beside a teahouse. There were 296 prayer wheels in rows, along the center of the village - plus one BIG one, at the high end of town. Took hike. Ate supper in the main downstairs room.

November 19 - Awoke to the sounds of the sherpas beating the snow off the tents. By morning there was about 6 inches of powder. We walked around and goofed off until lunch, which we ate at the table OUTSIDE on the second floor of the teahouse. Chili con carne with yak cheese and onions and chapatis. Great. Then a short hike, crossing the Marsyangde Khola for the last time, to Braga. The sherpas cleared off the snow for our tents to be pitched. We went up to the old Gompa, which is alleged to be 900 (or 500) years old, 500 (or 300) feet above the trail. Tricky steep alleys to get up to it! Handsome inside. Four of us took a walk up to Manang, to check out the place, and mail some postcards. Cool, grey, and snowy. We bought some cinnamon rolls. Supper in a room inside a corner room of a big building (barn), followed by singing and dancing. Chang (locally-brewed beer) for the porters, too.

November 20 - Yesterday's snow and grey weather was followed by beautiful CLEAR skies, and the sun hit the peaks by 6:15. Great views of the whole range to the south of us, especially Annapurna III and Gangapurna. We hiked up to Manang, and went on to Tengi, where we had great views across, and back toward Manang. Continued on until the Yak Train caught up with us. Great pictures. Lunch with Buddi's famous Ramen Soup and Chicken Noodle soup - excellent on a cold day. Above there, we saw Yaks out on the steep slopes above and below us, as we came to Yak Kharka (= Yak Pastures). Stayed in an almost-warm tea-house. Then the yaks all wandered back through town, as it got dark. (The sherpas cleared off the snow, about 5 inches, so our tents were just on frozen ground.) Supper in one of the tea-houses.

Daybreak!



Annapurna III and Gangapurna

November 21 - Morning was very clear - and cold, about + 8 degrees F. We soon came to a frozen stream, tricky to cross. Rest stop at Letdar. Beautiful views back to the Annapurnas. As we approached the bridge over the main stream, it was a steep descent, and the trail was iced over. The sherpas started cutting steps, and we eased along, down to the bridge. Just then the Yak Train (which went up yesterday) came down. I had to get out of the way - had no battery to take video. They were coming down empty. In 80 more yards, we stopped for lunch. Great views. After lunch we continued to ascend, a lot today. Ascended to get over some slides. Then we ascended more to get up to the highest level of Thorong Phedi (Phedi = the foot of the pass). We saw some wild sheep ("blue sheep") across the valley. I took another hike up before supper, just to check the feasibility of hiking above 15,000 feet. Not bad, and the trail was good, too. On the broad scree slope above Phedi, more than 1/2 of the trail was bare. The other half, snowy, was not bad, either. (Note, about 100 people had gone up from Phedi that day. It was never clear, how many crossed from west to east.) Cool supper in the dining tent.

November 22 - An early wake-up at 5 AM led us to breakfast at 5:25, and we started up the trail at 5:45. It was + 8 degrees again.

Annapurna III and Manang

Lunch Stop

Click on an image to enlarge

The actual trail was not bad, not unpleasant nor scary nor steep nor hard work. After we got to the top of the main scree slope, the trail angled right, then left and right, etc. It never got very steep. It occasionally got fairly flat. There was nothing really remarkable about the trail - except it went up from 15,000 ft. to 17,000 ft and higher. It was really a nice trail - which was a good thing, because we did not want to waste any energy. At 16,500 we came to a small stone hut where we could get a cup of tea. I was still well-hydrated from breakfast - not interested. Continued up. Nice hiking. But not much of views, as the ceiling was barely above us. Finally got to the top of the pass about 10:45. Not much view to the west, as the clouds were infringing on our elevation. Nancy and Carol got there a few minutes later - about 11:00. We took a few pictures - Nancy started down, and I went up to the knob 80 feet above the pass, on the south, to take some pictures. Then we fled down the slope to the west.

The first couple miles was pleasant hiking, often bare trail, not bad at all. Then it started getting steep and slippery and bitchy - as we had been warned. About 100 people had gone down this trail yesterday, and 80 more today, and it was packed and slippery. We dug in our heels, and walked along the side of the trail where the snow was not badly packed. It was slow going. Nancy and Peter and I often walked off on small goat trails where the traction was better, perhaps 20 feet down the slope from the trail. After much delay and slow hiking we got to Phedi at the west side of the pass.

Did we want to camp here? No. It was 4:45 so we stomped down another couple miles, to get to Muktinath. This day was allegedly 7.5 miles of trail, according to one book, but it was 6.58 miles as the crow flies, per my GPS machine. I find 7.5 miles pretty hard to believe. Maybe 9 or 10. We camped on the grounds of the temple's barns, NOT at the village of Ranipauwa.

November 23 - Woke up to 5 more inches of snow. We stayed in camp until lunch. Went up to the temple to see the 108 spouts of water coming from the 108 bulls' mouths - handsome, in the snow. Hiked down to Ranipauwa (a rather small town, smaller than I expected) and then down to Jharkot. We took an hour to wander over the old town. I mean, OLD. The main ruins were made with stone and mud. Maybe they were only built 200 years ago, but they looked older than any ruined Scottish castle I have seen. Descended to camp 1/2 mile below the town.

As soon as I came into camp, up on an elevated terrace, I saw a nice white goat. I figured out that this goat was not there as a coincidence, nor as a joke. He was there for a purpose. For supper. For details, see above at "Goat Mc Nuggets". The goat stew was very tasty.

November 24 - Easy descent down to the west - but we did not go to Kagbeni. Rather, we looked DOWN on Kagbeni, and on the Kali Gandaki (on that River and its broad dry bed) which was a great view. Went down to Eklebhatti (= "Single Teahouse"). Then hiked down along the Kali Gandaki River, across its bed, to lunch in Jomosom. We crossed the river, ate lunch near the airport. Excellent "Goat McNuggets", with spring rolls. Then descended several miles through pleasant farm areas (now we were down below 10,000 feet) to Marpha. Visited the Gompa there with great music from horns and chanting. Came to our camp at Om's Home, on the south end of town. The hotel did not have rooms for all of us, but Nancy and I were assigned room #6. (Many other rooms were filled up with casks of brandy, aging.) They had apple, peach, and apricot brandy for about $1.70 per bottle. Not great, but pretty good; we all sampled around.

November 25 - Started down further. Grey day with no views of peaks, which all the books say are great to see. Lunch at Tukuche. After lunch we wandered out across the broad river bed. The bed was a full 1/3 mile wide, with several fast-flowing streams coming down through, which we crossed on small bridges or beams. After a while sprinkles and rain began. We went down to Kalopaani (= black water) and camped below a tea-house. Sat around in the teahouse to avoid the sprinkles. Chocolate cake for desert.

November 26 - The sprinkles and rain continued all night, and into the morning, so we stayed in camp until lunch. After lunch, the rain stopped - so we walked a few miles down the trail to Ghasa. Great marigolds all around the camping area - beautiful. Meanwhile we saw hawks soaring over 1500 feet overhead - far above the 1000-foot cliffs that bordered this valley.

November 27 - Clear weather. Descended over rough trails to the big waterfall at Chhuharo Rhupse, then lunch at Dana. Camp at Tatopaani. Thanksgiving Day. We had chicken and veggies and Potato Chops for supper, with dressing. John C.'s birthday - another cake!

November 28 - Rest day. I hiked 4 miles down toward Beni, nice views of peaks and farming and the raging river.

November 29 - Ascend 6000 stone steps to Chitre. Lunch at Sikha. Some good views of 99% of Dhaulagiri. (I don't think we ever did quite see the summit.)

November 30 - Arrived early in Ghorepani. After lunch several of us hiked up Poon Hill, 1300 steps above our camp. Nice views.

December 1 - We were awakened by thunder and lightning (fortunately, over 2 miles away). Snow and rain. NOT a good day to walk up Poon Hill before breakfast. Descended through the rainforest. Passed the 32 Korean gals, several times. Camp just above Ulleri. As we were waiting for tea, sleet and hail came down, then rain, then clearing. Good views.

December 2 - Descended the 3300 stone steps to the river, then along moderate trails (1000 more steps) to a small teahouse for lunch. Then a short hike to Birethanti, with great views of Machhapuchhare. Break-up party, with tips for staff. More singing and dancing.

December 3 - A bare mile to the bus. Took 2 hours to ride to Pokhara. Shower and lunch. Goof-off afternoon. Supper adjacent to hotel.

December 4 - 6:40 AM start on the long ride to Kathmandu. Ali and I had Dahlbhat; the rest had fruit and cookies. I checked with the Lotus guys in the PM.

December 5 - Nancy and about 8 other people departed at 11 AM for Bangkok. I set up for my 4 PM lecture at the Mountain Hotel. Lecture went well with 80 attendees, coffee and tea and cake and cookies. Supper with Peter, pizza at Fire and Ice.

December 6 - Rented a Yamaha GXR135. Rode north to Ring Road, then to Nagarkot, great views. Checked out the ropeway.

December 7 - Discussed technical problems with engineers at Lotus. Supper at Thamel house with engineers from Lotus.

December 8 - Rode down to Beresshi, then up to Pulchowki. Rocky road! Good views from 9000 ft. hill. Returned to hotel by 1. Picked up new glasses, signed off paperwork at Lotus. Returned motorcycle in perfect condition. Supper at Austrian restaurant.

December 9 - Ride to airport with Debbie. Delay due to bad weather for inbound flight to land. Off to Bangkok. Finished reading 7 Years in Tibet. Crossed International Date line and flew home.

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THE BEST OF BOB PEASE

What's All this Trekking Stuff, Anyhow? - Maxi-Report Conclusion

[Previous-Diary] [Directory]

Teahouses
Guys like Steve Kocsis tell all about the merits and pleasures of tea-house trekking. I am sure that can be very nice, too. But I like the advantages of going with an organized trek like Peter Owens'. I will probably continue to go with Peter until I retire and have a lot more time than money.

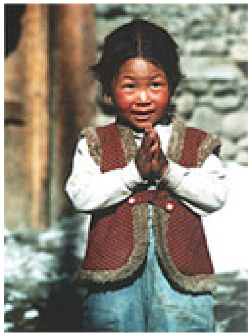
HOWEVER, we did come into a lot of contact with teahouses. We ate many of our meals INSIDE teahouses, and also on the teahouses' tables, under little thatched-roof shelters, or under their porches. If you ignore the 4 cases where I cannot remember where we ate, we ate about 28 times inside a teahouse; 9 meals under the roof of a shelter or porch of a teahouse; 11 meals in our dining tent; and 11 times out in the open. Of course, all the meals were cooked by Peter's staff, and all on dishes carefully washed by the kitchen boys.

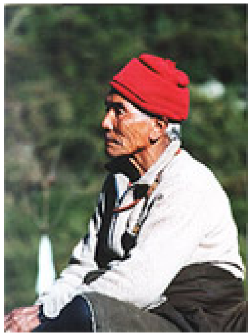
But some of the teahouses did seem quite nice. Some seemed reasonably wind-proof, but sleeping in their beds sure would be colder than in our tents! The menus in the tea-houses were largely all the same, with a few exceptions. Largely vegetarian. Probably quite tasty. Of course, if you didn't like dahlbhat (rice with lentils) you would not find the choices very wide. But edible, I'm sure. And there sure were plenty of tea-houses. Someday I might like to go back to the Annapurna Circuit and try that. No hurry.

Nice People
When we got into BesiSahar, the first thing we did, after stowing our duffels in our tents was - of course - take a walk up through town. *

I was immediately struck by the nice, friendly people. I began to think: What if some ugly American came through town a month or two ago? What if he was grouchy, or drunk, or stupid, or pissed off, and cursed a couple Nepalis, or kicked a dog, or screamed at a shopkeeper? Then the people would not seem so friendly. What if some nasty German or Israeli or even a Canadian, or ANY westerner, got mad at the locals, and they remembered that nasty guy? Then I might notice that the locals were not so friendly, but suspicious. I convinced myself that in THIS TOWN, nobody had been unpleasant to the townspeople, or the kids, or the dogs, for many, many months. I smiled at everyone I met, and said Namaste. They smiled back and said Namaste.

All the way around the Circuit, in 40 or 50 towns, I saw the same situation. Now, this is an area where 100 or 200 (peak) trekkers a day often pass through, or stay in a town. Yet for the last 100 days, with over 5,000 trekkers, there seemed to not have been any bad eggs, at any place or time. Honestly, I was impressed. Almost astonished. I mean, surely a trekker could start out with some honest disagreement over a bill, or think he was mistreated, and start a grouchy argument. Yet it seemed as if this occurrence of unhappy disagreement was down under the floor of perception. Everybody was very nice and agreeable to us - and I think we all tried to be nice, too!


Young child


Old Man

Click on Image to enlarge

* Peter did keep at least one porter or sherpa assigned to camp security, to make sure nobody sliced open tents, etc. But there was not much obvious need for security. Of course, the need for security seems much less, when you have taken a number of reasonable precautions....

** A book on trekking by Kev Reynolds put out in 1993 said, when hiking near Birethanti or Ulleri or Ghorepani or Pokhara, it is good to not walk alone, in case thugs or muggers might attack.

Peter Owens was usually very good about security, and he did not warn us about this. This was surely NOT because he forgot to, but because there are no longer thieves or muggers operating in that area. So we were not worried. But I must say, the rainforests were pretty deep and dark, and WET, too, coming down from Ghorepani to Ulleri. / rap

Bureaucrats in Nepal

When we were in Peter's room, before the trek, Peter and Buddi said this was a good time to exchange large bills for smaller ones. So I exchanged several 1000-Rupee notes (about $16) for 50 and 100- Rupee notes. I figured I was in pretty good shape for the first half of the trek. Also I wanted to buy 80 15-Rupee stamps, for post- cards, but was only able to buy about 20. That's OK, I could buy the rest at post-offices along the way. I would not be mailing many postcards until I had gotten over the pass, anyhow.

By the time we got to Muktinath, I was all out of small bills, and I needed stamps. When we got down to Jomosom, I could go to one of the banks and change some of my 1000 rupees notes into 100s and 50's. WRONG! I tried the two biggest banks in town, and they refused to change the larger bills into smaller ones. They would not make change. So, don't assume that banks will do what you expect them to do.

By the time I got down to Tatopaani, I had a big handful of postcards to mail. I found the post-office. They only had eight 16- rupee stamps. In other towns I was able to buy 4-rupee and 12-rupee stamps, to make up 16, but the post office there had nothing bigger than 3's, and I could not fit 6 of them on a post-card. Ghorepaani had no post-office. So I finally was able to buy as many as I needed in Birethanti. Do not assume that you can be sure to buy stamps at a post-office.

Some books advise you to bring your post-cards to a post-office and have them "franked" or cancelled. This is supposedly to prevent dishonest people from steaming the stamps off the cards. I suppose that would be a wise move, but I have mailed hundreds of postcards, with over 99% delivery rate, so I've never found that to be a problem. Finding a post-office open may be a problem. They seem to be open from 10 AM to 3, but maybe 4 PM in some places.

Mail boxes are not usually easy to spot. It takes a sharp eye. They are not painted any particular color. Usually up high, at least 5 feet off the ground. Post offices may be marked with one sign, so if you are going up the trail one way, it's not hard to see, but if you are walking the other way, there is no sign to see! Local advice is often needed, to find the post office.

Spelling

If I do not always spell things "right", don't fret too much. In Nepal, there are many acceptable alternate ways to spell the names of towns. What is the correct spelling of the town where Manang's airport is located? Is it Hongde, or Homde, or Ongre, or Humde? Answer: yes. I spell Tatopaani with a double a because this stuck in my head. You can spell the town's name as Besi Sahar or Besishahar, or BeshiShahar. I try to use BesiSahar, as a good compromise spelling, but I refuse to worry about whether I got the spelling perfect. Nobody else worries much about that, in Nepal.

Motorcycle Rental

- I decided to rent a motorcycle for a few days, after the trek. The fact that I had never ridden a motorcycle before did not bother me, as I had done a lot of bicycling. I had no problems. About $8 per day, for a pretty good little Yamaha GXR135. I rode up to Nagarkot where the views were fantastic, from Everest (a little blip 90 miles east) to the Annapurnas, 120 miles west. Two days later I rode up Pulchowki, a 9,000 foot hill south of Kathmandu. The road was a little rough. But the views were nice. The complete write-up of this adventure was published in Electronic Design, in early February (February9 E.D., page 141).

Lecture in Kathmandu

In the last year, I have given a lecture on analog circuits (and also, how to tell when your computer is lying, and what to do about it) in 20 places in the US, and several places in South America. I decided I should also give a lecture in Kathmandu, even though there are not many customers for semiconductors there. I sent an email to Adam Friedensohn and Jeevan Goff and Shree Raj Joshi at Lotus Energy in Kathmandu. Lotus makes good rechargeable battery systems, and lighting systems. On our trek, Peter brings along a solar panel and a little fluorescent lantern, made by Lotus. It works pretty well, after a sunny day, and requires no kerosine. Good "green" engineering. Lotus also makes systems for homes, so on a good sunny day you can get several hours of fluorescent light in the evening, from a set of solar arrays and some long-life lead-acid batteries. Of course, you need a good controller, to make sure the batteries are not overcharged or badly discharged.

Adam hired the hall, and sent out the invitations and publicity. I paid for the rentals, not expensive at all. About $219 total. Adam told me there were 75 people signed up. So the hotel set up 75 chairs. I was impressed when we had to bring in several more chairs, a good large crowd. Many of them laughed in all the right places. I gave my basic lecture, but I dropped out most of the sections referring to cars, as very few people in Nepal drive a car. I added a couple short sections about why people like to use op-amps, and why/how to use regulators. And Simple Switchers.

I put in a few foils as a plug for Lotus. Also I gave Adam a few minutes to talk about his philosophy, and he put in a pitch that he was trying to hire a couple design engineers. (Not easy to find in Kathmandu.)

I did speak slowly in most places. (I told Adam to throw his shoe at me if I went too fast.) I did not use sub-titles as duplicate slides, as I was told that would not be necessary.

The lecture seemed very well received. We had refreshments, with coffee and tea and cookies and cake. There was plenty of time for the attendees to come and see me and talk, after the lecture. A very enjoyable afternoon, from 4 to 8 PM on December 5, the day after the trek ended.

There were about 25 students in the audience. (Hey, it's good to catch 'em at an impressionable age.) There were some professors from the university. There were some sharp guys in the audience. There were some technicians and a few engineers. I'm glad I did it.

Thailand

I enjoyed spending several days in Thailand, back in 1989, and I could recommend that to travellers. However, if you do NOT stop over more than 24 hours in Thailand or elswhere, Thai Airlines will let you take 2 bags EACH weighing 70 lb, NO KIDDING. NOT a typo. If you stay over more than 24 hours, you are supposed to be limited to the usual 44 lb.

total. (Though I am not sure exactly what they are enforcing these days.)

If you make a reservation at Louis' Tavern, which will rent you day-rooms in the transfer area of Bangkok's airport, you do not have to do the long wait of going out through Thai immigration and customs, and the expense and struggles of coming back in in the morning. You just stay in the transfer area. The rental for 6 hours is $45 for 2 people; for 12 hours, $90. That's what I do when going to Nepal. Nice and simple. Phone number for reserving a room at Louis' Tavern is: 011-66-2-5353710.

There is a mediocre snack bar adjacent to Louis Tavern, but there is also a very nice restaurant, up on the third floor of the airport. Their prices are reasonable, and their food tasty. I can recommend that.

If you DO go through customs, you can stay at the Amari Hotel, which is 3 minutes' walk beyond the terminal. You do not have to even walk outside, as there is an air-conditioned walkway over the roads. The normal room rate is, of course, over $100, but if you make reservations early through your travel agent (call Govind Shahi at Himalayan Treasures & Travel) you can get a chit for about $60. Then you have a nice room, and have your choice of several good restaurants. That's what I like to do on the way home. But if you are travelling light, staying over in Thailand can be another wonderful adventure. Just one problem: In Thailand, the restaurants do NOT serve "Thai Iced Tea" as they do here in the States. /rap

Where NEXT?
Where are we going next? Carol said she wanted to go to Rolwaling. Nancy is interested to go somewhere east of Everest. Or to Dolpo. Or to Mt. Kailash. Or maybe to Kanchenjunga this October. I am probably interested to go to Everest Base camp, and Kali Pattar, someday. I think we will start planning our next trek gradually, and try to go back in 1999. Everybody seems to be interested in trekking more. Not everybody wants to go as high as 17,800 feet again, although it is nice to know that we have done it, and we could do it again if we want to. Note, there are many treks that do NOT go nearly that high, not so strenuous. But if you go on the Dolpo trek, there are 3 passes that go up to about 17,000 feet.

Nancy and I went to Langtang in 1989, and that's a good moderately easy trek, and I'd cheerfully recommend that. We went to Dhorpatan in 1996, and that was nice too; we only saw a dozen gringos in 20 days. (Around Annapurna, we often saw 40 or 70 gringos (trekkers) every day, and if we had peeked into tea-houses, we would have seen MANY more.)

- Is there any place in Nepal I do NOT want to go? Probably not. But some have a better priority than others.

Recommendation?
Would I recommend this trek for other people? Yes, I sure would recommend it for any good hikers. This is some of the best trekking and hiking in the world. Some of the best views. I almost said, for any STRONG hikers. Let me say instead, "for hikers in pretty good condition", who can take enough 10-mile practice hikes to get in shape. At least one 10-mile hike per week for 10 weeks, wearing the boots you plan to wear on the trek. I must say, some of the trekkers had not taken a lot of hikes, and they were in fairly good shape, and they got along fine.

- If you are going in November, be sure to take enough warm clothes. If you have never done any cold-weather camping, but you have done SOME camping, you can figure it out as you go.

Would I recommend going with Peter Owens? Absolutely. His plans and food and operations are excellent. His people are excellent, competent, and nice people. His prices are very reasonable, lower than most. Unfortunately, he is not running this trek in November of 1998. Maybe he would run it in April of 1999?

P.S. I realized after I had read this a dozen times, I had not written much about Peter Owens. Well, every part of this Trek was planned by Peter, and it ran so well that we did not even think about his planning. On a good trek, that's how it is! So now you know a lot about how Peter runs things. Peter is a wise and fun guy to travel with, and a good explainer in several languages, and I sure enjoy being with him. He lives just a few miles down the peninsula in San Mateo, and we enjoy visiting with him when he comes back here for a month, between treks.

P.S. - and we sure had a lot of fun, too!

Your comments are invited! - and, good hiking to you!! / rap

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THE BEST OF BOB PEASE

Trekking In Nepal Gallery - The Annapurna Circuit, November 1997

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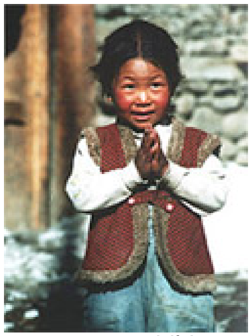
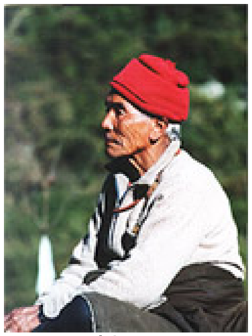
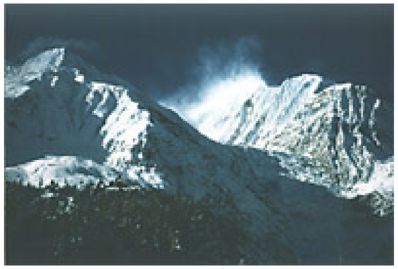
Lunch Stop


Young Child


Old Man


Annapurna III and Manang


Day Break


Annapurna III and Gangapurna


Thorong La Scene

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THE BEST OF BOB PEASE

Everest MAXI-Report -- PART 1

Report on our Trek in Khumbu-Everest area, Oct. 4 - Nov. 18, 2000.
(The Everest Extravaganza)

THIS half of the MAXI-report isn't too long, perhaps 24 pages if you print it out. This report is now added into my web-site. My OLD maxi-report for our great 1997 trek around the Annapurna Circuit was about 40 pages of text, and I still recommend it for the basic facts and details about trekking.
http://www.national.com/rap/nepal/info.html

CHANGES:
There are VERY FEW out-of-date things in the OLD (1997) Maxi-report. The Nepalese rupee is now (in late 2000) worth 1.4 cents, or $1.40 to buy 100 rupees. A stamp for a post-card to the USA is now 18 rupees, or about 25 cents, still a bargain, and nice cards are mostly 10 rupees (14 cents). *Now 1 rupee = about $0.013 in 2001.

NOTE: Many countries soak you $0.80 or as much as $1.10, for the postage for an international post-card. Apparently they think they can soak the tourists who have no way to complain. Nepal seems to think that keeping the postal rates at a low level will encourage us to write MANY cards - and I do. I sent out dozens. What an inexpensive, CHEAP, EFFECTIVE way for them to encourage tourism and good P.R.!

NOTE: Many times, when you go to a post-office in Nepal, it is easy for them to be all out of stamps. But stores that sell post-cards do NOT run out; you can usually buy stamps there. I took my BIG address list, and editted out a lot of names that I would definitely NOT be sending a post-card to, and then I printed that out with a small font. Very effective.
(See: "What's All This Address Stuff, Anyhow?" 6 March, 2000) at: http://www.elecdesign.com/Articles/Index.cfm?ArticleID=7405&extension=html

The only post offices in the Khumbu area are at Lukla and Namche. Closed on Saturdays.

GREAT PHOTOS:
Our guys took some. See Jim's at: www.geocities.com/jimmikkelson Sigrid took some wonderful slides. We'll see more soon.

I am working on my videotapes. I have about 25 hours, and I have to leave out all but the best, to get down to a final editted version:

- A 2-hour tape to show to friends; plus a 2-hour tape for just us trekkers. That will have lots of things that are hard to explain, except for those of us who were there! Plus an hour of STAFF, Singing and dancing, and any other video we get. Plus an hour of YAKS for Noah. This will be called "The Yak Channel: Always Yaks - Yaks All The Time."

PLACES:
Where did we go? We hiked to many places where the great Everest climbers went. If you have read books about the great expeditions to Everest - we went to many of those places. If you don't have a map, they may not mean a lot. If you have a map, or if you remember the old stories of the walk-in to Everest Base Camp - they are "Names To Conjure With". See below at MAPS.

- We flew into Lukla. We camped at Phakding, Manjo, and Namche Bazaar.
- Next up to Thame, and Thengpo; and we day-hiked up to 16,060' on the trail to Trashi Labsta.
- Next, back down to Khumjung, then up via Mong La to Phortse Tenga, Dole, Machhermo, and Gokyo.
- We descended to Na and Phortse and then up to Pangboche.
- Up to Pheriche, Dughla, and Lobuche and Gorak Shep. (Gorak Shep at 17,100' is sorta the last place on the earth, where it is so remote that a Coke (TM) costs $3.50, the same as a can of beer, mostly due to portering charges.)
- From there we hiked up Kala Pattar, a cute little hill that rises 1500 ft above Gorak Shep. Also some of us went up to Everest Base Camp, (about 3 hours of HARD hiking NE of Gorak Shep.)
- Then we retreated to Lobuche, and then to Dingboche, and then up to the EAST to Chhukhung.
- We camped at Dingboche, and Chhukhung; back down to Pangboche, and Deuboche, while we visited the great monastery at Thyangboche. Then down for a quick snack of pastry in Namche, continuing down to Manjo and Lukla.

What did we SEE?

MOUNTAINS! Beautiful MOUNTAINS!!
First we saw Thamserku, east of Namche. Next, Khumbila, north of Namche. Next, Kongde Ri, SW of Namche. A whole ROW of glorious and beautiful ridges west of Kongde Ri, extending west all the way up to Trashi Labsta (which is the dangerous pass to Rolwaling).

One of Peter Owens' clients sent me an e-mail: "I saw some pictures of beautiful fluted snowy ridges. Where should I go trekking to see those?" I told him, "Go anywhere in the Khumbu, toward Kala Pattar or Gokyo Lakes." Some of the best fluted snow is West of Namche, SW of Thame, west of Kongde Ri, and south of Thengpo; also, SE of Dingboche, or south of Chhukhung. And on Nuptse.

We saw Lhotse, Nuptse, and Everest. Mount Everest, despite its exalted status, is one of the LEAST beautiful or impressive mount- ains. It is massive, high, and DISTANT. But not GLORIOUS, compared to other mountains in this area.

We saw Cho Oyu, which like Lhotse is one of the 8,000-meter peaks, looming off in the north. We saw Makalu, FAR in the east. We saw Chola Tse and 3 other handsome (steep & scary) peaks between the Gokyo area and the Everest area.

We walked up Gokyo Ri. In this region, Ri means, sort of, BIG HILL. Tse means PEAK. Nup means WEST, so Nuptse means western peak. Lho means SOUTH - so Lhotse means Southern Peak -- which it is, just a couple miles south of Everest. THESE are MUCH higher than anything we walked up - and much harder. From Gokyo Ri, the views were GLORIOUS.

We walked up Kala Pattar, which translates to "black rock". It's just north of Gorak Shep, and just below Pumori. It is listed in most books at 18,200', but its higher northern peak is at 18,600'. Don't plan to HURRY up there. I walked up there just fine, and 5 of us did, but -- don't count on any particular speed. The trail is very nice and easy and safe, but when you get to the top, please do NOT hold onto the summit cairn for support -- it's very wobbly.

The summit views from Kala Pattar were very good. The views from Gokyo Ri were just about as good. And the views from Scoundrel's Rest (4.1 miles north of Gokyo) were just about as good. The views from Everest Base Camp? (EBC) - no view of summits, there. MOST places, there was not a good view of Everest. But there was no problem with a lack of views of handsome and BEAUTIFUL mountains. We never had a shortage of THEM. Personally, I'm a SUCKER for those beautiful fluted ridges - the ones south of Thame, and south of Chhukhung.

We saw a lot of Ama Dablam, 22,356', which is one of the MOST IMPRESSIVE and beautiful mountains in the world, even if it is thousands of feet lower than Lhotse or Everest. It has a great shoulder on the west, and a HUGE long ridge of fluted snow extending miles to the east, at about 19,700'. "Ama" = Mother, in Nepali - a useful and easy word to learn. "Ama Dablam" = Mother's Locket.

We saw Taboche (or Tawoche), west of Pangboche, and Lobuche Peak. Pumori. And at least one un-climbed peak, not far off from Ama Dablam Base Camp, off in the east.

We also saw Island Peak (Imja Tse) off in the east from Dingboche, and Cho Polu, a lovely rounded conical peak, just east of that. Amphu Peak. And we kept seeing Lhotse, and Nuptse, and Ama Dablam, Thamserku, and the two horns of Kang Taiga, and many other AMAZING and beautiful mountains and ridges, much higher than we could hike. These view were very inspiring, almost any time of day. You stop to rest, and you turn around - and off in the distance you recognize - a friend. Like, Peak 7561, so very pointy.

Views of EVEREST?

Yes, we did get to see the top of Mt. Everest from the trail, an hour below Namche. We saw small parts of its summit many times, from Pangboche or from the Park Headquarters on the East end of Namche. Often we saw it with a snow plume. Or clouds - sometimes lenticular clouds. We saw it from Gokyo Ri, from Scoundrel's Rest, from Kala Pattar. But there are a lot of places you cannot see the summit - such as from Everest Base Camp. Still, as magnets go, Everest draws many people to this area - but it is EVERYTHING ELSE that's beautiful.

HOW CLOSE did we get to EVEREST?

At Gokyo Ri we were about 14 miles west; at Kala Pattar, just 6 miles. At Everest Base Camp, barely 4 miles west of the summit, & barely 2 vertical miles below the top. We had climbed ~2/3 of the way up Everest. Of course, we did the EASY 2/3; the higher 1/3 is prohibitively difficult. At Imja Tse Base Camp, just 6 miles south, we had walked 1/3 of the way around Everest. Probably the only people who walked ALL the way around Everest, are the guys who got to the top, plus Tilman and Shipton in the 1930's. Note, even though at ITBC and at EBC, we were pretty CLOSE, there was no view of Everest.

Where ELSE did we go?

MAJOR DAY HIKES!
- We did a LOT of day hikes - just about every afternoon for 17 days, plus 8 or 9 all-day day hikes with light packs, far above our camps.

GOKYO RI
We climbed up from the 3rd Gokyo Lake, to Gokyo Ri, a pleasant and easy 17,800 hill just northwest of the 3rd Gokyo Lake. EXCELLENT views in many directions. No matter how much you may have heard about Gorak Shep and Kala Pattar -- this is ANOTHER beautiful area, with great views. About 1200 ft of ascent.

SCOUNDREL's REST:
The next day we went up to Scoundrel's Rest, a pleasant easy hike 5 miles North of Gokyo, just east of the 5th Gokyo Lake, by beautiful trails along the glacial moraines. Very good hiking, with many nice easy trail options. Great views in many directions.

Waypoint 192, Scoundrel's Rest: N 28d 00' 23.7" - E 086d 41' 22.2"

NOTES on hiking to EBC / EVEREST BASE CAMP:

When you get up to Gorak Shep at 17,100 ft, you are quite possibly NOT in a good mood, not in good shape for several hours of brisk hiking. But if you want to hike up to EBC, the book says it is a "3 hour hike" from Gorak Shep - and it is a surprising long 3-hour hike. Even with an early start, you have to hike briskly, or the day is shot - or you may not get there. And hiking briskly at 17,500' is not so easy.

We got a pretty good 8:30 AM start, & ambled at a good rest pace NE up to the edge of the Khumbu Glacier at 17,400 ft. From there, an amazing flat "airline" trail goes up straight north for almost half a mile, straight and level, along the edge of the moraine overlooking the great Khumbu Glacier. This trail is not scary or steep, but it is a high open ridge that drops off at a nice slant to the west, and drops off more steeply on the East. If it did not drop off so much, it would make great bicycle riding. The trail is so smooth and flat, you can stare as you walk, out across the glacier with its rough surface. SOON, YOU will be wandering around out there. The GPS location of the end of this airline, are:

WP 201, Gorak Shep: N 27d 58' 47.2" - E 086d 49' 50.4"
WP 206, Airline South: N 27d 59' 33.2" - E 086d 50' 39.6"
WP Airline = Airl. NORTH: N 27d 59' 53.0" - E 086d 50' 50.6"

(All data are in dddmmss; UTM data are in Appendix G.)

This airline trail is important, because one of my friends once went up to Gorak Shep and then immediately EAST out onto the glacier, and then had a long rough struggle up to EBC. If you know about this "airline", you'll save a lot of time and energy.

At the north end of this "airline", the trail dives down some steep slopes and crude trails, and out onto the glacier, which really is a huge area of hidden ice, covered by gravel and shale. The trail is not bad, just a bit rough - and a bit hard to find at times. Fortu- nately, our sherpa Puri Rai was quick to see where the trail went, and I just followed him, and we didn't waste much time, which was good. (If I had had to pick the trail, I would have wasted some time, and I'm usually pretty good at trail-finding.)

There were no expeditions camped at EBC. There were no campers there. There were only 2 or 3 hikers there, just like me, wandering around with their Nepali guides. One Italian fellow, Bruno, and I joined in an animated multi-lingual agreement, that this was an amazing and impressive place. A place we had dremed about, for years. Even if there was not much to see. Even if I understand very little Italian, and if he understood only a little English, there was no question that we were in great agreement. Even if there was nothing to see but - great ghosts.

There was very little trash or junk there; it had been cleaned up quite well. There were very few indications to show that this was indeed Base Camp. There were a few pieces of masonry, set up as the corners of a big old stone building. THAT was unmistakeable. A couple small monuments. But - hey - on a surface of ice, not much of permanence can be expected.

Some old maps indicate that in the old days of Hillary, their EBC was located just south of the south edge of the foot of the Khumbu icefall. That place was filled with extremely steep, sharp ice peaks or seracs, and would not be usable now. The place we went was just west of the NORTH edge of the Khumbu ice-fall. The actual GPS location is:
WP 204, Everest Base Camp: N 28d 00' 21.9" - E 086d 51' 46.5"

The elevation of EBC was around 17,740 ft. Since we'd hiked up to 18,600 the previous day, hiking up to nearly 18k was not a big deal, but hurrying was not a good idea!

There was no flat place where you could pitch a tent. There was not even hardly any good place to pitch a 1-man tent. If you wanted to camp there, you would have had to scrape away the gravel and rocks, and hack the ice to flatten it out some. It would take a LOT of hacking, for a 3-man tent. Not to mention, for several 3-man tents, or a big expedition!

There were a lot of boulders sitting up on pillars of ice. There were boulders as big as 300, 800, 3000 lb, each perched on a pillar of ice 1 or 2 or even 3 feet high. Apparently the rock protected the ice from melting in the sun. They looked funny as heck! We did not see this on any other glacier, only on the Khumbu Glacier near EBC.

I walked up a couple hundred easy yards EAST from EBC, up to the foot of the Khumbu Icefall. I walked up and patted some icebergs. The location was:
WP 205 = Khumbu Icefall, N 28d 00' 19.0" - E 086d 51' 51.5"

The views of the great Khumbu Icefall, from the bottom, where I stood, were not as DRAMATIC or SCARY as the stories tell. I guess you have to clamber a long ways up in there before you see the huge crevasses. It was IMPRESSIVE from where I stood. That was close enough for me, at 17,780'.

All the time we were there, we heard no significant icefalls or rockfalls or avalanches, though other people had heard them on other days. The big gravel wall at the North end of this area did have a few small rocks falling down. (This was just 150 or 200 yards north of the EBC area. I mean, you could not go much further.) You could hear them. If you looked to see what was falling, there was nothing big or obvious. If you SQUINTED, you could see an occasional small rock, not much bigger than a fist, sliding and bouncing down the steep gravel slope, which was 300 yards high. Occasionally this rock would hit another rock, but no large avalanche effect occurred, even though a rock would fall every few minutes.

THEN it was time to get out of there. It was going to take about 3 hours to get BACK to Gorak Shep. It was a good bit of work, but we moved along and got back in about 2.9 hours, about 3 PM. THEN after some water and a snack, I had to hike a couple MORE hours to get down to our camp at Lobuche. Fortunately, most of this downhill grade was not so bad. (The first 1/4 mile was really rough and uphill and slow and fatiguing, I admit, especially after 6 hours of hard hiking.) Even at 17,000 ft, downhill moves along ok, and I got back as the shadows of Lobuche Peak were spreading out broadly at 4:45 PM. (It was getting cold.) So if you want to hike up from Gorak Shep to EBC, just be aware that it is a good piece of hard work.

KONGMA LA:

The very next day, I decided it would be a good hard piece of conditioning hike to take a short-cut from Lobuche to Dingboche via Kongma La, an 18,200' pass east of Lobuche. First we had to cross the Khumbu Glacier, but that only took half an hour on a nice adequate little trail. Then up to Kongma La, a beautiful pass overlooking some handsome milky-blue-green ponds.

McGuiness' book is usually accurate; it said the trail to the east and south is not always easy to follow. But I found that it was very easy to follow, and a very nice little trail. I got some GPS readings that are adequate, so you could do this on cloudy day with a foot of snow on the ground.
WP 198 = Lobuche: N 27d 56' 51.2" - E 086d 48' 44.4"
WP 199 = Moraine: N 27d 56' 27.6" - E 086d 49' 16.3"
WP 207 = Kongma La: N 27d 55' 45.4" - E 086d 50' 18.3"
WP 208 (trail) N 27d 55' 32.7" - E 086d 50' 43.3"
WP 209 (trail) N 27d 55' 22.9" - E 086d 50' 42.3"
WP 210 (trail) N 27d 55' 19.2" - E 086d 50' 55.5"
WP 211 (Dingboche) N 27d 53' 35.1" - E 086d 49' 59.9"

IMJA TSE (Island Peak) Base Camp:

Conversely, the walk up from Chhukhung to Imja Tse Base Camp was long, but very easy; a pleasant and easy and nice trail, with great views. Yes, the ascent amounted to about 1500 ft, up to the Base Camp, but it did not seem very hard or nasty or steep, after the first 1/4 mile walking up the moderately-steep ridge trail. There were nice views onto streams, rivers, playas, and lakes. McGuiness' book says the ITBC area is grubby and a cesspool, but it seems to have been cleaned up, and was NOT very grubby.

I expected a very quiet area. I saw about 35 porters going up, and about 20 tents up there. Some were climbers, preparing to ascend the summit of Imja Tse; and others were just trekkers. It seemed like a nice place to camp, as a base for wandering around.

Island Peak really IS like an Island. It is surrounded on its whole E, NE, and SE side by a big long glacial moraine, a shallow trough that was easy for walking. If you walked over on the right, to the EDGE of the moraine, you could look out on a SEA of ice and glacier. A huge area. The map indicates these glaciers add up to 1/2 mile x 5 miles - just ENORMOUS! So the mountain really is surrounded by two concentric moats, one MUCH narrower and easier to walk on. The other, much rougher. One could climb down onto that glacier, if one wanted too, but it did not look very attractive.

You could see a BIG row of BIG mountains, mostly fluted with snow, looming up over those glaciers. The handsome conical, rounded peak of Cho Polu at 21,980' was one of the few named peaks, as many others were un-named. Some were impressive; others were beautiful. Far off on the south, a big wall was the obvious location of the pass "Amphu Labsta." It looked like a very rough, steep empty lonely area, and indeed somewhat dangerous.

There was not much water in this area. (You could hear hidden streams rushing, off under the glacier, but not accessible.) There was a big rockslide near the lower end of the ITBC area, and porters were often going up there to collect water.

There was a small trail starting up the slope of the mountain. Obviously, this was hike-able. I got some video of me starting up there - "The intrepid hiker Bob Pease starts up Imja Tse" - followed by, "...and changes his mind and comes right back down...." This was at about 16,950 ft elevation;
WP 213 = Imja Tse Basecamp: N 27d 54' 12.7" - E 086d 56' 19.9"

I could have easily ascended a few hundred feet, but it would not have been any significant accomplishment, and I thought it was not a good idea, so I did not go up further.

We then continued up to the NE, along the moraine. I could have hiked another mile, but it was turn-around time, and I went back down. All along, as we hiked on the edge of the moraine, the views down - and UP - were GRAND - and desolate and kinda scary. The walk back was leisurely, and handsome. We also saw one small camp on the SOUTH side of the river; our trail was on the NORTH side of the river. All along, the mountains and walls and ridges east of Ama Dablam were just glori- ous. We got back good and early. I took some photos, and lots of video.

AMA DABLAM Base Camp
This area was MUCH more interesting than other base camps as it was full of campers and climbers. We talked to a guy Jared who had recently climbed to the summit. He explained there were other climbers up on the summit cone less than an hour from the top, and showed us where we could look with his binoculars. He explained that after you spend a night in hammocks at camp 3, under the bulge of the "Mother's Locket", just 600 ft below the top) you ascend some vertical ice and then slant over to the left on a "relatively easy" 70 degree slope to the top. Sure enough, we could see some little specks up on the vertical snow, and 10 minutes later, the specks had moved. This guy had a lot of experience at rock and ice climbing in Southern Cali- fornia but had never been over 14,000 ft before. Without even acclim- atizing above 14,000 ft, he went up to the 22,300 ft summit, no problems. MUCH too steep for me. Much too hairy.

OTHER DAY HIKES:
We also went on many other, smaller day hikes that were very pleasant. Some guys came with me (and griped that I walked them too far). ("Hey, this is just an ACCLIMATIZATION HIKE!") Others went on their own. We finally had to hit on a new rule: No hiking farther than 1 mile from camp, without a companion (trekker or sherpa). So I just dragged a

sherpa along, and tried to wear him out! Every day, a new sherpa tried to wear me out. Fortunately, I took good care of myself, and had no problems, with or without a sherpa.

OMOGA:

When it was time to descend from Pangboche to Deuboche (which is not much over an hour of hiking, downhill) I decided to take a round- about route. At the bridge across Imja Khola, at the high end of Pangboche, cross to the east bank, and wander south. In 25 minutes you come to a nice little valley of empty huts and yak pastures called Omoga. If you descend, you'll find no way to cross the stream, except to take off your boots and wade. Cold. We did that, once. But if you stay high and wander eastward, the trail brings you to a dry-foot stream crossing. Circle around west and south, and a very HIGH trail takes you - not to Deuboche, but all the way to Thyangboche. It was a glorious trail, with not much hard work. We got back to Deuboche a bit late for lunch. Well worth the effort.

OTHER nice and wonderful places for day hiking? DZONGHLA is west of Dughla, on the way to Chola La. Its views are very good; the trails are smaller and less cluttered with people, but not really LONESOME. If you started from Dughla at 7 AM, strong hikers should be able to get up to Chola La and back, but some years this pass is much snowier and it might be more difficult. Apparently this year, it was relatively easy. I did not get within a couple miles of that pass; I stopped barely 1/2 mile above Dzonghla, but it was very pretty and great hiking.

THENGPO is a nice cozy yak pasture about 3 miles west of Thame, (7 miles west of Namche) with camping at 14,400 ft. This is a great way to do some acclimatization above Thame, above Namche, without being bored. The day-hike opportunities up toward Trashi Lapsta are excellent. We went up to 16,060 ft and turned around, just as the glacier begins to give poor traction. Pretty, and relatively un- cluttered. (Note, hikers are always warned to not go too high, and not ascend too fast. BUT taking a day hike high and sleeping LOW is fine. It's the elevation where you are SLEEPING that counts.)

KONGMA LA:

THIS is a shortcut from Lobuche over towards Chhukhung. Of course, saving 1/2 mile for the privilege of climbing over an 18,200 ft pass is not everybody's cup of tea, but for strong members of a party, it is a good piece of work to wear them out and bring down their residual energy near that of the other hikers. The book says it's better from SE to NW, but that makes a lot more ascent. We went from NW to SE, and it was grand.

Day Hike up towards THAMSERKU:

We made an early stop at a camp in Manjo, just outside the Park, so we decided on an afternoon hike. We must have ascended a couple thousand feet from the top of Manjo, and the wood-cutter's small but adequate trail gave no hint of petering out. We were nowhere near snow-line. We had seen woodsmen and farmers carrying down large loads of hay. We never did get up near their hay fields. Still, a good half-day hike. It might have made a good ALL-day hike, but it got kinda cloudy and there was not a lot to see after 3 PM.

SCOUNDREL's REST:

This is marked on some maps, but not others. It is not an exact place, but a broad area with excellent views, especially toward Mt. Everest. This area is just east of the East End of the fifth Gokyo lake, which is ~5 miles N of Gokyo Lakes "Resort". This area offers some very handsome views of Mt. Everest about 14 miles to the east. Even if you don't climb above 16,500 ft, it gives you some great views of various parts of the adjacent Ngozumpa Glacier, which is the biggest glacier in Nepal.

Adjacent to the 5th lake, there is a big hill (very small mountain) which appears to go up to 18,000 ft. We saw a couple hikers walking down that hill towards us. I have no doubt it would give even more GLORIOUS views, but we all decided to save our energy for another day.

Trail across NGOZUMPA GLACIER:
Starting near the south end of the second Gokyo Lake (about 1 mile from Gokyo) there's a very decent trail going across the low end of the Ngozumpa Glacier to Dragnag, which is the WEST entrance to the trail to Chola La. We went over this trail as a good alternate route to Na. We thought about hiking up toward Chola La, but the visibility was poor, and we just wandered down to our camp at Na.

Great trails:
If you ascend to Gokyo by way of Mong La, Dole and Machhermo, that is a great route. But if you return by the same route, you are missing a great alternative: return from Na through Thare to Phortse. Phortse is a small town with fairly large farm lands, but it is a pleasant and restful place. It can be seen for many miles in all directions. The trail from Na to Phortse is wonderful, as it lets you see across the big valley to the trail ascending through Dole and Macchermo. Of course, the view from the Dole-Machhermo trail is great, looking across the big valley at the northern route!

AFTER you get to Phortse, there is a wonderful trail up to Pangboche. While there are big drop-offs beside the trail, most experienced hikers who do not have extreme vertigo or acrophobia will find this trail very enjoyable and challenging. Sometimes the trail is 4 feet wide; sometimes 8, sometimes 2. But very good footing, never scary. We all agreed, this is a great trail, one of the finest hikes in the world. If you get nervous, just ask a sherpa to hold your hand.

WHAT ELSE DID WE SEE?

Rivers:
- Dudh Khosi ("Milk River")
- Bhote Khosi (Bhote = from Tibet)
- Thame Khola
- Imja Khola (or Imja Drangka) (coming down from Imja Tse)
- Khumbu Khola (coming out of the great Khumbu Glacier).

All great rivers. We crossed all of these on sturdy bridges. If you fell in, you would be lucky not to be dashed against a rock by the raging flow, in the first half-minute, or frozen within the first minute. Fortunately the bridges are quite safe. Just be careful. We saw a yak-herder climb out onthe side of a bridge, to free a Yak's jammed horns.

STREAMS?
We had a number of small stream crossings, but we rarely got our boots wet. Early-morning stream crossings might involve ice on the rocks, and it was a challenge to not slip. Videotape of people dipping in their feet does exist...

YAKS:
We saw a LOT of YAKS. Probably 50 to 100 every day. Many were heavily laden with trekkers' gear or local produce; sometimes with salt from Tibet. Others were just grazing. Most were very docile; a few were very nervous, and were giving their handlers a hard time. These great, handsome beasts were very photogenic. But we were quite wary.

We heard that 2 women had been recently gored to death by yaks, and one woman was recovering after a yak pushed her off the OUTSIDE of a trail. We were pretty careful to step to the INSIDE of a trail before the yaks came by.

PEOPLE:
We saw many local people, and many trekkers, and porters carrying every kind of load. A great number of very nice people. Kids and grandmothers. Old men, young men, and women carrying loads in the ballpark from 60 to 120 lb. I even carried a porter's load 1/5 mile, using just a tumpline, but it was only 60 or 65 lb.

On a typical day, we often saw 40 to 80 trekkers, and double that many of porters. But while there was often a big line of people to pass, most of the day was as empty as you could ask for.

NAMCHE BAZAAR:
We saw the every-day bazaar with many Chinese goods, clothes, shoes, STUFF, dow

THE BEST OF BOB PEASE

Everest MAXI-Report -- PART 2

EQUIPMENT LIST:
Peter Owens' basic Equipment list is very good. (see at http://www.InstantWeb.com/p/peterowens/visas.html#EQUIPMENT) That list with my add-on list (see Appendix E.) is even better. We rarely got in trouble with that combination. We brought most of the items on Peter's list of cold-weather gear, and we were glad we did.

We all brought a few things we did not need - not a big deal. And there are always a few things we wished we had brought. I brought extra sun-screen and lip-balm, in case I wore out mine, or ran out, or lost mine. I never ran out. I brought extra pants and jackets, and when I figured out I had enough warm clothes, I loaned these to my favorite Nepali porter, to help him keep warm. I brought an extra sleeping bag, in case I got very cold. When I heard a buddy complaining that he was very cold, and I was sure I'd be OK, I loaned it to him. I loaned out a couple spare pair of mittens, to guys who had brought gloves, or mis-placed their mittens. (Mittens are MUCH warmer than gloves.)

(Several guys said, "I think I lost my mittens" or, their what- ever - but they always turned up in a day or two.) When I got back to Kathmandu, I could not find my airplane ticket. I searched and ransacked and perused every piece of paper I had brought, and could not find it. Just before I called the airline to ask what I hould do if I could find my ticket, I asked my wife if she had them. She said, "Of course not..." - but when she checked, she did have them. It is easy to misplace something in the midst of your stuff. But hard to actually lose it. Don't assume it was stolen.)

I had my day pack which I carried, which typically weighed about 18 lb., with all my battery-charging equipment strapped on. (*See* the February 8, 2001 column, "What's All This Battery-Charging Stuff, Anyhow?" at: http://www.elecdesign.com/Articles/Index.cfm?ArticleID=14176&extension=html

But on any day I was going for a day-hike, I did not want to bring all that heavy, bulky stuff along. And there were about 17 days when we went for a day hike after we got to our early camp. I found a neat little Adidas day pack, weighing just 8 oz., which I bought for $7 in Namche. It had a mid-sized main pouch and 4 small pockets, and was perfect for my parka and lunch and a water-bottle or two. Other guys agreed that a small "summit-pack" can be handy.

BRING NEXT TIME?
When I asked my friends, what should we bring next time, one guy wrote: "Well, let's see; I guess the number one thing I would 'like' to bring the next time is either a hot tub or a sauna. The question is, how in the hell do I get it carried? The second thing would be a good bartender with a very well stocked bar. The only other thing I can think of would be the lady at the Oriental Hotel in Bangkok that gave me the foot massage while I was there. There is no question what we would LIKE. I think the big issue with all of these items is 'how do we get them up there?' Any and all suggestions as to how to accomplish these worthy goals would be appreciated."

Another guy made his list of "Should have brought": Wind proof mitten covers, Neck gaiter or scarf; Small day pack.

Never used: "Ice creepers; Third camcorder battery; spare battery- charging circuit; ASA 400 film - (the light was plenty bright)".

- Still, it's good to have such stuff as back-up, even if you never use it.

Some of us used 1 walking stick. Some used 2. A couple old-timers were adamantly opposed to walking sticks. All did well.

One of our guys said that next time, he would bring along some big POSTERS of the Himalayas, and go down to Vern's Frozen Food and Meat Locker, in his home town, and stand around in the cold, and walk on a treadmill, and eat some hot soup. Think of how much money you could save on airfare, and be just as miserable as you want! (But he's a great kidder, and he's already planning his next trek.)

FIRST AID:
We had very little need for first aid. Sunscreen, lip-balm - I brought along several spares; never needed. You literally cannot buy glacier cream (high-altitude suncreen, loaded with zinc oxide so your face begins to look like a clown's) but HIGH-SPF sunscreen does pretty well.

WATER BOTTLES:
I found that carrying a water-bottle on my camcorder's fanny-pack waist-strap, every day, all the time, was a VERY good idea. EVEN when I had 1 or 2 liters of water in my main pack, it was good to keep water AT HAND, to sip as often as you wish. Water in your pack that you can not easily drink - does not get consumed, and does not do you any good. When you are hiking hard, especially at high altitude, drinking AS MUCH WATER AS POSSIBLE is an excellent idea. Getting thirsty is a bad idea.

MAPS:
YOU can buy an excellent map by Schneider for $16. You can order from www.Adventuroustraveler.com . There are other very good maps. I just bought two maps from Omni (http://www.omnimap.com/maps.htm), and they are excellent as they have the UTM grid on the maps. The Sagarmatha map No. 278604 covers the Everest region while the Namche Bajar No. 278603 covers the area west of the first map. Actually, here are the catalog numbers and names from the web site:
- http://www.omnimap.com:80/catalog/int/nep-50.htm
Number 65-0454-2786-03 Namche Bazaar $11.95
- and 65-0454-2786-04 Sagarmatha (same price).

GPS:
I did bring along my Garmin GPS12, just for fun. It was really never essential, but if you got caught in a sudden storm and lost the trail, it might be helpful for navigation. I brought it to mark some reference points that are not well marked. The location of Everest Base Camp, the airline trail approaching it, and Kongma La and the trail east of it, are not well defined, so I'm glad I got the data. My receiver went flakey and would turn itself off if bumped, so I just had to be careful to not bump it. Then when I got home, I found a big offset (210 meters west and 640 meters south) compared to our true location. Supposedly a "User's Grid" will correct for this, with a scale factor of 0.9999, per the map, but my "Users's Grid" refused to give readings, so I had to just add a constant offset (210 meters east and 640 meters north) to

each reading. When I send my GPS-12 in for repairs, maybe they can fix that.

HEALTH and ACCLIMATIZATION: Pills:
We brought along some little pills, just in case we needed them. Some of us brought Diamox pills, which are good for you if you have trouble acclimatizing to high altitude. Most good trekking books explain all about these. I and some other guys did not bring diamox pills, as we had been to high altitude before, with no problems. We did not think we would need them. But in retrospect, we SHOULD have brought them, and if you are going to sleep up as high as 14k, you should bring them.

Sleeping pills? These are a bad idea when you are at high altitudes. If you cannot get to sleep, a Diamox is safe, and most sleeping pills are NOT.

Other pills: We also brought along some Viagra pills, in case we had to do some debating with difficult bureaucrats. In concept, you might like to have available for such conflicts, as "baksheesh", a bottle or two of whiskey, to help convince such bureaucrats to see that your point of view was valid, on any technical point. Like, in case the airline agent wanted to auction off our guaranteed reserved seats on a plane to some higher bidder....

But bottles of scotch are kinda heavy to carry along on a trek. Viagra, which is a universally-appreciated drug, is not normally available in Nepal or India or Asia. ONE PILL can do the same political job as a bottle of scotch -- but MUCH lighter.

Potassium: I always take 3 potassium pills with breakfast, to make sure I don't run low. I volunteered to give such pills to anybody who needed them in case of leg or foot cramps. Nobody had cramps on the whole trek, though on some training hikes, and on previous treks, the potassium was valuable to prevent or cure leg cramps.

ACCLIMATIZATION:
We did pretty well because we allowed plenty of days to acclimatize. As a general rule, if you walk up from low levels, you can walk up as fast as you want up to 10,000 ft., but you should not ascend faster than 1000 ft. per day above there. If you fly into Lukla as we did, you should not go above Namche without spending a couple days in Namche. McGuiness' book is quite clear on this; see pp. 223-230. We went up slowly to Namche, and after a few days, we went slowly above there. THIS is all to prevent Altitude Sickness (A.S.). Later, after we had been high, we were able to go up faster than 1000 ft/day.

FOR EXAMPLE: After you have been up to 15k ft (as you are at Gokyo), after you descend, you can then go up again to 15 or 16k feet easily and quickly, so long as you do not spend more than 4 or 6 days down low. A couple guys who started without Diamox decided to use it after they came up with some preliminary symptoms of altitude sickness. They very quickly got better. I never had problems, even up at 18,000 ft (3 times) or at 18,600. A couple of us got along fine - but just because you can do this once or twice, does not mean you can be confident to do it again. We met people who had a friend who had to get helicoptered out, from 15,600 ft., even though he had spent a lot of time above that previously, with no problems. And he had not gone up too fast. Damn' shame - but at least he was smart enough to get out safely.

We saw a LOT of helicopters - about 2 or 3 per day - going up the valleys and promptly coming back down. Most of them were carrying out hikers or hikers who went up too fast. We sure did hear a lot about people with A.S. One of our guys didn't feel well at all above 12k ft (barely above Namche).

Too many people were going up too fast. Too many trekking organiza- tions CHINTZ on the time they take to acclimatize you properly. Too many people getting sick; too many people chintzing on their diamox. I did not bring diamox, and a couple other guys and I did not take any, and we were just fine, BUT we were lucky.

One afternoon, a friend of mine and I went on a day-hike over to Dingboche, to take photos, and see the town. We were strolling through Dingboche, and came across a stretcher, sitting in the middle of the trail, with several people standing around. We noticed the boots sticking out. We noticed that the person's body and face were all covered up. We noticed that there was NO HURRY about getting the person any further down. We concluded that this unfortunate person had been carried down from Chhukhung and POINTS EAST (Imja Tse area?) and was now dead.

Our friends were AT THAT EXACT TIME, attending the daily lecture on A.S. in Pheriche. The doctor had just started her lecture, when an aide handed her a radio-telephone. She turned aside, listened to the phone, and gasped, "She's DEAD?" Apparently she had been in touch with this rescue effort, and expected the person to arrive in Pheriche shortly, in poor shape from A.S., but alive. Well, the people at the lecture sure did pay attention after THAT! They thought it may have been a trick, to get their attention - but we saw the body, in Dingboche.

TECHNICAL REPORT on SAFETY:
One British friend wrote: Recent info by the Royal Geographic Society (RGS) shows trekking in the Himalayas as very low risk regarding deaths.

I could not really find anything you can print out. However, I believe what he said, that the risks are not too bad. That's consistent with our observations and experiences. Hey, these trek organizations have mostly done their home-work well, and know how to avoid bad risks.

More on DIAMOX:
A couple of our guys discovered that if you could not get to sleep after midnight, if you POP a diamox, you could get back to sleep. I'm not sure if this is the best recommended procedure, but it seemed to work for them. One guy who did NOT discover this was plagued by sleeplessness, and by loss of appetite (which are both manifestations of A.S.). He lost 22 lb. But he is recovering. (He did not feel well above Namche; although he's normally a strong hiker, he got half-way up Kala Pattar and had to quit as he had ZERO strength, due to his inability to eat.)

I must say, we started out from Lobuche in the morning and went up to Gorak Shep, and stormed up Kala Pattar to 18,606, and I felt great. I was obviously in better condition than anybody else on our hike. Then we descended over the southern horn of KP, and down the trail to Gorak Shep. When we crossed the sandy area, and I actually had to ascend 40 feet to our tea-house - I was REALLY very tired! I was really glad I did not have to ascend 100 ft!!!!! So, being in "good condition" can fool you a lot.

CONDITIONING:

On this trek we knew we would be doing a LOT of work at high altitudes, where the air is thin. I did a lot of running up and down stairs, at sea level, for conditioning, for months before the trek. I was able to run up and down 65, 70, 80, and sometimes 84 standard 10-foot flights of stairs, in 20 minutes, and I did most of my breathing through my nose. I found it very useful to be able to do such good practicing, even at night, even in case of bad weather, even when travelling. I think I was in better shape than any of the other trekkers, when it came time to just work uphill.

Breathing through your nose is quite important. It's a real handicap if you can only breath through your mouth; it dries you out excessively, and can chill you badly. If you want to be in good shape for any high-altitude hiking - even 12,000 ft - practice breathing through your nose as you increase your exercise.

Of course, climbing up and down stairs should not be your ONLY exercise. Keep on hiking, too! But if your only hiking trails did not have much rise, or if you could not fit in enough good exercise at least 3 or 4 days per week, then stair-climbing can be a very important part of your conditioning.

Of course, as with any other kind of exercise, don't do more than you should. Some nannys say, "be sure to consult your doctor before running up stairs", but I recommend, "don't over-do it, don't increase your exercise faster than you can handle, and use common sense. And be careful not to trip and fall down the stairs."

I think that's a pretty good disclaimer....this is in addition to the good advice in the 1997 trek notes.

Another good thing about running up and down stairs is, it strengthens your legs for descending (which riding an exercycle or a "stairmaster", or a treadmill with an upgrade, can not do). I ran up stairs, 2 steps at a time, and then scampered down at a fast rate, up 13 steps in 7 seconds and down in 8 seconds. I've never before been in as good shape for down-hill hiking, and I must recommend stair-running for all these reasons.

Kathmandu:
As usual we spent several days before and after the trek in Kathmandu, staying at the very inexpensive ($7 per night) Potala Guest House: http://www.stayxs.com/new/booking/Facilities.asp?WSID=61&HHM_ID=602

We went to see the usual interesting places, Swayambhunath and Boudnath, and Pashupatinath; and Patan and Bhaktipur. We are still looking for new and interesting places. Dwarika Hotel is an amazing combination of a fine new hotel with a museum of old woodcarvings: http://www.dwarikas.com .

I keep looking and finding new things to see in that fascinating town!

TELECOMMUNICATIONS:
There are many Internet parlors in Kathmandu. They were charging about 1 rupee per minute, or 85 cents per hour. The keyboards were often a bit flakey, and the server rates were slow. But a good typist can put out an email easily. I got myself a hotmail account (no cost) so I could send and receive email.

At Lukla, there were a few e-mail parlors, and allegedly one internet parlor. If I'd been stuck overnight, I would have checked that out. But we were able to leave town with only 4 hours of delay. Up in Namche Bazaar, there were at least 3 e-mail parlors, but no internet parlors. They said any e-mail you typed would go out at 4:30 or 10:30 PM, by satellite phone. Fine by me. The prices seemed reasonable, but I did not use them. I did not have much to write in Namche when

I had time to spend, and later I did not have much time to spend in Namche when I had things to write.

Most every town at Lukla and above promises phone connections. Our Sirdar tried to phone out to Kathmandu, and while the phone worked occasionally, it seemed to FAIL for a week or so. Fortunately we did not have any great NEED to talk to the world. No emergencies. Later, the phones got fixed.

When we finally got back to Kathmandu, I sent out a quick 1/2 page note to close friends and family, so they would not worry about if we'd gotten ourselves killed or hurt.

WEATHER:
We had no rain for over 4 weeks. But we did have a lot of clouds, on many afternoons, and sometimes they even came in before noon. Especially if we got to camp early and washed some clothes, we discovered the theory that PUTTING CLOTHES OUT TO DRY CAUSES CLOUDS TO APPEAR. This theory has been tested and is very close to 100% valid....

Morning were usually cool down between 10 and 40 degrees F. If it had been windy, this would have been brutally cold, but it was rarely more than 1 or 2 mph, and even this breeze dropped off as the sun rose. We had a few windy afternoons.
We had some DUST, but not that much. Yaks would kick up a little dust, but yaks walk so slow, they don't kick up MUCH dust.

Weather changes: One morning we started out in nice weather from Na, and soon hit a rush of icy air coming down the glaciers. I had not taken off any warm clothing, except one mitten. Other people had already stopped to take off a jacket, and when they were hit by this cold air, they had to stop and put their jacket on, and later, stop and take it off.

It is important to be able to MODULATE your body heat, by slight adjustments of your warm clothes. Don't stop and waste 2 minutes taking off a jacket. Take off one sleeve of your parka, as you are hiking along. If you are STILL too hot, keep walking and take off the OTHER sleeve. Take off one mitten. Stuff your hat in a pocket; then you can pull it out of your pocket and pull it back ON. It is important to be efficient in the way you match your clothes to weather conditions. Not just in Nepal, either.

WATER:
Up on Kala Pattar, or on Gokyo Ri - there was no water. But these were only 3-hour trips. On the hike up to Imja Tse, or over Kongma La (6-hour hikes) we never ran low on water. But there were streams if you needed water. We always brought along iodine drops, so we could purify local water supplies. I think I did that about 4 times in 35 days. Our water-filter provided good filtered water every morning and night, and many noons, too. Of course, sometimes there were delays while the sherpas thawed it out...

OVERALL:
- Would I recommend hiking in this area, the Khumbu area of Nepal, going up toward Gokyo Lakes and Kala Pattar and Everest Base Camp? Oh, my, yes. What a handsome and beautiful area. If you are a good hiker, you should consider this area for some of the best hiking and trekking in the world. Read the notes in my web-site on trekking, about other treks.

This was a great trek, and if you can spare 42 days, you can go to all sorts of great places, all in a row. But if you can't spare more than 22 days in a year, you can still go to places like these

- it will just take a couple years to see it all.

Would we recommend this kind of LONG 35-day trek to any strong trekkers?

Sure, but it would be best if you have already been on a trek, or can go with a friend who has been on a trek. Peter Owens would be happy to set you up with a full package, all food and staff and porters and equipment. Could you just go to Kathmandu with a couple friends, and hire a couple porters and go on a tea-house trek? Yes, you could, but I think you would have more fun, better food, and better health, tent-camping with Peter's cooks and sherpas.

This was not the same as any other trek, and not EXACTLY the same as a merger of Peter Owens' Gokyo Lakes trek with his Kala Pattar Trek, but similar to that, with some extra side-trips added in. Refer to Peter's website per http://www.Instantweb.com/p/peterowens

As that web site says, Peter can design special trips (as he did for us) in addition to his standard scheduled treks.

Peter Owens' Treks:
This is as good a place to say it as any: my wife and I have been on 11 treks total with Peter, and Sigrid has been on about 14 all by herself. Peter was too busy to come on this trek. But he gave us one of his BEST crews, with 3 great sherpas and Salamsing Tamang as Chief, and Tara Rai as Cook, and 4 great kitchen-boys, and a couple dozen porters. Every one of them was skillful and personable and helpful, and any one could cover for any other's job if needed. One day a porter was sick, and Salamsing lashed his pack on top of the porter's load and went racing down the hill with 100 lb. I didn't even get my camcorder out fast enough to record that!

A great and wonderful group of NICE GUYS! I hope to go trekking with them again, soon!

CONCLUSIONS:
We had a very good trek, and fulfilled almost all objectives, including not getting sick or hurt, and NOT getting anybody mad at anybody. We had about 30 days of great, clear weather, with great hiking, great views, and no rain. The last day, we almost got skunked out of our flight from Lukla to Kathmandu, by heavy low clouds, but the Yeti airlines pilot came in to land at Lukla when all other airlines had QUIT, and got us back safely to KTM. See at Appendix LLL.

WHERE NEXT?
I'm still trying to figure out where to go. I would like to bicycle around the Annapurna Circuit. This would be a tea-house trek. Not sure how much interest there would be in this. Starting on June 1 from Pokhara. It shouldn't take more than 24 days.

APPENDIX BC:

Battery Charging:

My text and circuits on how to charge up your camcorder batteries, were published about 10 March, 2001. It's posted on the web; Go to: http://www.national.com/rap

- and click on E.D. Columns, and it's easy to find my columns, and the column, "What's All This Battery Charging Stuff, Anyhow?"

APPENDIX D:

The old MINI-report". (Revision C.)

Date: Mon, 27 Nov 2000

Subject: Mini-Report

- Mini-Report on Trekking in the Everest-Khumbu area, Oct-Nov. 2000.

Hello, Friends: Here you go:

Ten of us guys flew from Kathmandu to Lukla on 11 October. We hiked from there up to Namche, at 11,600 ft., and went up higher and did a lot of hiking for a month, most of it above 14,000 ft. We hiked with Salamsing Tamang as our chief guide, and Tara Rai as our cook, and 3 sherpas, and 20 porters, and 4 kitchen boys, all engineered by Peter Owens' Asian Treks. (http://www.Instantweb.com/p/peterowens)

The moon was about full when we got to Namche. We had heavy rain for an hour on the evening of October 13th.

The moon was about full AGAIN when we got back to Namche. We had a little drizzle on the afternoon of November 12th, as we departed from Namche.

In between, NO RAIN AT ALL. Many sunny mornings, and great views. How's that for nice symmetry - and great weather?!

We had several objectives - including Gokyo Ri and the upper Gokyo Lakes; Kala Pattar and Everest Base Camp; Chhukhung Ri and Imja Tse Base Camp; and Ama Dablam Base Camp. We really did get to all of these. Most of us got to the top of Kala Pattar at 18,600', and the other trekkers got most of the way up, with great views of Mt. Everest and several other great peaks (Nuptse, Pumori, Ama Dablam, Tchola Peak) and several great glaciers. And we got to many other wonderful places that we never put on our wish lists!

We wanted to go up to Chola La, and Kongma La. Chola La was too much of a climb, and too far from our trekking route, so we did not quite get there.

But all of us who wanted to, made it over Kongma La, an 18,200' "short-cut" pass from Everest Base Camp to Chhukhung. (OK, I was the only one who wanted to. It was beautiful, and worth the effort.)

We visited a few dozen handsome, small, high Nepalese towns, and some of the excellent trails connecting them. (And some of the lousy, rough trails, too.) We did a LOT of cold-weather camping, with morning temperatures between 8 and

38 degrees F. But the weather for hiking was usually excellent.

Nobody got hurt or sick. (One person had some altitude sickness, loss of appetite, and sleeplessness, and had to retreat to lower altitudes.)

It's surprising that despite all the advice and medication, some people just can not beat the altitude problem.) (Another person THOUGHT she had altitude problems, and descended before we could talk her out of it.) Nobody got gored or pushed off a trail by a yak. (We saw about 100 yaks every day, and some of them were pushy....) Nobody had his boots fall apart. Nobody even got a BLISTER on his feet!

We planned to see the first day of _Mani Rimdu_ at Thyangboche. But the first day, not much was actually happening, just a big BLESSING ceremony, and by the second day when the morality play got going, we were 10 miles away, nearly at Lukla, waiting for our plane. Fortunately, the day BEFORE the first day, there were rehearsals of some of the dances, and we got to see plenty of THAT.

Our recording altimeters said we ascended (and descended) 55,000 ft, and I figure I did 20,000' more than THAT. Almost every day, we had opportunities for short or long afternoon hikes.

Four of us had camcorders, and carried solar panels to charge our batteries. I got about 25 hours of video, which will take up a big chunk of my Christmas vacation, trying to edit it down to an hour or two of good stuff. Several trekkers asked us, "I left my camcorder home because I couldn't figure out how to keep my batteries charged. Tell me how you do it." Report is available on request, about February 8; see Appendix BC above.

The book by Jamie McGuiness (Trekking in the Everest Region) available from Amazon.com and elsewhere for about $16, was an EXCELLENT guide, and we recommend that.

We engineered this hike so we could see EVERYTHING, and not miss any great places because we didn't have enough time. Some treks go to Kala Pattar, for example, but don't have enough time to go to Everest Base Camp. We had plenty of time to do every- thing RIGHT. It was wonderful.

(If you are interested in the MAXI-report, it should come out about January 10. If this mini-report was addressed to YOU, I'll send you the Maxi-report, too. If your name was not on this, just ask for it. I'll try to get it posted; but sending this costs so little, I'll send it out, and if you are not very interested, you can delete it, not a big deal. It's not like sending paper....)

For any inquiries about the GREAT hiking in this region, you could ask me, but also take a look at Peter Owens' web site listed above. Peter has several 15-day treks in this region, every year, to Kala Pattar and Gokyo...

Best regards. / rap and friends... / 22 xi 2000

P.S. - we are already thinking about plans for our next trek. Noah wants to go to Mt. Kailash; Nancy is interested in going back to Mustang; I am curious about Dolpo, or maybe going around the Annapurna Circuit, by bicycle. Sigrid - Sigrid has already been almost everywhere!

P.P.S.: When we left Singapore, it was Nov. 18, and when we got to SFO - it was - of course - Nov. 18. I told Jim, while we waited at the baggage claim, " This is Ground-Hog's Day. If you don't live it right, you have to go back and do it again. You may have to go back to Lukla and break rocks while waiting for a plane...." All he could do was GROAN.

APPENDIX E:

Extra Equipment beyond Peter Owens' List:
Recommended by rap:
Pillow-case; New watch batteries; only new water bottles. Decongestants.
Postcards from your home area. Whistle. Hip flask & holster for water.
(Bring to Kathmand

THE BEST OF BOB PEASE

Midi-Report on Climbing Mt. Fuji In Japan

What's All This Mt. Fuji Stuff, Anyhow?

Hello to friends:

- I'll throw in some notes on a recent hike I took up Fujiyama. A piece of cake, except for some minor details - such as - doing it between 10 PM and 5 AM.

This report on Fujiyama shows MOST people how much they are missing of pain and misery if they don't go up; but for strong hikers, no big deal. Still, any time you start at 50 feet elevation, take a bus up to 7400 feet, and then climb up 5000 feet more, the conditioning and acclimatization is NIL, and the possibility of altitude sickness, to one degree or another, is always there.

Subject: Final Draft --- NOT copyrighted. Pass it along to anyone who is interested

Technical Report on Mt. Fuji hiking, by Robert A. Pease.

- a tale of a "typical" walk up Mt. Fuji, July 16-17, 1999.

What's All This Mt. Fuji Stuff, Anyhow?

Once upon a time there was a darned fool named Bob Pease who decided that the next time he went to Japan, he wanted to try to climb Fuji-san.... (It is more correctly called that, than Fuji-yama; but this "san" is not the same "san" as in addressing an honored person or friend.)

When I was invited to Japan to lecture at a Nikkei Business Publications Conference in July, I started to do my research. And to do enough exercise so my legs would not give out too quickly.

At the end, I was climbing 30 to 60 flights of stairs, every day, at the high-rise hotels.

Mr. Sunohara (formerly of NSC), told me several web-sites about climbing Mt. Fuji. I saw a good write-up in United Airlines' HEMISPHERES Magazine, May 1999, and they recomended several other web-sites. See at end. I got some advice about all the insanity involved, from Mark Levi. He made it seem plausible despite the crowds, and the crush, and the hiking around in the dark.

Mrs. Tomoko Mizushima, the wife of my old-time friend John Mizushima from Takachiho Koheki, also gave some advice. She has climbed the 10 highest mountains in Japan, and she said she would be happy to recommend several other nice hikes that are much more pretty, green, and scenic. But, she observed, of course I was going to be climbing Fuji-San - because it was there - right? I replied that of course she was quite right. That's the way I am - and she could tell. She understands many men, quite well!! But, NEXT time I will ask for her recommendations for nice hiking. Fuji-san was not just a pleasant stroll, unless you are a very strong hiker. Even then, you can never be sure how the high altitude will hit you. But it was very impressive, as expected, and a great experience.

I got a little advice from Ichirou Anzai at NSJ. Then I was introduced to Douglas Waggy, also in National's Tokyo Office. He's climbed Mt. Fuji several times. He gave me several chunks of advice, and answered my questions, until I was comfortable that I could climb it safely, if I did not get any bad health, bad weather, or bad luck.

Then Doug decided he could come along and climb with me. We planned a departure from Shinjuku station, the busy and popular train station on the western edge of Tokyo, about 7:30 PM on July 16. I could have started earlier than that, except for two items: Waggy-san was not able to get out of work any earlier than that, and there were no busses between 8:30 AM and 7:30 PM. A 2 PM bus would have suited me fine, but there were none. (If you can understand the Japanese language well, you could easily take some trains to the desired town at the foot of Fuji, and get a bus or taxi up to the desired trailhead. You could do this at almost any reasonable time of day, or time of year.)

So I had a good supper at 6:30 PM and bought a couple beers (to help keep me hydrated and also to get me sleepy on the bus), and Doug and I started out on the west-bound express bus at 7:30. Price in 1999 was Y2600, about $21, not bad.

NOTE: the comprehensive LIST and posted CHART and MAP of all bus stops in the Shinjuku station area covers a large number of local and long-run busses, and in 1999, down near the bottom, is listed bus stop #50, which is the Keio Express Bus Office. This is clearly shown on maps. They have busses to cities such as Nagoya and Osaka - and to Fuji Go-Ko (Fifth station). The bus may actually leave at the nearby bus stop # 26, so you must be prepared to move over to a new place. Don't be surprised by anything!

The guide books said that it would take 2-1/2 hours for the bus to get up there. I was sure it would take at least that long, but traffic was light. At 9:28 PM we stopped. Was this some kind of intermediate stop?? Not so. Time to start walking!

I bought a handsome octagonal walking stave (with noisy jingle bells on top, which I pulled off carefully, PRONTO) for $8, because I had mis-placed my jointed walking stick. I could have paid 200 yen to get this stick branded at EACH station, but I refused to pay. I did get it branded for 300 yen, at the top. Hey, I couldn't have gotten a brand on my good METAL walking stick! This walking stick was a 1-inch octagon, a full 59 inches tall. I usually set my hiking staff at 51 inches. This one was ok for downhill, but too tall for up-hill. Don't let the guy sell you one longer than you want, just because it is a bargain!

We started off on a 1% downgrade. Soon we could see most of the road in the dark. It took only a BIT of peripheral light from any of the hikers' flashlights, to see how to go, as the road was very smooth gravel. Shortly we started up a grade. Though the night air was around 12 degrees C, we started at a nice comfortable pace. Didn't get cold, even in shirt-sleeves. The pace gradually got a bit steeper, then rockier. We passed the sixth station which just had some safety advice, brochures. Then it began to get steeper and rockier and rougher. It began to get hard to pick your steps. If it were in daylight, it would not be a big deal; you could easily see a good place to step, a good route. But at night, it was definitely challenging. I found it hard to maintain my balance on some of the difficult steps. Normally I never have any trouble with balance, but I began to wobble and lurch between steps, just occasionally. I think it was just another aspect of trying to hike by flashlight. About every 2/3 mile, when there was a hut, they had a big floodlight, and then we could easily see where to walk. (Floodlights and coin-operated vending machines were powered by gasoline generator sets at each station.)

Fortunately, after about half a mile of rough, rocky, steep steps, it became less rough, and reverted to an ordinary trail. It was mostly wide enough for two columns of people to walk side-by-side - basically, two lines of slow traffic. Often one line would stop, and we tried to stay in the other lane - the passing lane - because the slow lane just had too many stops. But the slow lane had better packed dirt to hike on - less rocks and scree to trip over.

This continued most of the way up, until daybreak. Namely, at least half the time, from the 6th station onward, there were crowds, small mobs, and minor delays. Not a disaster, but a definite slow-down.

About 1 AM, we got hit by a little rain. Fortunately, after I got my raincoat on, the rain stopped. An hour later, it rained for another minute. And quit! We were REALLY lucky with the weather.

The trail was just steep enough, and the pace JUST slow enough, we were able to keep warm, and not get too tired. (If you went up in the daytime, it would definitely be warm hiking!)
Just before daybreak, you could see the sky starting to lighten up in the north, then in the northeast. (For the whole night, we could see the lights of towns in the valleys below us; and the dim glow of clouds 40 miles to the northeast, lit up by the distant lights of Tokyo and Yokohama. But not lit up quite enough for hiking without a light.) IF it were perfectly clear, you could probably see the skyscrapers of Tokyo, but we don't expect that very often in the summer.

The books all say that the busy, popular climbing season is in July and August - especially in the vacation month of August - but they neglect to mention that this is also the rainy season. If you got started up and got a LOT of rain, that would not be much fun. I don't know your opinions on hiking in rain, but I don't find it fun at all. Hiking up Fuji in the rain - well - you know what they say about owning a yacht: like standing in a cold shower, tearing up thousand-dollar bills... Same darned kind of no-fun. If you happened to be in Japan in June, you might avoid the chances of rain and most of the crowds. Or in September. But then the huts would not be open. Still, for a long day hike, (well, NIGHT-hike) it is NOT that big a deal to carry your water and munchies.

I carried up a LOT of water. I was well hydrated with beer and coffee and noodle soup, when I started up. I was carrying 5 liters of water, plus a can of beer plus a can of iced coffee. I drank about half of that, and kept WELL hydrated; even though I kept getting thirsty, I just drank away - to lighten my load. I carried about half that water all the way up and down and back to Tokyo. It's nice to have a big safety factor. I could have bought water or juice or similar, at any of the huts. About Y300 or $2.50 for 10 ounces. Pretty steep, but not any surprise. But I didn't buy any - I had plenty.

I went to the toilet at the last bus stop, at 9:50 PM. And at the top - and then down at the train station at 4 PM. The air was drying enough, I never did have to go to the john more than that. Despite drinking at least 3 liters. So, as on any tall hill, keep pouring that water in. Keep well hydrated. Meanwhile, don't leave all your change behind - bring several 100-yen coins to make a contribution at the toilets. Bring enough money for food or drink in case of delays.

Every time we came to a hut, there was typically a crowd of 100 people. Some were just hanging around; some were ducking inside for shelter or food or rest. We tried to go to the upper end of the crowd, above the hut, and get a minute or two of rest, and drink some water. Then I'd propose to my climbing-mate, "Do you want to start up in 4 minutes or 2?" I think this is a good way for a small group to go up a hill: as soon as you stop, try to agree on how long you will rest and stay before starting. If one guy proposes

2 minutes and the other guy says, "I need 10 minutes", you can sense each other's condition. Doug and I were in pretty good synch. Even though some strong hikers would go hiking past us, we knew were doing OK, and if we kept a nice slow pace, we would get up there. Hurrying is definitely a bad idea. This is another place where an experienced hiker can use good judgement to not go too fast.

I never did get seriously out of breath. My legs never did get extremely tired. That's because I was holding such a slow pace. All the way up. I was working on the classic trade-off of air, legs, and time. If you don't do anything foolish, you will get there.

When we stood at the top end of the crowd at a hut, sometimes we were able to get started a minute before 100 people all started up. That is a lot better than getting started JUST as 100 people are suddenly starting up - or just behind them.

HUTS: The Fifth Station (Go Gome) at Kawaguchikoguchi is a bus-stop with shops and hotels that stay open all the time, in the high season. The sixth station is just a safety check-point with pamphlets in English and Japanese. Not sure about other languages. Here's where it gets complicated: the "seventh stage" consists of about 4 huts, and the eighth stage also about 4. None of them are labelled or signed worth a hoot. Maybe people who can read Japanese well, can tell where they are at. Even Doug Waggy, who can, was a bit confused. Even if we had had a map, it would have been hard to tell where we were, in terms of making progress. A good altimeter would be useful, to tell your progress.

Adding to this is the factor that, after 4 stations at 7 and at 8, there is not any 9th station open. By then we could see the TOP, but it was hard to believe we could see it.

Somewhere around the 9th stage was when the daybreak began. About 3:50 AM. We could see we would not be at the top for sunrise - but, we knew we were not in trouble. We'd get there pretty soon.

For some reason, Doug was getting tired and cold, and his stomach did not feel very happy. Altitude. We sat down. It was a good time to take pictures for the daybreak. Doug was getting a bit tired and shivery, and he was not in a mood for eating or drinking, even though eating a bit of high-energy food would probably be good for him. After a few minutes of rest, we got good pictures of us, and of the sunrise. Which was beautiful and GLORIOUS. Very fine sunrise. The sky was pink and orange and red for over an hour.

Then we resumed the ascent. Slowly. (Most people who were ahead of us before daybreak were storming up to the summit, trying to make speed. Most people below us were slow, and pacing themselves.) At sunrise, we were still just 500 feet below the summmit. Nobody who was actually on top could possibly see any better view of the sunrise than we had!

Could we have gotten to the top in time for sunrise? If we had had NO slow-downs due to traffic, possibly. The sunrise was at about 4:30, and we got to the top about 5:00. But it's hard to say - if we had not had so many slow-downs, we mightta gotten MORE tired, and gotten in other kinds of trouble. A really strong and/or lucky hiker can make it up from the 5th station to the top in ~ 6 hours. All the rest of us have to take in the great sunrise from a mere 12,000 feet, or lower, if we do not get a start before 10 PM. I am convinced there were only 1400 people above us at 4:30 AM, and 300 below us. If it were HIGH season (wait 2 or 3 weeks) the numbers could easily DOUBLE. There were at least 15 or 20 busses in the parking lot at the 5th station. A LOT of people. And I think the parking lot was just 1/2 full. Conversely, if you avoided a weekend, traffic might be MUCH lighter - but maybe not in August.

Ascending above 12,000 feet, I saw an old gentleman who was nursing his leg cramps, and his daughter was helping him rub them. I gave him a couple potassium tablets, and I was sure he would feel miraculously better in a few minutes. Potassium gluconate is really good for cramps. If in doubt, take along some potassium pills. I always do.

We eased over the last bit of the hill at 5 AM, through the Tori gates. Not a bad hill. Doug was feeling a bit tired, so we went into one of the huts, and he took a nap, sitting up, and I finished off writing my postcards - about 25. I was torn between trying to stay awake and write, and taking a nap. I think I got 5 minutes of nap. Combined with 5 minutes on the bus, and 15 minutes of nap down near hut 7 on the descent, that was about all the sleep I got. It was enough. (Until we got down to the 5th stage, and had to wait an hour for the bus; and then I got a good nap, almost an hour, lying flat on the parking lot.)

After an hour I tried to find the post-office - it was alleged to be 20 minutes south. (CW around the crater.) Yes, I hiked about 18 minutes south, past the telephone office, to the area of another store/hotel, shrines, and post-office. I mailed my cards in the post-box. NOW - should I continue around the crater - or go right back? NAW - I'll keep going. I ascended (CW) to the highest point, up by the weather station. Good views into the crater, about 1000 feet deep, with some snow in it. (There had been a few patches of snow on the NE slope, about 12,000 feet.)
Some views over clouds, off to the south and west. Then back to the mini-hotels. Met up with Doug. We agreed it was time to start down. I had a good sun-hat, and put on some sun-screen. I shoulda put on a LOT of sunscreen, as I got a bit of sunburn. The sky, even though overcast, lets through a LOT of ultra-violet at those altitudes!

Clothes: I had a wind-parka and a rain-poncho and a inner wooly jacket, and stupid cotton gloves, and I used all these, and when the cool winds blew, above 11,000 feet, they felt good. I had a wooly hat for cold weather, and a sun-hat, and I alternated those. I also had 3 BIG garbage bags, in case we had to hunker down in bad rain, and I had 2 shirts and an extra pair of pants, and socks (which I could use for mittens), and these I did not use. But I had some good safety factors.

I had two good little flashlights, using AA cells. I think I used less than 1/2 of a set of batteries, by using alternately the light of others. Don't bring just 1 flashlight and spare batteries; bring two flashlights, as bulb life is iffy.

NOTE: Unlike any other mountain I have been on - the trails on this hill have different routes for uphill and downhill. So we started down a zig-zag trail of gravel - actually a tractor road, where the caterpillar tractors bring up supplies, food and water, every day. We started down about 9 AM. The walking was on soft gravel, not hard, but not exactly easy, either. Hey, if you are going to descend 6000 feet, that is a brutal amount, but this was a relatively easy way to do it!

We kept passing some of the huts we had passed on the ascent. They did not bear much resemblance to the confusion we saw on the way up. Weird!

Further down we started down a straight descending trail. The trail to Subashiriguchi. Every step was a nice 6-inch step down plus a 4-inch slide on the gravel. (I read that the Gotemba trail has faster slide trails.) Half an hour on this was making good progress - but quite wearying. And again and again. We had to stop every 10 or 15 minutes to empty gravel out of boots, despite our care.
The nap at 10 AM felt good. By noon we were down at an unofficial rest stop, still above the
5th station - maybe station 5-1/2. I drank the beer I'd carried so high and far. Good stuff. Then about 1/2 hour hiking through woods to get to 5th stage.

(Caution, try to avoid bumping into foliage on this stretch, as I got a bit of poison-oak-type-of-allergy from plants I could only have contacted here.) (There were NO plants up above the 6th stage - quite barren...)

After almost 2 hours of wait, we got a 3:00 PM bus ride down from the 5th station at Subashiri, directly down to the town of Gotemba, right to the train station. What was the fee, about $10. The bus driver had a speed limit of 30 km/hr, about 18 mph, all the way down. BORING, to drive for an hour at 18 mph!! (It was tempting to hire a cab, but that might have cost $80.) At Gotemba, the JR (Japanese Rail) ran in two ways. We could have gone down to Numazi, south, along the sea, but decided to take the more direct route east to Tokyo.

We'd just missed an express train to Shinjuku, but we took a local train to Nazu (about $5), and then changed to another train that ran through Yokohama to Tokyo. We arrived at the 5th stage at 1:05 PM, took the 3:00 PM bus down and arrived at Gotemba at 3:55, and took the 4:13 train north. The train ride was pleasant. It was a local train, and had about 24 stops on the way to Tokyo. Still, we got back to Tokyo less than 22 hours after we left.

When we got in there, Doug called his wife to try to find me an inexpensive hotel. Hey: when we started, there was NO WAY to GUESS when I would be returning. So I could not exactly book a hotel room for my return. I was prepared to get back on Saturday - OR Sunday or Monday. Whenever I got back, I would not complain. Doug's wife booked me in at the YMCA on Hongo-Dori - not far from Kanda station. BUT as of 2004, this YMCA is closed. Ask me and I can tell you a couple other inexpensive hotels or a YMCA or a Hostel.

Would I recommend the Mt. Fuji hike for good hikers? Yes, for any experienced hiker in good shape. If you are not fairly strong or in good shape, you might get tired, have an accident or fall. If you are not experienced, you might also not recognize what is going on. It would help to have a friend to go with. It would be nice, though not essential, to have a friend who can read and speak Japanese. Bring LOTS of water, and a little food. It would help if you can get an encouraging weather report, and/or bring a good full set of foul-weather pants and coat. AND a cover for your knapsack, so it will not get its contents soaked.

Is this an adventure? - yes, a very good one. In the whole "theme park" of Japan, this is one of the great adventures. I'll recommend it to good hikers. I'd even recommend it to my wife - but she would greatly prefer the day-time ascent! (The night-time ascent is often favored, because you get to see a great sunrise from the top; and the hiking at night keeps you warm, yet you avoid hiking in the daytime when it can get quite hot.)

Food: I brought crackers, cheese, sausage, chocolate, nuts, and I ate almost none of that. On the ascent, I just ate a few Kit-Kat sticks, and they really were comfort-food - they made my tummy feel good, and seemed to give me energy. Inspiring, on a cool uphill.. I don't recall eating anything at the summit. But down at the 7th stage, I ate a few more ounces of chocolate. Soul food! I never did get hungry 'til the next morning! Except I did enjoy an ice-cream-cone down at stage 5. But I was glad that I had plenty of food and snacks and munchies, in case of a delay.

Boots: I had a new pair of good heavy hiking boots, but I left them home and took my old worn-out ones. They are very comfortable, and I didn't care if they got ripped up. (They didn't.) I considered wearing light hiking shoes, but they would have been ripped up badly by the rocks and would not have protected my feet so well. I think the heavy boots, despite their weight, are better. You can do what you please - but don't be surprised if the lighter boots give problems on the rough rocks.

Which trail??? Most books say the best ascent for a first-timer is to take the Kawaguchikoguchi Trail. Others say the standard approach is the Yoshidaguchi Trail. Don't be too confused:
If you are ascending on the north side, the express bus will bring you to the trail-head at Kawaguchikoguchi 5th Station, and you start up on the trail of that name. If you start up from the bottom at station 1 (most of us do not) - that is the Yoshidaguchi Trail.

These trails join at the 6th station, and become the Yoshidaguchi-Kawaguchikoguchi Trail. Don't be surprised to hear it called by any such name. This trail goes up the Northeast corner, giving great views of sunrises, like a huge theater. This trail from station 5 is "only" about 5 miles, and ascends "only" 5000 feet. If we could do the standard AMC trail time, that would take about 5 hours. We took about 7 hours, which is not bad for hiking above 10,000 feet with no acclimatization and heavy crowds - by flashlight.

Be VERY careful when planning your descent. We took the Subashiriguchi Trail down. It goes due east from the 8th station. This trail stays merged with the Yoshidaguchi-Kawaguchikoguchi Trail down to the 8th station, which in itself is a warren of cross-trails and of at least 4 huts. No, in detail there are about 6 huts: Hakuunso, Gansomuro, Fujisan Hotel, Tomoekan, Munatsukiedoya, and Edoya. These are surely not labelled in English, and probably not clearly labelled in Japanese. But if you know the names of all 6, you can ask, which one is this?. Then you can refer to the map. Our descent was 5900 feet, and took barely 4 hours.
Be sure to get on the trail you want, there. The descending trails will generally NOT be the same trail as the ascending trail. So don't be surprised if they don't look familiar.
We met one unfortunate guy at the foot of the Subashiri trail (down at 1980 meters), whose car was over at the Kawaguchikoguchi trailhead. He had no money with him. His cell phone was back in his car. He did not have much choice but to climb back up to the 8th station at 3250 meters, to get to his car. So that is what he was going to do - climb back up 4000 feet. Pain. One book says there is a traversing trail that goes around the base of the mountain at the 5th-station level. Maybe there is, but it is not marked with signs nor on a map, so don't count on that.
We could have taken the Gotembaguchi trail, which goes down to Gotemba via the southeast angle, starting from near the Telephone building at the south edge of the crater, but we did not. It is alleged to have steep gravel slides for a fast descent. The other trail is the Fujinomiyaguchi Trail, which leaves south from near the Post-Office. There are no trails on the whole western half of the mountain. (If you are not very well versed in Japanese, the common thread here, "guchi", just means "entrance". The name of the trail is often given without the phrase "Guchi" at the end. Don't be surprised at anything.)

Be sure to get a decent map of the mountain. (I could give you an adequate photocopy.) Many maps that you can buy or scrounge have no contour lines, or are extremely vague. Most are only in Japanese, not labelled in English. The map I have is a folded sheet, double A4 size, about 8" x 12" with a handsome blue-ish color photo on the front, showing a lot of switchbacks. It is labelled "Climbing Mt. Fuji". I got a free copy at the foot of the Subashiri trail. I sure wish I had had it before I started! Inside are maps nicely double-labelled in English and in Kanji:
- a map of the whole upper mountain with the 4 major climbing trails; a detail map of the summit loop around the crater; a fine-detail map of the area around the 8th station, so you can go down the correct trail. And a transportation map on the back cover, showing all the roads, trains, and access routes.

References to add: web sites from HEMISPHERES, and from Mr. Sunohara:

http://www.city.fujiyoshida.yamanashi.jp/div/english/html/index.htm

http://www.sunplus.com/fuji/guidej.htm

http://www.sunplus.com/fuji/livej.htm

- I have checked this typing recently. URLs seem to be working.

At least one of these sites may be inoperative. At least four of these have good info in English, and some are mostly in Japanese, but some of the pictures are nice.

There is a good guide-book that I bought at Amazon.com, about $25. It just had 3 pages on Fuji-san, but it had MANY pages on other good Japanese hiking, so for that I'll recommend it for my future hikes. That is by Paul Hunt, "Hiking in Japan: An Adventurer's Guide to the Mountain Trails".

In one of the web sites, I read the story of a guy who took 10 hours to get up to within 400 vertical feet from the summit. He gave up and went back. Maybe he was feeling lousy... if you are, that is a wise thing to do. But when we got a few hundred feet from the top, we knew that a slow-but-steady pace would get us to the top. No problem.

Etiquette: There seems to be no special etiquette on the mountain, compared to the rest of Japan. It's bad form to fall down in the dark and bump into people. It's bad form to go out into a passing lane and then stop or slow down, if you have any choice. Most hikers are fairly polite, and wait until their line moves, and do not wedge (excessively) in front of other climbers, in lines. Passing on an alternate path is OK, and maintaining the two lines of ascent seems to work OK. The normal path has the best footing, but the hikers seem to do a lot of stop-and-go. The passing lane is usually rougher footing, but does not do so much stop-and-go. If you are a strong hiker, it goes OK. There is no special greeting between us "pilgrims". "Konbanwa" seems to work OK, at night, or "Ohayo gozaimasu" in the morning. I tried "Namaste", and got nice replies of the same! "Hi" or "hello" is almost universal, especially for greeting westerners. I think about 2% of the hikers were some kind of gringo. About 40% of the climbers were women.

Breathing: I suggested to Doug that he try breathing through the nose, one full breath per 2 steps. He said that did make him feel better. I often do that at elevations above 7,000 feet, as the enforced rhythm helps keep you moving and breathing; and that helps you avoid drying out your mouth.

When I came off the mountain, and got on the bus, I felt pretty good. The next day I got up and still felt good. But when I actually started walking around, my legs did feel a little sore. And the NEXT DAY, they STILL felt sore. But not too bad. I did have a little headache on top, but only a very tiny one, not much of a bother. It sorta went away as I descended.

If you have any questions, feel free to ask me. This is intended as a guide for any English-speaking person to figure out what is going on, and solve some of the mysteries of hiking in such a strange yet wonderful place!

Respectfully submitted,
Robert A. Pease, Hiker
rap@galaxy.nsc.com
(Comments invited.)
20 July / 2 August, 1999.

*** Here are some comments from John and Tomoko, with suggestions for other nice hikes in Japan:

>From John

Date: Sat, 7 Aug 1999 21:18:21

Dear Bob,

Sorry! It is delayed to reply to your question, but my wife Tomoko was in her home town for two weeks; this morning she came back home.

I hope her recommendations are in time for your final version of your text. *** I think so./ rap

She asked me to tell you two mountains for hiking which are located near Tokyo. They are not so tough for climbing, but you can enjoy good flowers and good mountain views in season.

One is "Takao-san (mountain)" which is suited for one-day hiking.
Some people say going there is not a hike, just a picnic.
And there are many paths in Takao-san area for hiking.
It is the best to go there during April 1 to the middle of May.
And you can enjoy unique Japanese flowers called "Sumire", a kind of violet.

Another is called "Kumotori-yama (Kumotori mountain)" and this is suited for two days of hiking. This is more tough than Takao-san for climbing.
A guide book tells us you will walk four hours and 10 minutes at first day and three hours and 45 minutes at second day.
*** (Can't I do that in 1 day?)

July first to end of August is claimed to be the best time for enjoying.

Above two areas are located in Tokyo metropolitan. So it will only take one and a half hours to two hours for going to the foot of these mountains by train. *** (Can you tell us what STATIONS?) &&&&

The last one is called Japan South Alps and Yatugatake mountain area.
Maybe this area is suited for two to three days hiking.
There you can see Fuji-san from the different view-point too.
By using a limited express train (not Shinkansen) it will take two hours to go there from Shinjuku Tokyo. You can enjoy traditional Japanese views in mountain and local towns also.

Tomoko listed these above three areas which are a little bit easy for you to go from Tokyo. Of course there are other good places too.

Please tell me if you have further questions and need specific information.
I will try to get it.

Thank you and best regards, / Tomoko and John Mizushima
----- End Included Message -----

*** My comments: John, I will surely check out 1 or 2 of these big hills, the next time I can. Thanks to you and Tomoko for your help and advice. / rap

....

Some of YOU guys are serious hikers - and you might actually wind up in Tokyo, trying to climb a mountain - here's something to add on the end of my Notes on Climbing Fuji-san:
....

Shopping in Tokyo.
I wanted to buy some hiking supplies in Tokyo, and I didn't know where to buy them. Reading in the Yellow Pages is NOT gonna work for me or you, though asking a Japanese friend MIGHT help. Finally, I was shopping around Shinjuku. A helpful clerk at a hotel told me, "Takashimaya Department Store has everything!"

Here's how to find it. Go along the Shinjuku station, inside or out, on Street level. At the south end, there is a very broad one-way street (Koshu-Kaido) and right over the tracks, there is a broad crosswalk. Cross to the south side of the street - away from the station. You can look out over huge expanses of RR tracks. Over on the left of the tracks is a big set of buildings, 10 stories high.

Go left (East) perhaps 100 yards, and you can see a train station - this is part of the JR (Japanese Railways) station. Turn right, (south) and walk past the station - on the EAST side of the station. When you get abreast of the station, STOP and look East, over the railing.

- Down on the lower street level, you can see a compact store that sells camping equipment, skiing and hiking equipment. Stoves, ski poles, hiking sticks, etc. THIS is a SECOND good place to visit.
- First, continue to walk south and enter the Takashimaya Store. In 1999, the hiking/outdoors/camping equipment store is in a little boutique or specialty shop, at the FAR south end of the 5th floor. This, too, had surprisingly good selections, and I had a choice of walking sticks, ropes and cords, rain gear, etc., all at reasonable prices.
- It's only about 5 minutes to walk from the one store to the other store, so you may easily want to visit both. These places are only about 12 minutes' walk from the bus station, so if you are planning to take the bus from Shinjuku to Mt. Fuji, this is really pretty convenient.

There may be bigger and better stores in Tokyo, but this is "good enough". Pretty good for shopping for hikers.

Best regards / rap / September 1999.

Return to Directory

THE BEST OF BOB PEASE

Invitation to our NEXT TREK

I know a lot of you guys will really be interested in this next trek I am proposing to lead; I already have a few people very interested. Sigrid and Nancy and Noah? No, not exactly! They wouldn't touch this with a 10-foot pole. No, Hideya and Matt and Eric. Maybe Jeff and Tom and John. We're planning to go around the Annapurna Circuit by mountain bike.

This trek will be much shorter, and much cheaper. Even if you have to buy a new $400 mountain bike, this will barely cost $1200 plus air-fare.

I did look at a lot of the photos from this trek in '97. Most showed LOVELY smooth trails. Some showed narrow trails; others showed steps. Some places we recall very well were rough and rocky; many places were steep hard work, whether on foot or by bike. Not a big deal. We will go down from Tatopaani along the Kali Gandaki River, to Beni and Baglung, to avoid the 7,000 + 7,000 stone steps going through Ghorapaani.

NOBODY in his (or her) right MIND would want to come on a trek like this - UNLESS they were an experienced and skilled and fairly strong mountain-bike rider. My friends and I hiked up to 17,781 feet at Thorong La, just north of the Annapurnas, in Nepal in 1997. See complete write-up:

http://www.national.com/rap/nepal/index.html. It was a great trek.

Now I want to ride around this whole 150-mile loop - the Annapurna Circuit - and all around those BEAUTIFUL HIGH mountains, and over that pass, on my mountain bike, with a few friends - and maybe with you, or a strong, competent mountain-bike rider you know. This will be a good 25-day trek, not nearly as long as our recent 45-day trek to Gokyo Lakes and Kala Pattar and Everest Base Camp. About 50% less expensive, too. But we can make a lot of miles per day, and still have plenty of time to stop and take photographs of every great view, and stop off and wander around every handsome Nepali town we ride through! And still get to our tea-house early.

The scenery is glorious; the weather at this time of year is usually OK just before the monsoons. Start about 24 May, going home 19 June. We are sandwiched between our 2400' start and the 17,781' pass, and our 2400' finish. Don't worry about the altitude, as we will be going up so slow we can easily handle it, by good acclimatization. So, if you like biking on wide and narrow trails, and steep and shallow, inquire.

Some people have said that you have to carry your bike 50% of the way, but that would be true only if you were VERY stupid. Other people say you have to push it 5 or 10%, and carry it 5 or 10%. If we are good riders, I am sure we can keep each of those down well below 10%.

My wife refuses to come. Most of my hiking friends refuse to consider it. But if YOU are a strong and competent biker, just inquire to: rap@transtronix.com.

Space is limited. More soon./ Best regards / rap Robert A. Pease

*** (If you want to see more GENERAL information on trekking, go to my main web site: www.national.com/rap

- and look at the large amount of info on Trekking... info from our 1997 trek, that is still LARGELY up-to-date. /rap

P.S. - While I'm going to go around this circuit by bicycle, I absolutely do recommend Peter Owens' Annapurna Circuit trek for hikers. Refer to: http://www.Instantweb.com/p/peterowens

It is great, and quite inexpensive. I'm not at all mad at Peter, and I'll go back for another trek with him in '03. But this bicycle trek is just too good a challenge to pass up. / rap

THE BEST OF BOB PEASE

A Bicycle Trek - June 2002 - around The Annapurna Circuit

The Vision....

When we hiked around The Annapurna Circuit in Nepal in 1997, it was a wonderful hike, and quite challenging. Some of the trails were rough, some were slippery - but others were LOVELY! And some would be good for bicycling. We never went above 17,800', up at Thorong La. So over the years, I kept thinking about the possibility of a bicycle trek around that Circuit. We did other treksin 1998, and a full month in the Mt. Everest region in 2000. Why couldn't I set up a good bicycle trek around The Circuit in 2001?

The Permissions

As soon as I began to inquire about this trek, I began getting strange stories. Several people said, "No problem, you can just go. "But I kept hearing little statements that it is impossible to go up there by bicyle. After much haggling, we finally got in touch with ACAP, the Annapurna Conservation Area group, which is in charge of rights and permissions in that area, and upon close questioning, they stated that it is now impossible for foreigners to get permission to ride a bicycle up there. H'mm. Apparently as recently as a year ago, any tourist would be as free as a bird to go around there, with no special permit required; but now it was impossible. H'mmm.

Some of my friends in Nepal helped me get in touch with some Important People in ACAP. After much pointed questions, and many delays, and many confusing answers, we finally got a statement that a group could get permission to ride bicycles up in the Annapurnas, for the purpose of making a movie - a documentary film. Of course, there would be big fees for the bicycles, AND a big fee for permission to make the movie, and you could only ride up there in June or July, or January or February.Ahem. In January, the snow is only 5 feet deep on the pass, whereas in February it's 10 feet deep. And in June and July, the Monsoons arrive, making many stream crossings impossible.

So these old men (who probably never rode bicycles) in ACAP had made it substantially impossible to go bicycling in that beautiful area. I mean, I definitely wanted to take some video in that area, and I was willing to jump through hoops, but paying a fee of $2000 for a camcorder, or $20,000 for a movie camera, was a BIT MUCH....

The more the rules made it impossible, the more I wanted to fight the rules. After MANY conversations with some of the important guys in ACAP, I finally got a new interpretation. We could pay $10 per day, in addition to the usual $100 fee, and we did not have to pretend to be making an official movie. But we still had to get in and out in 14 days, maximum - and we could only go in June, July, January, or February. This was allegedly so we would not interfere or clash with the thousands of hikers that go around every year.

We sent our friend Kalu to the ACAP Office in Kathmandu. They told himit was impossible to get any permission, so if Mr. Gurung in Pokhara said he could get us permission, he would have to travel to Pokhara (a 6-hour bus ride) to arange the permission. Oh, these guys were SO helpful! But we did send Kalu on a trip to Pokhara, to carry in our money, and we got our permissions.

The Monsoons

We talked with Peter Owens, who runs many treks in this area. He said he knew some people who had gone trekking around the Circuit in June, and the weather was not necessarily bad. I talked with some of these people. They said that in June the rains are not always heavy. The rain was not very many hours in a day. They did not always have heavy clouds. So we would expect to see some peaks. Not all socked in.

So we figured, if the monsoons came on schedule, we should get around the Circuit by June 14 and not get very wet. If they came a week late, we wouldn't get too damp. If they came a week early - we'd just get wetter. We decided to go for it.

The Riders

The primary instigator was Eric Mack, who had done a lot of bicycle trekking across the Andes, etc. He was really interested in bicycle trekking over high Himalayan passes. When I told him that I'd been across Thorong La, and that it was bicycle-able, he was hooked.

Hideya and Matt worked right down the hall from me. I had not known they were such good mountain bikers. But they were. THEY signed up.

We had several other people who expressed interest - but they all pulled back, as they were not quite serious enough to want to go. Then Jeffrey Fisher, from the Atlanta area, got interested and he signed up. We all sent in our money for the permits.

And then - - Hideya had to stay home in respect for his dying father. Matt had to have two knee operations, for old hockey injuries. And Eric had to stay home because his company was having serious financial troubles, and he had to stay home and help his new boss raise funds. He had his air tickets and everything - and he bravely abandoned his tickets and pre-paid fees, and stayed behind to help his friends in his company. Sigh. So, that left Jeff and me.

And Kalu. When we started to plan this, I asked Kalu if he would like to come and be our co-ordinator. Kalu Tamang had recently led us on some other treks in Nepal. He is a great guy, and a great leader. We did not really need a GUIDE, as we knew we could not really get lost. But it would be fun to have Kalu along, as an interpreter. Kalu could ride a bike, when we first talked about this. In just a few months, he mastered riding a mountain bike, very well. He was, of course, terribly strong. He could ride up steep hills very well, sometimes even farther than Jeff could. And his technique was excellent. I could see him hold a line between rocks, sometimes even better than Jeff could. He was a VERY strong and steady rider. So we had a lot of fun, riding with Kalu. And dining, and goofing off.

Kalu, the Guide

Kalu's first value was to make sure we stayed at the best "teahouse" in town. This minimized the chances of us getting poisoned. Bad gastro-intestinal problems can not only make you feel miserable, but slow you down. We had very good dining. We did not get sick. He also helped us avoid the two or three places where it was NOT OBVIOUS where the main trail went.
He also helped us hire a porter, when we needed it. He also helped us lugour bikes across a few places where the trail was narrow and rough and lousy. (More on that later.) He helped interpret what we were doing in towns, etc - obviously, if we didn't have Kalu to explain, we would have had to put a LOT more time in learning Nepali phrases.

And Kalu was a good man, cheerful and friendly. A good friend. If you wanted to go around this Circuit with Kalu, there's about

10 reasons why you would want to bring him along. If you wanted to go around WITHOUT Kalu, you would make it, but you might have less fun, and more effort. Is there anybody else anywhere near as experienced or wise as Kalu, at bicycling around here? Not likely. If you want to hire Kalu, you should contact Peter Owens at peterktm@mos.com.np

The Travel

Jeff flew in from Atlanta, and I met him at SFO. It costs about $75 to bring a bicycle box on a domestic flight. Bringing a bicycle box on a trans-Pacific flight is - at no charge. Of course we had a pleasant flight from SFO to Korea (refuelling) to Bangkok (overnight nap) to Kathmandu. We were fed well and taken care of nicely on Singapore and Thai Airways. When we picked up our baggage at KTM, Peter Owens met us and helped us get carted to the Potala Guest House.

A couple days later, Kalu went over and talked to the bus operators. He hired a small bus that would easily carry us and supplies and bikes, to the start of the ride. He only had to pay $90 - if WE gringoes had gone to hire a bus, it would have cost us a higher rate.

Training Rides

As soon as we got settled, we planned to go on some good practice rides. The first morning, we started up to Bhaktapur. (Tip: don't take the main road, crowded with nasty stinky traffic, but, take the side road through Thimi.) Then we went up 1600' to Nagarkot. The weather was nice and cool and in fact slightly drizzly. We started out fine, but I had stupidly neglected to bring my potassium pills with me. I got leg cramps on the shallowest grades, and I had to walk up a lot of easy hills. I was embar- rassed. I was sure the others were thinking, "Boy, are we in trouble if Pease can't make it up these easy grades". But at the top, we had some lunch, and then rode down some good dirt roads, back to Kathmandu.

The NEXT day, we decided to go up Pulchowki, a 5000' ascent. It was afairly rough gravel road with rocks and sand. I had to push my bike about half the way, but I moved along OK. Jeff was very strong, and so was Kalu, but I didn't slow us down much. We got up as high as we could - and then we were turned back by polite soldiers at the new security gates. THAT day I took my potassium pills and had no trouble with leg cramps.

There was another good "training ride" we took, but AFTER the trek. We started up the road NW from Kathmandu, toward Trisuli Bazaar. This was a pretty good paved road without much traffic. After we ascended about 800', then the road ran off further to the NW. We rode for a few hours, but since it was getting cloudy, with no more chance of good views, we started back and ate lunch.

We then started on a woods road around Nagarjun, another tall hill overlooking Kathmandu. After an hour, the others decided to go back to town, but I decided to keep going. I thought I could take a short-cutto circle back to the main road. But I guess I mis-remembered the map, so I wound up at the summit at about 5 PM.

The view was glorious, looking down more than 1700 feet onto a view of Kathmandu, in the day's late golden sunshine. I walked around the summit area - temples, shrines, and great viewpoints, looking out through a cloud of more than two thousand colorful, waving prayer flags. Then, time to hurry down back down to town.

Another place that might make a good training ride would be to start from Naubise on the road to Pokhara. Take the Old Highway up to the high point and then down toward the Terai at Hetauba. The thing that is wrong with this is, the highway from Kathmandu to Naubise is fairly narrow, and crowded with many big pushy busses and trucks, and it would be EXTREMELY dangerous to try to ride down to Naubise, and even more dangerous to ride back up. You should get a taxi to take you down there, and wait for you until you come back. I really would like to ride that.

Another day ride would be to go out past Bhaktapur to Banepa, and then take the paved road up to Panautai. From there, the dirt roads go west, uphill and downhill to Patan and home. But I haven't tried that road.

Anyhow, there are many combinations of dirt roads and paved roads, around the Kathmandu Valley. In most cases, if you ride a long way out of town on a paved road, there may be a paved road just a couple milesaway, but the dirt roads are too tough to drive a car over there. But you can always ride a bike over there.

Just avoid the main road west out of town toward Pokhara - it's much too crowded with busses and trucks, and dangerous. The main road to Bhaktapur ain't much better. But it can be avoided.

Dining

As we discussed the eating facilities in the tea-houses along the way - I proposed that if we ate things that have been cooked good and hot, they are less likely to poison us. I ate a lot of fried rice and fried noodles, with meat and veggies and cheese, and they were VERY tasty, and we did not get sick. Dahl bhat (lentils and rice) was always good. We often had Roesti Potatoes. We often split a large beer with dinner.

For lunch, we usually got a good quick bowl of noodles with vegetables. This was very tasty and salty, and we knew we needed the salt. This was WONDERFUL!!

For breakfast I usually had pancakes - they had been fried hot, and they seemed safe. Of course, I usually put jam on them, or honey, and these had been hanging around in the open for several days. But maybe the extra sweetness prevented them from harboring germs...?? Since Kaluwas trying to choose the best tea-house in town, that probably helped.

Usually we each paid about 500 rupees for supper, 1/2 of a good bigbeer, lodging (a small private room), and breakfast. About $7.50 - agood bargain.

Bicycles

I had bought a new Specialized Rockhopper A1 FS (last year's model) and had practiced and trained and I had about 500 miles on it. It all worked well (except the seat occasionally started to get loose and tip, and we had to re-tighten it.

Jeff had his good old bike, a Cannondale 900 HT Killer-V soft tail with a spring-cushioned comfy seat, and it ran fairly well. Finally, his wrist-twist shift control got looser and looser, though, and the gears would slip up, and finally he clamped it into low gear. He was quite grouchy that it had gone bad. He also had a brake cable break, as we rode around the town getting ready to start the last day. That was a good time for it to break. We put in a spare. We carried lots of spares.

Kalu had rented a bicycle that was in fair shape, and it ran pretty well. He had no problems. He returned it when he was over the trek, though he had an option to buy it.

Uphills

We did Ok on uphill rides in general, but we got slowed down a lot on steep hills with rocky steps.
On moderate uphills, Jeff would ride, and I tended to ride a short distance, and then walk and push. I was not much slower going up-hill. The higher we went, the less I wanted to ride very much. However, as we went higher, I got stronger at pushing and hiking, and Jeff seemed to get weaker at that, so I was not weak enough to fall behind. But Jeff and Kalu were ALWAYS much better

riders, faster and stronger up-hill, and faster and bolder downhill. But I was strong enough and bold enough, to get there.

Downhills

We had a couple days of excellent downhill riding, one from Muktinath to Eklebhati. And one from Jomosom down to Ghasa. And a lot of the riding from Jomosom to Beni was pretty good. And the ride from Pokhari Dukhure to Manang was so flat, it was a piece of cake.

Kalu and I went up the valley toward Tilicho Lake , to check out the trail. It was hard work, and the going was slow. It would have taken much over a day to get up there. We just got as far as Thare Gompa, by noon, and then we went back down. The descent was fun and challenging riding.

The main problem was: good riding went by very fast; pushing and dragging a heavy bike uphill went by rather slowly. So the ratio of TIME - was - LOUSY, even though the ratio of miles was not quite so bad.

The MAP

Back in 2000, I bought a map that showed how some bicyclist had ridden around the Annapurna Circuit in a small number of Days - and he made it look easy. (More later on how it was misleading.) etc..etc.

The START

We got an early start from our hotel on May 30 and rode over a mile to the Bus Park, and loaded up - that did not take long. The bus road went on the familiar, crowded, busy road toward Pokhara. We stopped at Dhumre - had some lunch. When we went up the road from Dhumre to BesiSahar in 1997,the road was all rough gravel, and we had to ford 3 large streams, and traverse some rough gravel-slide places. To my surprise, it was almost all paved, with 3 new bridges, and not bad at all. We stayed at the hotel Kalu recommended, and it was quite adequate. Good supper.The next morning, we got a good breakfast and I found the post-office,to mail the last few post-cards, and we started.

DAY BY DAY - Day 1 (June 1)

We started down the trail - really a dirt road, here. I went down 60 yards, and I set up the camcorder, and recorded our start as Jeff and Kalu came down the hill. Then they went ahead, and taped ME. There were a few small rivers or streams to ford that day. There were a few muddy spots, but we made good progress. At the end of the road, we crossed the long suspension bridge to Bhulbhule - now, no more roads, no more vehicles. The trails were pretty good. (Day-by-day will be reported in a separate section.)

Camcorder

Usually on a trek, when we stay in tents, I carry a 15-ounce solar panel (0.4 ampere x 19 volts) on the back of my knapsack, and charge my spare camcorder batteries as I hike. But we were going to be staying in Teahouses, and I made an estimate that almost 1/2 of them would have electrical power (220 VAC) - and I was right. I brought along my standard 16-ounce line-powered SONY battery charger, to charge up the batteries in the evening, and had no trouble. (I probably would havebeen OK if I relied on the solar panel, but there was NOT a lot of sunshine, as I had suspected.)

I had my Sony CCD-TR-818, and it worked quite well. NO, I have not yet editted down my 12 hours of tape. I did a little taping WHILE riding. I would turn on the tape when stopped, and let the camera hang from my neck, and get started riding, and pick up the camera, and point it in the right direction. Some of the film was - adequate. Not wonderful, but I did catch a female sheep making a ewe-turn.

Cameras

Jeff had a good digital camera. It worked quite well, and he got hundreds of mediocre shots, and hundreds of GOOD shots. He put them on CD-ROM, and my friends have enjoyed them. We were both pleased how well it worked. I agree, if in doubt, take a shot, and if it's only mediocre, you can decide LATER whether you want to keep it. This attitude does help you to make more GOOD shots.

The Weather

Altogether it wasn't bad. We had rain several times - after we were securely in camp. We had two absolutely clear days, with great views of the peaks, on the WHOLE day going into Manang, and on the rest-day inManang.

We had a rather damp drizzly afternoon from Kalopaani to Ghasa, but wechose to ride and walk down a few miles, rather than just make an early stop in Kalopaani. We had evening rain in Bahundanda, and Dana, and a few other places, but, no problem. We had light drizzle on the our long ride to Pokhara, but notreally rain. So, the weather was about as good as we hoped for, and we couldn't complain.

When we got to "High Camp", a full half mile above Thorong Phedi, and a few miles below Thorong La (the high pass at 17,771') - we knew we were in pretty good shape. We were all in good health, going strong, and we already knew our porter Bim Tamang was a steady strong guy. The altitude was not bothering us. We set up an order for pancakes at 5:00 and we were ready for a 5:30 start.

I happened to wake up at 4:00 and walked over to the toilet. The weather was grey. When I came out of the toilet at 4:02, the weather had started to drizzle. In a few minutes it turned to snow. By 5:00 there was almost an inch of snow on the ground. NOT a good time to start. NOT encouraging. By 6:00, two inches, and still coming down.

I was VERY negative. Is there any chance there won't be heavy snow on the top? Will we even be able to get back DOWN? I was a real pessimist. I was annoyed. I was unhappy. The snow kept falling.

About 8:00 the snow stopped. We were ready. Could we force our way through the snowdrifts?
After the first half mile of ascent, we found - NO SNOW! The snowstorm had been very small and focussed on our camp. Outside of a half-mile radius of our hotel, there was no snow. Amazing! All the way to the top, no snow. All the way down the far side, no new snow. So we were pretty lucky that the snow we got at 5 AM did not spread very far.

Descending from Muktinath toward Eklebhatti - we were hit by the hard winds we expected, which blow up the Khali Gandaki every afternoon. For some odd reason, they bothered Jeff, forcing him to walk, sometimes, whereas I was able to keep riding. These were strong winds, 40+ mph (DC value) with gusts above 50. For some reason, these gusts did not bother me. I guess it helped that the "trail" was over 6 feet wide, so I could veer as needed, to keep my bike under me.

Actually, while were marching along the Khali Gandaki river-bed approaching Jomosom, we actually did get a few drops of rain - out of a clear sky! I never saw that before!! It was still VERY windy.

Viewing

We had fairly good views at random times. The day going up to Manang, and the next day (rest day) were almost perfectly clear, with GREAT viewing. We had some good views down by Jomosom - mostly clear views - but still no view of Dhaulagiri. Heck, almost nobody gets clear views of Dhaulagiri. Dhaulagiri is one of the 5 highest mountains in the world, and very dangerous for climbers. And, hard to see. When we were riding to Pokhara - we got to the top of the hill at NauDanda - and, eerily, the great peaks came out of the clouds. We gota good eery view of Macchupucchre (the famous Fish-Tail Peak) before we left to swoop down to Pokhara.

Tired muscles

We all got tired, but we did OK and kept going. We did need rests, at times. As I mentioned in a column, *** half-way up the big hill going to Pokhara, I ran completely out of potassium pills, and I started getting leg cramps. But after the drizzle cooled me off, I was OK, the rest of the day. The drizzle cooled my legs so the lack of potassium was not abig problem. The worst I had for tired muscles and bad cramps was the first practice ride, where I had forgotten to bring my potassium.

Tires, Tubes

I had a minor blow-out on the second practice ride, when my brakes heated up the tire descending a long steep down-grade. Even though I had rested to cool the brakes. My brakes were not really hot - it must have been a lousy tube. After that I had no tire or tube troubles - my tires were very new, and very heavy, and very strong. I kept up to about 35-40 lb. pressure, pumping every few days.

Coming back to Manang after our rest-day ride, Kalu noticed his tire bulging, at a place where the tire had gotten tired and frayed. He let out most of the air, and eased back to Manang. Kalu was worried, as we had left our only spare tire behind in KTM. We did that because Jeff said, "No problem". Jeff showed Kalu how to sew a scrap of leather onto the tire, to hold the pressure. It took him a full half hour, on that quiet afternoon, but after that it held perfectly - "No Problem", indeed!!

Jeff had a leak develop as we were leaving Muktinath - he replaced the old tube - no more problems. I had not been riding much on mountain bikes until just recently, so I was very impressed at how durable the tires are. Really durable, riding over bumps, down steps, etc. Really good traction - we almost never skidded.

Brakes

Our brakes were almost always perfect. We rarely had problems. About 5 days in, we had to change some brake pads. By the time I got back to KTM, one of my rear brake pads was kinda shot, but no problem. I should have turned it around. But I didn't really have to.

Mileages

I wrote down the indicated mileage at the end of the day. My speedometer would indicate even at 1/5 mph, but Jeff's would notindicate unless he was doing 1.5 mph, so his odometer never read true, when pushing slowly. I had all the mileages on the envelope where I kept my maps. When my maps got wet, I moved them out of that envelope to dry out. After the trip, I never did find that envelope with the list of mileages.

I do remember that it was about 10.6 miles from High Camp (above Thorong Phedi) to Muktinath, and about 10.0 from there to Jomosom. Also, after a 6% correction factor, it did indeed take about 135 miles from BesiSahar to Beni. In these mountains, you aren't supposed to measure the miles; you are supposed to count the hours. Well, many old books gave utterly confusing mileages from the START of the trek to the end. In the old days, from Pokhara to Pokhara, it probably was about 200 miles, as you had to hike from Pokhara to BesiSahar, and then from Birethanti to Pokhara. Since the roads now got to BesiSahar and to Birethanti, the books often say ~150 to 140 miles. We went down the river valley from Tatopaani to Beni, and we did not go over the 7000 stone steps ascending up to Ghorapaani and then down to Birethanti, as that would have been awful.

So the hiking from BesiSahar to Birethanti probably is about 141 miles.

Fables. Baloney

I read some guy (on the web) writing that he rode around the Circuit, and came around a corner too fast, and nearly crashed into an angry yak. As I said, at the time, that sounds like pure baloney. After the trek, I knew it was pure baloney. It's easy to keep your speed down, and it's hard to come around a corner and find a yak. There aren't many blind corners, and yaks are only found above Manang.

Trails

Many of the trails were quite good for riding. Narrow, but fair. Many are rough and rocky. Sometimes you have to walk your bike downhill. At a few places, the descending slope is as bad as 50%. More later.

Slides

Between Danakyu and Bratang, there are about 6 big landslides or gravel-slides on the left side of the river, and after you cross the bridge at Thame, there are about 6 more on the right side. They mostly have very narrow trails that are somewhat flakey, but not really dangerous. Lots of pucker factor, anyhow.

There used to be about 2 miles of ratty landslide trail from Letdar to Phedi, but it was so dangerous and unstable they built a new trail on the south bank. It's not very nice, but at least it was not as hard as the old trails on the North bank.

Also there were some ratty slides below Jomosom, but they just slowed us down. NOT terrible, just annoying, when we thought were starting to make good progress.

Portering

We knew we might need porters up high. So at the end of the first day,when it had had some steep places, we began to wonder when we would get porters. The SECOND day, from Bahundanda, was tough rough nasty steep downhill (very little riding) followed by steep rocky up-hill to Jagat. Weshoulda had a porter there. The next day, again, lots of steep up-hill to Tal. We shoulda had a porter.

The next two days we did hire a porter, to carry most of our panniers. THEN we went up much more easily, to Danakyu, and the next day to Dukhure Pokhari. We paid off our porter with big smiles.

The next day to Manang was mostly, a piece of cake. Mostly not steep, and good easy riding on smooth tracks across meadows. Glorious! Shallow upgrades (plus one big uphill) plus some nice downgrades from the Deorali (small pass) that looks down on the Hongde airstrip.

When it was time to go up from Manang, we hired a porter for 2-1/2days. The trails were generally not BAD, but we were now up above 12,000 ft, and the porter's help was very good. When we finally got to the pass at Thorong La, (18,771') we paid off our porter - about $25 - and eased down the other side. Some of the trail was OK, and some was lousy, but a porter would not have helped much.

The riding on the west side of the pass varied, but when we got down to Ghasa, we started down. There was a bunch of big hard upgrades, and then a few HOURS of UP and DOWN over various rough trails on land-slides. Even the DOWN was very hard and ROUGH walking and un-pleasant. We didn't get very far that day, only to Dana, and wegot really tired. Even that day we could have used a porter.

Locals

Some local people asked questions, when they saw Kalu. I mean, they don't see a Nepali guy on a bike, every day!! One guy asked in Nepali, "Father, son?" A good guess, but not quite right! Others asked, "Crazy?" But of course that answer should be - "only a little". Yes, a little crazy. But I'm sure glad I did it.

Nice Kids

We found MANY nice kids who called and waved to us, and were nice. I mean, they don't get to see a bicycle every day - - or every year. I would say "Namaste" and they would reply likewise. Many kids were nice, and smiled, and clapped, and some even tried to help pushing our bikes on slow uphills.

Wise-guy kids

I was coming down through Rakhu, and I saw a little kid with a stick, getting ready to poke the stick in my rear wheel. I was rolling about 3 mph, and I NAILED the front brakes. I stopped instantly, and reached over and grabbed the stick, and started screaming "NO, NO, NO!" I took the stick, and broke it in half and threw it on the roof. Then I picked him up by his shirt collar, and screamed in his face, "NO NO NO", and then I set him down gently. Maybe he and his friends learned not to poke sticks into bicycle wheels.

There were a couple other kids who were running up a hill beside me on a long slow upgrade, at Raghugat. They reached over and started to push, and help me up the hill. That was very nice, and I thanked them. THEN they started to pull the other way! I guess they couldn't resist trying that, to see what would happen. As soon as I figured out what they were doing, I stopped and smiled and said, NO, politely.

Reminiscences

Many things n this trek were just the same as I remembered them from 1997. (In Nepal, many things do not change very fast.) Other things changed. It was still a glorious area. I'm commissioning a 2' x 5' painting of this Circuit, primarily of the things we saw in 1997. I have made a list of about 150 items, people, things that we saw, that made the trek memorable. I have found a good painter who has agreed to paint the whole panorama - like Breugel's busy paintings. THAT is going to be fun!!

Clothes

We were prepared for weather varying from well below freezing, to the tropics. I thought that starting from 2400' at BesiSahar might be oppressively hot and muggy, and going by Beni at the end might be the same. We were very lucky to not have hot muggy weather; it was really quite pleasant. At the top of the world, at 17,771', it was cool, but not too bad. We had plenty of warm clothes if we had to beat cold weather. Hats, gloves. Ponchos, parkas, sweaters. No problems.

Bike Shops

In Kathmandu, there are a couple bike shops up at the top of the hill in Thamel, (near Pilgrim's Book store) and there are several others about 1/2 mile south-south-east of Thamel. Some of them might try to sell you junk, but they will also sell you good spare parts, tires,tubes, and accessories. NOT terrible prices. But if you had to replacey our bike, mostly what they have is inexpensive Chinese junk.

CONCLUSIONS:

Jeff said this was the hardest ride/trek he had ever been on. I had to agree. Yet some of the good riding made it worth while. If there are 24 people in the WHOLE WORLD who have done this bicycle trek, I would be surprised. So it was a kinda UNIQUE experience. The hard parts were, indeed, brutally hard. The nice parts went by REAL FAST. But I am glad I did it. Jeff was a really good sport. He griped, but he kept on going. Every damn' mile!

Best regards. /rap

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THE BEST OF BOB PEASE

A Bicycle Trek - June 2002 - DAY BY DAY

DAY 1 (June 1)

We started out from BesiSahar, down the trail - really a dirt road, here. I went down 60 yards, and turned on my camcorder, and recorded our start as Jeff and Kalu came down the hill. Then they went ahead, and taped ME. There were a few small rivers or streams to ford that day. There were a few muddy spots, but we made good progress. We crossed a couple streams. At the end of the road, we crossed the long suspension bridge to Bhulbhule - now, no more roads, no more vehicles. The trails were pretty good, up to Ngadi Khola, and around the next hillside. Then we got a few minutes of drizzle, so we stopped under a tea-house's shelter, just enough for a rest. The drizzle stopped.

We could see the next town, Bahundanda, but there were some steep rocky trails with steps going up, which was NOT easy by bicycle. We got up to town, and found a good teahouse which had room for us to bring our bikes inside. We didn't want them left outside for kids to fool around with. We took a shower; it rained; we had supper, and quit. (I took a walk 1/3 mile east on a nice easy ridge trail, and returned as it was getting dark.)

DAY 2.

The descent from Bahundanda was steep and rough. Not bad walking for hikers, but not easy for riders. We got in very little riding. After we descended to the river (the Marsyangdi Khola, which we would follow 8 days) we shortly started a steep tough ascent over rocky steps. I knew this would be hard and slow - and it was. At the top of the hill - we descended to Jagat. This was the same elevation as Bahundanda - we'd made no net gain. But this was not a surprise. Why did we not hire a porter for the next day? I'm not sure, but from Ngadi to Bahundanda to Jagat up to Tukhure Pokhari, (a 4-day stretch) would be a good stretch for bicyclists to hire porters. Life would be MUCH nicer.

DAY 3.

We started out of Jagat on shallow ascents, which then got good and steep. Without porters, it was tough. After a while we crossed the Marsyangdi; then went up the long steep ascent to Tal. That whole stretch has no streams, no water, and not much shade on a sunny day - so that is a good day to carry extra water. We were pretty low on water, and pretty tired, when we got to Tal. We stayed there.

DAY 4.

Above Tal, everything flattens out for a few miles before more steep ascent. We stayed at Tal - and we hired a porter for the next

2 days. Yes, there was some hard ascent past Dharapaani and Bagarchap, but not too bad, as our bikes were lighter. There were several big gravel-slides before we got to Danakyu. The trails were - tricky.

DAY 5.

We started from Danakyu and made good progress. Our porter strode ahead of us and as soon as we caught up with him, he would stand up and walk away from us again! We walked along the hug CUT in the cliff, above Braga. This trail was blasted and cut as a notch about 12 feet wide and 20 feet high, about 100' above the river and rapids, for a couple hundred yards. It's very scenic. Not TOO scary. Then JUST around the corner you can see the fantastic wall of Paungda Danda - a huge smooth rock bowl that's over a mile high and two miles wide. After one more bridge, we ascended a long tough upgrade for about a mile through woods that look very much like New Hampshire. Then - a miracle - a good long downhill ride over pleasant smooth shallow trails - as wide as a good woods road - down to Tukhure Pokhari, the site of a tiny lake and 4 teahouses (half of which were closed for the season.) We paid off our porter, who immediately started back down the hill. We had a good supper.

DAY 6.

Miracles happen again! The day started DEAD CLEAR,so we got up early and enjoyed photographing the snowy peaks almost all around us, before breakfast! It was as glorious as usual. Then we started out on easy shallow meadows - easy riding. We had no trouble getting up to Pisang.

From there it was about a mile of moderately steep up-hill - mostly easy broad roads with NO ROCKS! until we got up to the Deorali (small pass) that overlooked the small airstrip (1100 ft. long at 9500 ft.) at Hongde. Then we had another GLORIOUS mile of down hill, followed by more easy meadows. We went past Hongde (Police checkpoint) and across a couple small bridges and more great and easy riding up to Bratang. We had a good lunch in a very handsome tea-house and then walked over to the Gompa (temple) and took a tour around there. Then we boomed up into Manang and got booked into the best teahouse in town, as far as cooking was concerned. We got laundry done, and batteries charged, and we still had plenty of time to walk around town.

DAY 7.

We decided to have a rest day, for acclimatization, and for rest. I wanted to go up toward Tilicho Lake, about 17,500'. Kalu and I took off and went up to Khangsar, and then up to Thare Gompa. The monks invited all us pilgrims in for a light lunch of tsampa, a gruel-and-tea dish. The descent back to Manang was quite nice. Khalu spent an hour sewing a leather patch on his tire. This was another PERFECTLY CLEAR day, no clouds. I took an hour to walk over to the glacial lake at the foot of Gangapurna Glacier. Nice hiking, good views.

DAY 8.

Starting up from Manang, we had a good hard up-hill PUSH for a few hours. When we finally got up to a crest, we then had a pleasant half-mile down-grade to Yak Kharka (Yak Pastures).

I had been hoping to see yaks on the trail, at work, but we saw none. We did see 4 yaks near Yak Kharka, about 100 feet above the trail. As we were photographing these great hairy beasts - one of them knocked down a rock about as big as my head. It rolled down and missed my bike by a couple yards. That's OK; we had spare spokes. We kept going to Letdar. I went for an hour's hike up on the hillside above there. It got - cloudy.

DAY 9.

We worked hard, mostly pushing, up the new trail. The old trail used to go across some slide trails, crossing some HUGE gravel slides on the left bank of the Jargeng Khola. After too many avalanches, they cut a new trail on the right bank. The new trail was quite safe, and gave us quite good views across to the old trail - but it was kinda boring, and after you had climbed an EXTRA 700' - you had to descend the 700' to cross the river to get to Thorong Phedi. And the descent was very rough and steep and nasty. We had to push the bicycles down a few feet, clamp on the brakes, walk down a few feet, and repeat the process. The descent was as steep as 50% - I measured it with my clinometer. See at "What's All This Clinometer Stuff, Anyhow?' (URL = ___)

We finally got to "Phedi" - this should actually be termed as "Thorong Phedi". "Phedi" means "the Foot of the Hill". Most big passes in Nepal have a resting -place below their foot, with the name "Phedi". We pulled up to there, and had a good light lunch, at 14,600'. Then we continued up to a NEW hotel called "High Camp", up at about 16,000'. Do you know anybody else who has stayed at a hotel above 16,000'? (YES, Gorak Shep has 2 hotels at 16,900', on the route to Everest Base Camp - I've camped there.) We had a good supper and quit early to prepare for a 5:30 AM start.

DAY 10.

As mentioned in the previous section, (Weather) we got light rain at 4:01 AM, snow at 4:10, and more snow at 5, 6, and 7 AM. When the snow quit at 8, with 2 inches on the ground, we started up, nervously, not knowing how steep the snowdrifts would be.

There were no snow-drifts. After a moderate ascent, we came to the house that sold tea at 16,500', in high tourist season - but it was closed. We continued up fairly moderate slopes. After a couple more hours we got up to the High Pass, Thorong La, at 17,771', about 12:30 PM. There were prayer flags, and good photo opportunities, and we rested briefly, and paid off our porter Bim Tamang, and he started back down to the east, and we started down to the west. Quite a water-shed!

The first mile of descent was very good riding, nice and moderate. We took several good photos, and video. But I knew it would get worse, and it did. It got steep and rocky and un-ride-able. So we had to walk and push our heavy bikes down the hill. After a few hours we got to "Phedi West" a tiny ramshackle hut that was not open, selling no services. We continued down a couple miles of fairly rough trail, and approached the temples of Muktinath. We rode right past them, half a mile down to the tourist town of Ranipauwa. Got a good room, had a good supper and 1 beer EACH, after a rather strenuous day.

DAY 11.

After breakfast, we walked back up to the temples of Muktinath. We visited and respected the temples which are revered by Hindus and Buddhists, with the handsome row of 108 bulls' heads. But most of the monks had gone down to a ceremony in Ranipauwa. We saw a big procession of monks, going down there, in a religious ceremony. We left our hotel in Ranipauwa, and, after repairing a flat tire, rode downhill to Eklebhatti, a GREAT downhill ride. This was about 3500' of descent, and almost all good riding. The high wind made riding tricky, but we got down OK for lunch. Then we marched and walked and rode a little to Jomosom, across the rocky gravelly flats of the great Khali Gandaki River. We went to the bank to exchange some dollars into rupees. (That took many minutes.) We COULD have ridden down to Marpha, but we decided to stay in Jomosom (the big town where the airport is). Big party.

DAY 12.

We started down from Jomosom on pretty good trails and roads - actually some tractors do rove around town, with trailers carrying sand, rocks, or people. And we even saw a guy on a motorcycle, and a couple kids riding bicycles in town. The streets of Jomosom are paved with fairly smooth flat rocks, and the streets of Marpha are paved with VERY smooth rocks. For a few miles we made great progress, but after a while, the trail went up high on steep trails rising 100 or 200' above the river-bed. Hard work, and we slowed down a lot. After lunch we had a tricky crossing of a high side stream on a shaky plank bridge. It began to rain lightly, but we put on our ponchos and kept rolling. A couple more bridges, and we got down to Kalopaani. We considered stopping, but decided to keep going a while, down to Ghasa. It never rained hard, but it sprinkled for hours.

DAY 13.

The sun was shining, and we started down. But we had to ascend, to get to a safe place to cross a huge old slide. Then we had to cross it and descend along the slide, which was brutal and nasty and slow. After lunch, the trails were still steep up-and-down-and-up and NOT fun. We got only as far as Dana, not as far as when we were hiking! More on this later. After supper, heavy rain.

Day 14.

The next day, the trails got better. We eased down through the small tunnel leading to Tatopaani - a place of Hot Springs. We just rolled through town - we didn't need to buy anything. The trail just south of town had become very difficult, as a HUGE avalanche on the FAR bank had fallen into the river, a few years ago, causing severe erosion and avalanches on the NEAR side, and after the landslides, the trails were not very good.

I had hiked several miles down the river trail below Taatopaani, on a day hike, and I thought the trails had been pretty good. But I hadn't paid attention to the mud puddles. When walking, you could walk right along, and just tip-toe around the puddles, and barely slow down. But on bikes, we had to stop at each puddle, and horse the bike around the puddle on poor rocky steps, and it was NOT so fun.

We also came to some very rough areas of avalanche, where 50 workers were digging out to repair the trail - but also to make way for a road. The area was all chopped up, and we had to lug our panniers over some really rough hills, and go back and get our bikes. Kalu helped a LOT.

We stopped for lunch at a small tea-house, and it started to rain. When we were finished with our lunch, the rain stopped. Later, it started to sprinkle, and we stopped under the shelter of a big rock. We could see that the canyon ahead of us, with huge cliffs, was utterly blanked out in view, by cloudbursts. But shortly all the rain quit, and we proceeded. We got about as far as "Ranipauwa" (Rakhu on some maps?) and quit for the night.

DAY 15.

After a small struggle across bad trails on a slide, we made fair progress, when suddenly we hit - a ROAD!! The government was extending the road PAST Beni and we hit some fair but rough road. I eased along - the others raced ahead of me. We eased into Galeswor - a bicycle! We eased across the river and that town was called Raghughat or Rahghat? - and there were cars and trucks! Oh, civilization was coming closer!!

The road kept getting better, but it was still kind of rough. We rode down into Beni. We were planning to meet the bus there - but that was 23 hours away. We tried to phone to Kathmandu, to tell the bus company to meet us in Pokhara, but we couldn't get through. So we volunteered Kalu to stay in Beni to meet the bus driver there, and Jeff and I decided to ride to Pokhara. Just 85 kilometers. We left Beni about 8:30 AM. The first 6 miles were surprisingly rough gravel, but we eased along. Then as we passed Baglung, the road was paved, and VERY smooth. The downgrades were OK - the upgrades were not bad. After a quick lunch, we continued uphill. But I ran completely out of potassium pills, and soon I was getting leg cramps. I had to walk and push my bike. Every time I tried to ride, the agony came back! Then it began to sprinkle. I wouldn't call it miserable, but it was not exactly FUN. A couple trucks and tractor drivers asked me if I wanted a ride - but I smiled and said, no, thank you.

After a while, I tried riding again. I did not cramp up! I was very careful to ride VERY gently and slowly, but it was faster than walking! I'm convinced the rain on my legs caused them to not get cramps. We kept ascending gradually - a very good and smooth road. We stopped for a coke - the smiling host told us we were at the top! That would be nice, but he was just telling us what he thought we wanted to hear. After that, we still ascended another 40 minutes.

Just as we got to Naudanda - (Nagdanda on some maps) - the summit of the hill, at 4700', a great viewing place that (in clear weather) overlooks all of the Annapurnas - some of the clouds drifted away, and we got some tremendous views of the famous "Fish-Tail Peak" - Machhapuchhare, just 10 miles away. It was a GLORIOUS view. Then it was all downhill into Pokhara. I had used mostly my 9 bottom gears for 14 days - but now I got into my TOP 9 gears. After a couple miles of just rolling fast, we got to the beautiful shallow downgrades along the Yamdi Khola, with handsome farms, and about 7 miles of beautiful 2% downgrade on a smooth road. And a good thing, as it was getting late, and it was getting dark. We eased into Pokhara, and found our hotel, and took turns at a GOOD HOT SHOWER - !! - what a treat!! With towels! And a great supper.

Day 16.

The next morning Kalu and the bus driver showed up about 7:30, and we got back to Kathmandu just after noon.

We spent a couple days shopping, and riding around, and then it was time to go home. But that was one heck of a fine trek - even though there was a lot more pushing than riding. The riding we had, was often excellent.

WHICH IS FASTER - BICYCLING or HIKING?

This is such a challenging rough trail, that the advantages of bicycling, in terms of speed - are fairly minor. Even on the days when we had good riding, we weren't a lot faster. Getting up to Manang - it took about the same 6 days. From arriving in Manang, up to the pass, took about the same 3.5 days, as we needed to take a rest day at Manang, for good acclimatization. You need to do that, to avoid altitude sickness - cerebral edema or pulmonary edema. SURE, we could have gone up faster, but it would be very risky, and we knew better than to hurry.

DESCENDING should be easier and faster. But to get down to Tatopaani, the bikes were just about as slow. Some places, we really did go faster - and other places slower. (When we hiked, we took a couple half-days off, so we would not hurry and get too far ahead of schedule. We took off a full rest-day in Tatopaani.)

South of Tatopaani, hikers go up 6000' to Ghorapaani and Poon Hill, a great lookout across the mountains. We knew this would be an INSANE place to go by bicycle, because there were 7000 stone steps to get up to Ghorapaani, and 7100 more steps to get back DOWN (and 2200 steps more to walk to Poon Hill). So we avoided that route, and went down the trail along the Khali Gandaki. We took barely 1 day to get out from Tatopaani to Beni. We had taken 4-1/4 days to hike out from Tatopaani, but it was really only 2 + 1/3 + 1/3 + 1/6 days of hiking. So we made it around in about 13.2 days versus 20.2 on foot - but we took the shorter and easier route.

THE MAP.

Back in 2000, I found a new map by some guy Sangalli Carluccio, which proclaimed that he had ridden around The Circuit in a surprisingly low number of hours. He said he rode a lot, and carried his bike a lot, and pushed only a little. We didn't believe all of that, but we were interested, that it seemed to prove the feasibility of the trip.

When we went around, we pushed a lot more than he did. Rode less, carried less. WHY? After the trek, we studied the fine print. HE had a 9-kilogram mountain bike. Just 20 pounds. With no panniers. No wonder he carried his bike so much - it was almost trivial. He must have had a porter (or 2) every day, to carry his gear, clothes, sleeping bag, and spare bicycle parts. I had a 37-pound bike, and 33 pounds of gear, some on my back, some in the panniers.

Jeff had about 60 pounds of gear. If he only had to ride up hills, he'd be OK, but when it got steep or rocky - pushing was how we got up there. So, unless you have a super-light bike, and somebody to carry your spare tires and rims (in case you bust a light wheel on a heavy rock) you would be more likely to travel like we did - pushing our bikes. Even when we hired a porter, we did a LOT of pushing - and almost ZERO carrying. Less than 1/2%, total. I only carried my bike a little on slide trails - they were very narrow and crummy, and I would roll the front wheel along on the trail, and pick up the back of the bike by the down-tube, and hold it beside me.

ELEVATION - ASCENT and DESCENT.

When we prepared to hike around here, I computed that the MINIMUM ascent would be the the 15,400' from BesiSahar to the Pass, and 6000 ft from Tatopaani to Ghorapaani. A total of 21,400'. Obviously we would have to ascend more than that because of various uphills and downhills along the way. But my wife had a recording altimeter that recorded the total ascent each day. There were several days when we ascended THOUSANDS of feet not indicated by the mere difference between the starting and ending elevations. So the total for the hike was about 29,000'.

On this bicycle trek, we did not have to ascend the 6000' above Tatopaani. Yet we surely had to ascend about 23,000' in 14 days - and about 23,000' of descent. Good hard work.

Best regards - your comments are invited! / Robert A. Pease / rap@galaxy.nsc.com

JEFF'S COMMENTS.

I'm looking for folks to tour with me again in Alaska, biking close-up to Denali peak. This will not be as brutal as the trek around the Annapurna Circuit. We will be RIDING.

Write to me at: jeffrey_k_fisher@hotmail.com

I'm also going cycling in Colorado for one month on my own starting Aug. 15. / Jeff Fisher

OTHER WEB PAGES:

I wrote about the general problem of Dilution of Pollution:
"What's All this Dilution Stuff, Anyhow?"
- http://www.elecdesign.com/Articles/ArticleID/2689/2689.html

And about the need for potassium if you have any problem with leg cramps:
"What's All this Doctoring Stuff, Anyhow?"
- http://www.elecdesign.com/Articles/ArticleID/2048/2048.html

And the design of my clinometer:
"What's All this Clinometer Stuff, Anyhow?" (To be at http://www.elecdesign.com/Articles/ArticleID/xxxxx.html ,August 2)

(xxxxx to be determined soon)

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THE BEST OF BOB PEASE

Trekking in the Annapurna Sanctuary, November 2005

Namaste and Hello to all hiking friends!

I just thought I should explain - - why did we go to the Annapurna Sanctuary on a TEAHOUSE trek? We USUALLY like to go with Peter Owens' whole crew, cooks and kitchen boys and tents and all.

There are many "Camping Treks". We did that last spring, when we went back to Langtang, and it was - very nice. But that camping trek was fairly expensive, and we weren't able to get anybody to come with us. So it was just the two of us. We love to go on the full camping trek, and it makes more work for more of Peter's good guys. But it doesn't do much good if we don't get a lot of people coming to Nepal.

When we decided to go to the Sanctuary, in November of 2005, we decided to go on the Teahouse version, to maximize the number of people who would look at the low price, and come with us. Getting more Americanos to go trekking, is more important than giving work to a few kitchen boys. That's what Nepal needs now. And that's what we got. The very reasonable price of $850 for the Teahouse version (versus ~ $ 1250 for camping) was probably instrumental in getting 3 more guys to come with us. Jeff, Arlo, and Vic were great hikers, and they had never been to Nepal before. So now we are encouraging them to bring their friends back to Nepal. I'm sure they will For info about this basic trek .
Besides, the Sanctuary has very good teahouses, we were told, and that is true. We stayed at about 11 excellent teahouses, and when we got to Tadapaani, all the good teahouses were full - and even the crummy one, that was the best one that SalaamSing could find, was not too bad. So, that's why we went on a teahouse trek. And in June, 4 of us guys are going back by Mountain Bike, to repeat the Annapurna Circuit - and staying in Teahouses.

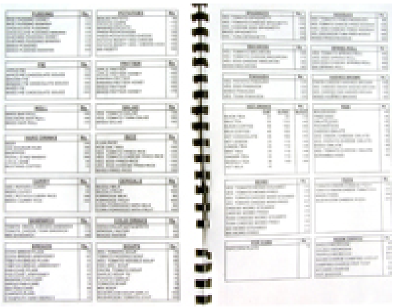
On this trek, some of the hikers were in their 30's and 40's, and some in their 50's and 60's. You don't have to be very young or old to enjoy trekking in Nepal. You just have to enjoy good hiking.

Here are the links to Arlo Aude's photos from Nepal:
http://share.shutterfly.com/action/welcome?sid=2Abs27Vi1cMX1A
http://share.shutterfly.com/action/welcome?sid=2Abs27Vi1cMXxQ

These are a couple good slide-shows.


Bob, Vic, and Jeff stand 12,000' below the summit of Mt. Annapurna


"Machhapucchare" translates to "Fish-tail Peak"


The Menu of a Tea-house, about 6 miles north of Chhomrong

Click on the images for a larger picture.
Credits: Photos by Jeff Nilles

Menus and Dining in the Annapurna Sanctuary Area.

I am writing all this as a service for people who are going trekking by Teahouse, and haven't got a clue what is coming. Such as the 3 guys coming with me up to the Annapurna Circuit, this May. Peter Owens can give this info to people who inquire. Several people have asked me, as they were signing up for a Teahouse Trek, "What will the food be like in the Teahouses? What does a menu look like?" I told them what I recalled from our 2002 Teahouse trek. This was a very thin recollection, compared to a real menu. But I inquired, and did not find any menu.

Finally I spotted a menu in an old book (~1990), and the prices were not relevant, and the variety was small, and obsolete. They did not show pizza or beer or similar items, so it was not relevant to trekking in the 2005-2006 era. When we went up into the Annapurna Sanctuary in November of 2005, we got some photos of menus, thanks to Jeff Nilles. In each area (about 3 towns, each at the ~same distance from the road) ACAP (The Annapurna Conservation Area Project) sets standard prices and standard, basic menus. If you travel another day's hike up the hill, the prices go up - due to portering charges. So the prices can vary, and the variety varies. Some things that are on the menu, will not be available, and if a yak or some chickens have been butchered locally, that can be a "special" that you might want to order. These notes, and this menu, from Nov. 2005, are based on an exchange rate of about Rs 70 = $1.00.

All prices are required to be the "same", in any town, but the cooking can vary. So the art of choosing the best teahouse, with nice cozy rooms, and a good location, and good cooking, is a fine art, indeed. We believe our guides chose our tea-houses for the best food, and for good rooms, and the food least likely to poison us. Could we guess this ourselves? Not so well. We think a significant part of our Guide's value, is to know which tea-house has very good food. More later.

Price List: The first item to look at, is "Room Charge". These rooms are not very fancy, but they are usually clean and secure. Some are even quiet! And some aren't. The room rates are set low, based on the idea that you will dine at their Dining Room. It's not sporting, to room at one lodge, and go out to eat elsewhere. I mean, $1.30 for a room? That is negligible, and the food is usually inexpensive, too. This often includes a hot (solar) shower. If you have to pay for a bucket of good hot water, 70 cents ain't bad, either. Sometimes it gets up to $1.40.... comments later, when I write about lodging.

The most important item is filed under "Rice": "Rice Dal Veg." - that is Dal Bhat. The listed price is Rs 150, but a poor Nepali traveller will probably have to pay only half of that. We affluent trekkers can afford to pay $2, for an "all you can eat" feast of rice and lentils, pickles and veggies. And we did, several times. NOTE: eating any food that is hot or boiled or fried, is very unlikely to rile up your tummy. When hot rice is put on a dish that might be imperfectly cleaned, the rice will probably stay sterile. That's the theory we went under. On our treks, nobody got sick. But, we did eat at some of the best and safest tea-houses in town...

Now, starting at the top:

"Pudding": I did not really try the "puddings", but I had some puddings or sauces spread over pies. They were not fantastic, but they were tasty, and did add to the pie experience. Chocolate or vanilla, it was - fair. When accompanied by banana or honey, the puddings would be - tasty.

"Pie". The Annapurna Circuit (especially the western half) is called "The Apple Pie Route". They grow LOTS of Apples, down by Marpha. And they make good apple pies. We tried "The" Apple Pie in about 8 places, and there were several variations - sometimes a single little pie baked FOR YOU - sometimes a piece of a big pie. All were good. They didn't need chocolate sauce or vanilla pudding, but these made pleasant variations, too. Some places did not have "apple pie" but they had an "Apple Roll" - sort of a turn-over - and they were good, too. When we go around the Circuit in June, it's unlikely they will have any apples left. Once I had a "Lemon Roll", and it was tart and tasty!

A **"Mars Bar Roll"** is a turn-over crust, deep-fried, with a candy bar inside. If you have a sweet tooth, it will fill it! No, I didn't try one.

"Hard Drinks". About 2 or 3 days from the road, you can buy a 0.66 liter bottle of beer for prices rising from 150 to 200 rupees (depending on the porterage). After you get further from the road, you'll pay 120 to 180 rupees for a 0.35 liter CAN of beer. That's what you pay, for porterage. Similarly, 180 rupees for a small bottle of rum or whiskey is not a bad price. I like their Khukri rum, served with my lemonade powder. I carried a half liter, from Kathmandu. You may have some choice of the beer, Tuborg or San Miguel or Everest. It's all pretty good.

The **"local wine"** is usually a mediocre glass of rakshi, made from the local millet. It's usually been over-distilled until its alcohol content is down. Not usually impressive. It's worth trying, once, maybe, but I'm not impressed. However, when WE get around near Jomosom and Marpha, we can buy the well-known Marpha Brandy, made from those Marpha apples. Fairly tasty, and strong. (They also make Apricot and Peach Brandy). "Mustang Coffeee" is coffee with a shot of rum or whiskey. I hear it's good.

"Curry". Many of these dishes are quite good and tasty. If they have any chicken, they will probably have chicken curry. It's worth asking for. Note that chicken may be boneless, or it may have bone chunks and bone chips, hacked up in the Chinese style. Never can tell... If you don't like meat, you can see that there are MANY vegetarian dishes.

"Sandwich". I never tried their sandwiches, and rarely their bread.

"Breads" - Ah, now we are getting somewhere! Many places sell a "Tibetan Bread", which is a big 8" circle, with slits, deep-fried, and fairly plain in flavor, until you put jam or honey on it - GOOD! The "Gurung Bread" sold in the

Annapurna Sanctuary Area, is a variation on "Tibetan Bread", with a little cinnamon and nutmeg, and I'll recommend that. In many cases, a "Corn Bread" is like a Tibetan Bread, dusted with cornmeal, and very tasty. In other place, "Corn Bread" might be a different concept. Well worth trying. The Pancakes are generally good, BUT I realized I missed having any butter or margarine. Next time I'll bring my own margarine. Chapatis are very plain breads.

"Potatoes". Often, you can get plain boiled potatoes to go with your curry, if you are tired of rice. Potato "Chips" are in the English idiom, French Fries. They are fairly good, but I might ask them to re-fry them a little longer. They fry them barely enough. If you need a French Fry "fix", there they are. We tried them several times. Up on the Annapurna Circuit, I had Roesti Potatoes, several times, and they were fried crisp, and quite tempting and delicious. I often split an order. In the Sanctuary, the "Roesti" potatoes were kind of mooshy and not crisp, and not such good flavor nor texture. I expect the ones on the Circuit will be better. The versions with Cheese can be very good; I did not try the "mix" or "veg." versions. Sometimes they have "Hash-Brown" potatoes, and these are very similar to what Roesti should be like. We had these a couple times, and they were very good. Great, with an omelette.

"Fritters". I was not impressed. Usually they gave you a couple meager slices of apple, dipped up in fritter batter and fried. They were OK, but not an impressive choice. Worth splitting an order? Just to try them out....

"Salad". Several people had salads with tomatoes or other greens, and they were VERY good. At any tea-house selling to westerners, the green veggies will be nicely washed in chlorine water or iodine water, and perfectly safe to eat.
And usually very tasty. Nancy ordered a fruit salad in Birethanti, and we shared it around, and it was excellent, apple and orange and banana. Salads were available mostly below 8000', and also at Ghorapaani, a well-known tourist mecca.

"Rice". I have tried the fried rice plates, and they usually were very good. Especially, "Mixed" or with veggies or tuna. Caution: "Tuna" may be canned tuna, BUT it may be sorta sardines. Don't be surprised at what you get. It's edible, and tasty, but it is - a surprise.

"Cereals". I did not try the cereals. Is the "milk" from buffalos or yaks, or dried milk? Not sure.

"Cold Drinks". Yes you can get Coke/Fanta/Sprite, and sometimes that is a special treat. ALSO in some places, they have "Cold Lemon", for a reasonable 50 rupees. Sometimes this is strong and wonderful, and I'll buy 2 or 3. Other places, they have diluted it a lot, and I won't.

"Soups". There are many kinds of soups, and I tried many. The noodle soup is always good, with or without veggies. The garlic soup is good, the potato soup is good, and if you ask for "Potato Garlic soup", they are good at complying. They can figure things out. It does no harm to ask for a dish that's not on the menu. The cooks are very resourceful! You can add garlic to 'most any soup, and it tends to be good and rich. Sometimes the garlic is cooked; other times, it is pretty raw - and wonderful! The tomato soup is often made with real live tomatoes (not from concentrate, or dried) (even in November) and can be VERY good.

"Spaghetti". Most of the tomato sauces are made with real live tomatoes, and it is not as rich and "tomatoey" as the sauce that we'd expect, made from tomato paste or concentrate. So it's not exactly what we expect, but it is edible.

"Macaroni". This is made with good macaroni and cheese, and is tastier than the spaghetti, I think, if you like macaroni. I enjoyed it. The Yak cheese is a good generally tasty kind of cheese. More properly it is called "Nak Cheese" as a Nak is a female yak.

"Pakauda" is - supposedly some kind of deep-fried pouch? I didn't try this. Not sure what's in it.

"Hot Drinks" - there are many kinds of tea, depending on what you like. We often had a large pot of Lemon Tea, to split between 3 or 4 people, waiting for lunch, and that was very good. Nancy often had milk tea with ginger. For breakfast, I often had one milk coffee at the start, and a hot chocolate at the end.

"Momos". We had these a LOT - for lunch, or supper. They are made in 2 formats: pursed together in a circle; or folded over like "pot-stickers". Most versions were excellent. Tasty. We often split an order between 2 or 3 people. These were always a winner; (but one time we had them fried, and these were not quite so successful, as they were wizened up and a bit tough; not as tasty.) These are usually served with a bottle of catsup and a bottle of hot green chili sauce. If someone orders them for supper - and if they are good - as they often are - order some for breakfast!

"Popcorn". Tasty with rum punch, once in a while. (Just put some of your rum into a cup of hot lemon tea.)

"Noodle" - there are MANY versions of noodles, and fried noodles. Most are very good; some are wonderful. I remember one order of fried noodles up at Tukhure Pokhari, with veggies and tuna and cheese, and it was grand.

"Spring Roll" - this is a big deep-fried pocket or "turnover" of various veggies, etc. These were good. Jeff points out, there's always cabbage, and various other ingredients such as onion, "spinach", potato.

"Egg". They had many kinds of omelettes. Most were very good. I liked their cheese. Some of the guys ordered a couple boiled eggs. Sometimes they came hard-boiled - sometimes soft-boiled. If you specified what you wanted, you might get pretty close to what you wanted. If not - send one back to boil some more!

"Pizza". They have many kinds of pizza, and good cheese. They are not very long on meat, so if you brought along some thin slices of pepperoni, to put on top, that could be very nice. If you order for supper (or breakfast), and they have plenty of time, the crusts may be lovely and crisp. If you order them for lunch, and you are in a hurry, don't be surprised if the crusts are barely cooked, and chewy, not so crisp. Jeff says the crusts were made with rice flour.

Options: House Specialties.
There must have been over 20 tea-houses in Chhhomrong. We stayed at the International Lodge, at the Top Of The Hill in Chhomrong, in a pretty good-sized town, and they had a freezer. Apparently the electricity from hydro is quite reasonably reliable. They had beef and chicken. Several people had a steak, and these were quite good. I had chicken enchiladas, and they were excellent. One guy had a "hamburger" but apparently it was made with ~ ham, or chopped ham, and was not a big success.

'Most every teahouse is likely to have daily special items on their menu, and inquiring is a good idea. Other places have a half-page or page or two pages of specialties bound into their menu. These can appeal to you. YOU figure it out! Just remember, if your buddy had something really good for supper - YOU can probably order it for breakfast! It's often a good idea to order an order of some item such as Roesti potatoes, or momos, to split. Just to try it out. Order what sounds interesting.

Teahouses like you to place your order on a paper order form, preferably an hour or two before supper; and if you want to get a decent early start in the morning, place your order for breakfast, right after supper. You can specify when you want your meal served. Then when you have finished breakfast, you can pay up and run. If you are planning to pump your own filtered water, it might be a good idea to request a big pot - several gallons per 4 people - so you can start pumping right after breakfast. (Or before.) In many places, tea-houses can be found every mile or two, but on some days, the water is kind of sparse, so you would bring not just 1 or 2 liters, but 3. The 2 miles stretch going up to Tal is kind of dry, and hot and sunny, for example. The 2 miles from Phedi up to Thorong La, and the first 3 miles down, is likely to be fairly dry, but I don't recall getting very thirsty. I guess I'd bring at least 2 or 3 liters, in case it got sunny. In the Annapurna Sanctuary, we rarely ran low on water.

The guidebooks recommend that if a group of several trekkers orders "many different items", that may take extra time, and take extra fuel to cook it. So if you can order several things that are "in common", that can save time and energy. For example, if 5 people order 3 different kinds of soup, and 4 different kinds of tea, and 3 different kinds of momo (or 3 different kinds of pizza) - they can all cook up in batches that will save fuel.

One of our guys developed a craving for pineapple juice. He found one brand of juice that he really liked. Every little town he came to, he bought a box. Basically, he bought the town dry. We finally decided to buy some comparable mango juice, and it was pretty good, too (even if it was a few months over its "Best if Consumed by..." date). We were able to buy bananas and oranges, along the trail - not bad, for November! These fruits were mostly down below 5000'. We found all sorts of tasty food. Nepal has all kinds of interesting food!

Portions: Usually we got a pretty good-sized portion, but I recall at the International Lodge in Chhomrong, the portions were about 50% bigger than normal. In many houses, 2 people might order 1 order of momos to split, and 1 order of Roesti potatoes, and a main dish for each person, such as fried rice, but in that place, that was too much food. We spent about 3 nights there, and we soon learned not to order quite so much.

Up at Gorak Shep, I remember, all the food was served sequentially, but for quite a while, the people who ordered dal bhat got nothing. THAT came out LAST. Don't be surprised at anything! This menu is PRIMARILY valid for the Annapurna Region. In other areas, it may vary a lot, but there will always be a lot of commonality. Can you imagine a Nepali Teahouse Restaurant without Dal Bhat? Nope! / Enjoy! Bon Appetit! / rap / Dec. 2005.

Comments invited!! / rap

Trails... in the Annapurna Sanctuary

The trails in the Annapurna Sanctuary are - generally very good. There are a few exceptions.

Starting up from the road and the trail head at Dhampus Phedi ("Phedi" = "The foot of the hill") the trail was moderately hard work, medium steep, with good footsteps and stone steps. Lots of ascent. After a while it levelled off nicely, on some terraced farmland. There were about 3010 stone steps up to Dhampus. As we had an early start on the day (our plane was not delayed, so we got up to Phedi before 10 AM) we did not wait and have lunch at Phedi, but started right up. We had lunch at a restaurant on the low end of Dhampus.

We were a bit surprised to find a new road carved into the hillside, and it went all the way up to Dhampus. Ah - progress! How can we tell the people of Dhampus, that they shouldn't have a road? We saw no vehicles on this road - I guess it was too new. Not even a tractor. The trails were generally good, up to the ridge at Pothana.

The next day, the trails were nice and gentle, over to Deorali. Then we started descending toward Landrung. It was a cool and damp area, on the west side of the ridge, and I found the stone steps terribly slippery. I slipped an inch or two, a dozen times, and sometimes 4 or 6 inches. I never fell, but I found it very scary. Even my walking stick had very little purchase. After we got down out of the shade, it was Okay. It must have been some kind of organic slippery stuff. We continued on past Thorka to Landrung, on mostly nice trails, up and down only a little.

I took an afternoon walk, after we got to camp, on the main trail toward Ghandrung. I descended about 2000 stone steps down from the Junction, to the bridge over Modi Khola. Pleasant, but a lot of work, to get back up to supper.

We started down from Landrung - about 500 stone steps directly down out to the bottom of town, and then a lot of up-and-down to get up to New Bridge. We asked, "How old is the New Bridge?" We were told, "About a month." I guess that make sense - it washes out every spring, and they have to build it new. But I am going to insist that they chain up the main beams on one end, so when the torrent comes down, they don't have to find new beams, but can re-use the old ones. The cross-beams are trivial...

The first 1/4 mile up from New Bridge is still (after many years) a rough, lousy trail, not well engineered or manicured. Then after the first few houses, the trail becomes pretty nice. It goes Up - and then back DOWN to the Kimru Khola. There's a lot of NEW steps down to a new bridge (~10 months old), because the old trail leading to the old bridge was wiped out by a slide, so they had to re-route it. Then a moderate ascent to Jinnu (side trip down to the Hot Springs) and then a long hard pull - about 1800 stone steps up to Chhomrong. We got to our hotel at the top of town. The map plainly showed a 300' descent from town, to the river. But we could see that it was obviously a BIG descent, and sure enough, the next day, we had a 1000' descent (1040 stone steps) to the Chhomrong Khola (which comes down from Hiunchuli). Nice steps. But the maps lied a lot.

Then a couple thousand feet UP to Sinuwa, and then up further to Bamboo, Himalaya and Dovan. The trails were fairly good, but there were several hundred feet of descent to Bamboo. Quite a bit of up and down. I counted the stone steps.

From Dovan we eased up to Hinko's Cave; and then a lot of up-and-down on rough trails to Deorali, for lunch.

Above Deorali, there were assorted patches of up and down, and finally we came around a corner to Machhapuchhare Base Camp (MBC) at about 12000'.There was a lot of snow on the north-facing slopes, but the snow was mostly melted off the south-facing slopes, and we took a fairly easy trail up to ABC (Annapurna Baase Camp.) A couple of our guys stayed up there, overnight, but Nancy and I came back down to MBC for the night.

The trails down were not too bad, but we couldn't hurry much. Down by Deorali, there was a set of steep steps up, followed by a steep set of stone steps down, that were perched on top of a newly-built rock wall (which dropped off on both sides). Wild!

From Dovan - the same old trails down to Chhomrong.

We left Chhomrong and headed south - then at an obscure corner, we turned West, and continued on a shallow downgrade with nice farming along the way. We traversed SW a couple miles.

Finally we made a steep descent to Kimru Khola (just before we got to a huge slide area) and then ascended the other side.

After lunch at the last tea-house, we ascended a couple hours in the dark woods, and arrived at Tadapaani. (NOT the same as Tatopaani.) There was a tiny bit of drizzle, but we sat around a wood fire in the courtyard, and smoked ourselves up, until it was time for supper.

Descending from Tadaapani we soon descended about 280 stone steps and 400' down - and right back up. We had a brief rest at a small teahouse which was poised at the top of ONE CLIFF, and at the bottom of some other cliffs. Looking down, we could see the little town of Ulleri, where we would be in a couple days! Then we made a lot of easy long ascent up to the teahouses at Deorali. Nice trails. Pleasant area. From Deorali, we took a long, nice up-and-down traverse to Ghorapaani. It was pleasant and we even had some views of Dhaulagiri (which is often shrouded with impenetrable clouds.) Then a moderate descent into Ghorapaani.

We planned to start out at 5 AM to ascend Poon Hill, for the early-morning views. But at 5 AM, there was no view. Solid cloud. I went back to bed. Then at 6 AM, Kul Rai rapped on my door - it was nice and clear! I pulled on my clothes and boots fast, and charged up the hill. By the time we got about 1/2 way up, the sun came up nicely and shone on Machhapuchhare - then shortly on Annapurna II - then 10 minutes later, on Dhaulagiri, and Ghustang, and Tukuche Peaks. It was very good viewing. We kept ascending slowly, and kept taking pictures. After awhile, the sun was up nicely, and we turned around and went back down to breakfast. The guys who went up to the top of poon Hill had no better views than we did.

The descent from Ghorapaani started out nice, and gradual. We stopped for lunch at Banthanti. Then after lunch the trail descended more steeply. Lots of steps down. We stopped at a Tea-House in Ulleri, the small town where we stayed 8 years earlier. I tried to find the back-yard where we camped in 1997. But I could not recognize any such place. We looked up the valley toward that tea-house near Tadapaani (the one at the top-of-one-cliff and the bottom of another.) Above that hill stood - Annapurna II. (When we looked up that valley, 8 years ago, we just saw a lot of clouds, and a nice rainbow.)

Starting down from Ulleri, we moved along nice and slowly, descending a few more thousand stone steps. It took 2700 steps to get down to Tirkhedhunga. Soon we were passed by an old, stooped woman. We politely asked her age - she was 90. She walked right past us and kept going. It's not clear how far she was going. She was walking with her grandson, and another woman. Many school-children were going down to school, and most were very polite, and walked along with us, and watched us - and giggled politely - and then scurried off fast down to school.

Below Tirkhedhunga, there were still a couple thousand steps DOWN, and hundreds of steps UP. But gradually it all flattened out, and the hiking was pretty good. Down below Hille, the old woman had gotten tired of walking - we finally caught up to her. Her grandson picked her up and carried her piggy-back, and they went in to town much faster than we did! We crossed the good old truss bridge at Birethanti (with Machhapuchhare looking over our shoulder) and pulled in to a nice hotel.

The next morning, the hike down to that "new bridge" was quite brief, and we wound up at the highway, and got into cabs to Pokhara.

Most of the trails were quite good, and only a small part was rough or steep or slippery. So long as you like going up and down the "Gurung Staircases". Most of the bridges were very good. Not weird or scary. Most of the footing was very good, except in the few places mentioned.

I would recommend this for some GOOD, HARD hiking.

The total number of stone steps was about 35,500 total, up and down. I kept count, every day, but I did not necessarily note the numbers down at night. From Ghorapaani to Birethanti was about 8820 stone steps down, and about 800 UP. Jeff and Nancy each had an Avocet recording altimeter. They tended to agree that the total ascent was about 25k or 26k feet. And the descent, the same. Pretty good work for a 14-day trek.

Side trails: Suitable for an afternoon hike after you get to camp: At Pothana, there were no side trails to speak of, just the trail ahead. At Landrung, I descended almost a mile to the river, Modi Khola, but it was a lot of work. At Chhomrong, Kul Rai took some of the faster hikers over to a quarry, on a day hike. In general, from there up to MBC, there were no significant side trails. At MBC, you could hike up onto the "hill" behind the Tea-house, and look over the edge of the lateral moraine. But I didn't have time to do this. At ABC, there was some area for wandering around, or up, but the snow was half-crusty, and half-soft under the crust, so it was not easy to wander around. I wandered just a little.

At Tadapaani and at Ghorapaani, there were small opportunities to wander around. At Ulleri, not a lot. At Birethanti, the trail up the valley was something I had checked out 8 years earlier, and it was very pleasant.

Best regards - I hope you go out and enjoy it! / rap / Robert A. Pease / Trekker.

Tea-houses - - Lodging - - in the Annapurna Sanctuary Area.

I already wrote up my report on the MENUS for the Teahouses, and the very good food and the Restaurants in the Annapurna Sanctuary area. So you should have read that. Now I'll comment on the lodges themselves.

The price for lodging in a double room is typically a couple hundred rupees, that is, about $3, in 2005. The lodges are not allowed to charge you more than the standard rate, so there is not much reason to make the place really fancy, except to make you want to stay and eat their good food. Most of the places were very good, quite nice. (The sole exception will be discussed.)

The cost of a hot (well, warm) shower is generally included with the room, except when we got up high. Up high, you might have to pay $1.40 extra for a bucket of hot water, which you dilute with cold water, and sprinkle over your carcass, and rinse yourself off. I was happy to stay dusty, as I didn't get very sweaty, up high.

Up high (generally above 6000'), there was a fee of "50 rupees for heat" in the dining room. Typically, they would put a big kerosine stove, roaring away, under the main dining table. Then the table has long tablecloths or coverlets, hanging down, to keep the heat in. You put your legs under the covers, and it's pretty cozy. So long as you don't mind a little kerosine smoke. We were cozy, as the outside temperature was perhaps 35 degrees, and inside, about 50 degrees. Under the covers was 70 or 80 degrees. If it got colder, this heat would be CRITICAL for our comfort. As this trek we were on was all-inclusive, SalaamSing cheerfully paid this fee for us. But if you are trekking on your own, 70 cents ain't a bad price.

Variation: Some places had the old style heating, with charcoal fires. We were very careful, to watch each other, and be aware of the possibility of carbon-monoxide poisoning. But we didn't have any real problems. I guess it is not GUARANTEED that running a charcoal fire inside, will be sure to give you carbon-monoxide poisoning. At one place, they had a catalytic kerosine heater, so no flames would be there. But when the reaction went out, it stank of raw kerosine, until they got it re-lit!

Electricity was provided, with lights in each room, at most towns, until we got up above 11,000'. It ran all night long in most places, as it was hydro power. They have BIG streams, with LOTS of flow, and LOTS of drop, in that area. A little shack on the low end of town usually housed a nice Pelton wheel and generator. Sometimes you could even see street-lights left on in the day-time, because the cost of turning it off would be much more than just letting it run. In some lodges, the excess electricity at night would be used to heat the hot water, so a hot shower in the morning was a dandy treat. We were able to charge up the batteries for our cameras and camcorder, about every 3rd or 4th day, quite adequate.

In Pothana, we spent our first night, in the "Annapurna Guest House". The hotel was not very new or fancy. The walls were made of thin boards. But it was clean, and nicely painted, and all the rickety-looking boards were nailed down tight, so it was OK. We considered that our guide might book us into a place with mediocre rooms, to get us the best food. This hotel was on the south end of town, whereas on the upper end of town, there were many campers, and much carousing, late at night. Our place was quieter. The electricity, however, was provided by a diesel-powered generator, whose noise we did get used to. It ran until 10 PM.

In Landrung, we stayed at the Sherpa Hotel. It was the first lodge in town, at the top of the hill, on the south end. Pleasant. Good food. The walls were thick stucco or concrete or whatever. Relatively quiet - - except, I heard that Pung - - - - - PUNG - - - - - PUNG - for several hours, at an 8-second repetition rate, as the condensation on the roof of the top floor would drip down, and hit on the edge of the roof at the first floor, and made a big PUNG. (We saw other houses, later, where the lower roof was set inside the upper roof, to avoid this.) Our room had a private shower, and a flush toilet, western-style. Okay!

In Chhomrong, we stayed at the International Lodge, at the ~ top of the hill, at the south end of town. The dining was EXCELLENT, as we already stated. We spent 2 or 3 nights there. We were able to leave off laundry to be washed, and when we came back down 5 days later, it was all washed and dried. It had GREAT views to the north. Two toilets and 1 shower for about 18 rooms... quite adequate.

In Dovan - good.

In MBC (Machhapuchhare Base Camp) we stayed at Shangri La Lodge, at the high (left, west) end of the area. The walls were thin, but, what do you expect at 12,000'? Most of the fooding was excellent. We stayed there 2 nights.

No electricity.

At ABC (Annupurna Base Camp) - I'll get comments from Jeff & Vic & Arlo, as they stayed there, and I didn't.

Descending, we stayed at Himalaya. Pretty good. We had spaghetti with meat balls, because Peter Owens gave us some meat balls to use up. Otherwise, un-distinguished. Yes, they had electricity.

Sinuwa - we arrived after dark. Good supper. The showers were said to be quite hot, in the morning, because at night, when nobody was using the hydro-powered electricity, they heat the shower-water. Good fooding. Then we descended to Chhomrong.

In Tadapaani (a full day's walk west of Chhomrong, and a day east of Poon Hill) we sent SalaamSing ahead, after lunch, to try to find the best possible lodging and dining. He did the best he could, but apparently all the good places were full, so the place we stayed was - - fairly crummy, and the food was not great. SalaamSing apologized - but we just allowed, that this was a good CALIBRATION, because every other place we stayed at was nicer. But we just went to bed after supper, woke up, and started hiking right after breakfast. At night, it was dark, so we could not see how crummy it really was. Anyhow, nobody fell through the floor. What was the name of this place? Mercifully, we forget. No electricity.

At Ghorapaani, we stayed in the big, neat, clean, well-lighted Sunny Lodge. The rooms were nice, and there were a lot of them. Perhpas 30 or 40? It was quite pleasant. They did also have 2 western-type toilets, on our floor. Nice for a change. We went up at 5 or 6 AM to Poon Hill, for the sunrise, which was quite nice. (But even if you stayed in town, in the courtyard of the hotel, the viewing was quite nice.)

Next, at Ulleri, we stayed at a little place right by the main trail, right next door to a couple herds of goats. They did not disturb us, but they were amusing to watch when they went into their pens, and went out in the morning. Food was good. The lights had power all night.

Down at Birethanti, we stayed in the second floor of a nice lodge. The dining was on the second floor, but after our dinner, we went down to the covered patio (which was labelled as a "Dinning Room" - how appropriate!) and danced and sang and drank beer until after 9 PM. In the morning, we could still see Machhapuchhare looking down at us, in the distance.

NOTE, "-thanti" means a place with lodging, which is why so many little villages have -thanti in their name. THEY had a lodge, many years ago.

We went down to the Fairmont Hotel in Pokhara. BACK TO - civilization. Nice enough.

BACK TO the Potala Guest House in KTM, for one night. Nice enough. But as we were coming back from our last morning shopping trip, the door refused to unlock. My key just turned and turned, and nothing happened. The MAIDS' key did not work. (That's when I got nervous.) The manager's key did not work. The Locksmith's tools did not work.What finally worked was - hammer and chisel.We grabbed our bags and fled to the airport!

*** IMPORTANT!!!! At all these places, the managers and cooks were very nice people, and pleasant, and responsive, and helpful. We just love wandering around Nepal, and meeting such nice people. If they didn't have any huge mountains, we would still enjoy going back. This was our 9th trek in Nepal. / rap & NJP.

Lodging in Bangkok.
If you go through immigration and customs, there are MANY good, inexpensive hotels to stay in, and wonderful dining. But on the way OVER, we had only 8 hours between planes, so we just stayed at Louis Tavern, a set of Day Rooms, INSIDE the airport. About $60 for 6 hours. It is somewhat quieter than the alternative, which is just - napping on the carpet, with your head on your knapsack. Either way saves a lot of trouble and time, compared to going through immigration, both ways.

On the return, we had about 12 hours at Bangkok. We planned to go over to the Amari Hotel, which is a mere 100 yards out the airport. If you get it booked in advance, you can get a rate of $100. If you just walk in, it costs double that. But they have a good restaurant. Many flights to the US leave early, but that's OK.

Weather. We had great views of the peaks, every morning. We had a very light dot of sprinkles in Chhomrong, Dovan, and Tadapaani. But that was after we were in camp, so we couldn't really complain. There was usually increasing cloud in the PMs, but that also made some beautiful vistas. Sometimes glorious.

The lodging around the Annapurna Circuit, when we went around in 2002, was - comparable. Some was very nice, some not so impressive. But all was - at least pretty good, ranging up to - Really Nice! We are looking forward to going around again in 4 months. By mountain bike. Want to come with us?

Comments invited. / Best regards. / rap

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THE BEST OF BOB PEASE

Winter Backpacking in NH - to Crag Cabin on Mt. Adams

Hello to Winter Crag Cabin hikers -

We were going back - 50 years after our first triumph in 1956 - to snowshoe again up to "Crag Cabin" on the north slope of Mt. Adams in New Hampshire. I first led this winter hike, at the age of 15, with Mal Peck, in weather down to -26 degrees. Now Mal and I were going back to reprise this hike, with our friend Jonathan. Crag Cabin and a couple other shelters in that area are managed by the Randolph Mountain Club

We drove up to Boston from DC on Feb 2, 2006 through nice weather, and up to Gorham NH on Feb. 3, through heavy rain and warm weather. We stopped off at Joe Dodge's at Pinkham Notch Camp, to confirm the weather forecast. We stayed at a decent motel on the east end of Gorham, "Town and Country". The room was big, which was good as we had to spread out a lot while packing.

The hike started off in an amazing way: There was actually about 3" of snow left on the ground, at the road, and it was 43 degrees F, all the way up! But the snow was all tromped down on the trail, as quite a few people had been up that trail; about 5 guys went up just ahead of us. We started at about 9:30 AM. As we went up, the snow got deeper, but the trail was still hammered flat, so we did not need our snowshoes. The bridge at 1st crossing was very easy to cross, as the 2" of snow was trivial, compared to the 2 feet we usually met. We kept going up - the crossing of Spur Brook at 2nd crossing was not too bad. We continued up, nice and slow. We had a trivial easy crossing at 3rd crossing - we could barely see the water, but we could hear it. Of course that's the end of the Amphibrach, and then we were on the Spur Trail, along Spur Brook.

Now, WE all remember how steep and bitchy the trail was, between 3rd and 4th crossing. WE all remember the CHUTE that went up just to the right of a big stone wall (small stone cliff), for about 80 feet. That was really tough and nasty, with no easy way to get decent footing. Well - that part was utterly gone, bypassed, somehow. There were several mild angles (not really switchbacks) that made the grade liveable. There were a couple log ladders, each about 50' long, ascending nice and steep, between 3rd and 4th. But it was pretty easy. We stopped at each of the major crossings, 2, 3, and 4, for a rest.

Even the ascent from 4th Crossing to Crag was not too bad. Not as bad as it used to be. There was one 60' ladder - with a handrail! When we got to the "Lower Crag", we knew we were in good shape, even though there were several more steep pitches, and we got into Crag about 4:15 PM, an hour before dark. We surveyed the cabin, and started cooking supper (lamb curry on instant rice). About 7 young guys from Middlebury College Outing Club had come over from Lakes Of The Clouds' dungeon, on a day of great weather. They were pretty cheerful, and mostly a bunch of good sports. When we had more curry than we could eat - they helped us finish it!

Crag Cabin, as rebuilt, is NOTHING like we knew, 50 years ago. There are 3 bunk rooms, for 8, 8 and 4 people. Ladders are provided to go up to the upper berths. The lower berths have about 4' of headroom. We had plenty of space on the lower deck. There is no wood stove, no fireplace, BUT there are about 3 nice long cooking areas, high counters faced in tile, laid out in a U. About 20 feet of counter, total, and a sink that drains into a bucket. We had plenty of room for cooking. Then there are 3 nice tables, and plenty of benches for dining. The east end of the building has LOTS of windows, and very good views. Unfortunately, it has a Cathedral Ceiling so the heat tends to rise. Crag now has no Mouseproof, and no steel-yard. But they have a nice new composting toilet.

About 30 minutes after we got in, the WIND began to howl. We were quite glad we did not have to go any further or later. The wind howled for an hour and then it began to rain. The weather reports had warned us to expect exactly that. It rained on and off, and then in the morning, it began to snow. Obviously we were not going up any higher, on Sunday.

The 7 kids went down, after we had some nice visits. They respected that after 50 years of winter hiking, we knew a few things they didn't - and of course they knew a lot of things we didn't. So we had fun talking and listening.

The Caretaker came over - Chris Fithien. We visited, and gave him a small vial of Blackberry Brandy, too. (We sent out small samples of Blackberry Brandy, to a few dozen friends, so we could all toast our old leaders of 1955, Jack Williams and Fred Torrey.)

We cooked up pancakes for breakfast -- as I'd planned, it took a couple HOURS! -- but they were tasty, with lots of butter and a pint of Maple-type syrup. About 2 PM, the weather had stopped being too nasty, so we hiked over to Gray Knob. We said hello to Chris, and put on our crampons, which took a while. Then we hiked up toward timberline. We got up a couple hundred yards, and turned around. We went back, and got all our water-bottles full at the spring (barely 60' below the trail, half-way between Crag and Gray Knob.) I had never found that Spring before, in winter. It was running about 2 liters per second. It was pretty good water. Signs warned us to boil or purify the water, but I didn't bother. At that time of year, the purity and dilution were ~ OK.

We made up supper of mashed potatoes and peas and Buffalo Burger. It was very tasty. Then Chris came over, and Steve Weber (whom I had met on the internet just a week ago). We all sipped our Blackberry Brandy, and toasted Jack Williams and to the memory of Fred Torrey, at the right time, 7 PM. We went to bed after a while.

The next morning (Monday) it was blowing harder. We ate our Cream O'Wheat with Apricots and Sausage. We decided to go up to Treeline and a little higher. We went straight up the Spur Trail, with our crampons on, right from Crag. We got up to tree line in about 20 minutes, and the wind was blowing hard. We decided to go up about 100 yards, and we went past 4 cairns, and turned around and retreated. It was definitely as far as we should go.

We knew that if we just filled all our water-bottles at the spring, we would run them dry very quickly. So I decided to bring over some Plastic newspaper bags. Each one would hold at least 3 or 4 liters, and they were not leaking at any significant rate. We filled them at the spring, and carted the whole mess back to the Cabin. The leak rate was - quite small. So we had plenty of water. (Even if I did have icicles leaking down from my pack.)

Unfortunately it was cooling off rapidly. The outside temperature had fallen from about 30 degrees to 12. We knew the water in the cabin would freeze, but we salvaged a lot of it in pots, and it didn't freeze solid. We cooked up the pea soup with veggies and turkey hot-dog, and that was very good. We used about 7 cups of water and we ate it all.

Next morning, the outside temperature was about + 4 degrees F, and inside was 12 degrees. It felt cold. About 7 AM , Jonathan called his wife, and she recited the weather forecast from Mt. Washington: -8 degrees C, with freezing fog, and about 50 mph winds, with wind-chill to -58 degrees. Well, obviously, it would be MUCH better at Mt Adams, maybe only -38 degrees F. We immediately decided to pack down 1 day early, as the next day's weather was forecast to be about the same. We ate our oatmeal, and packed, and started down on crampons, about 11:50 AM. If we had tried to descend without crampons, it might have been messy, but we did not go fast. We were being VERY careful on the steep pitches.

We got down to 3rd Crossing (about 0.8 miles) in - - two hours. We took a good rest there, and then got down to 2nd Crossing in about an hour. We had a good rest there, as it was quite tricky to get across the stream. Then it was about 3:45. We knew it would be getting dark in less than 2 hours, and we had 2 miles to go. We stomped down the hill at a deliberate pace, about 1 mph. We got out on the RR roadbed at 5:25, and walked back to the car by 5:45. We stowed our stuff into the car, and went back to pick up our stuff that we left at the Motel. We also had some soup. By the time we got down as far as Pinkham, it was 8:45 PM. But we felt pretty good. We had not reached the summit, but we knew how to do it, and we would have made it if the wind was not so strong. We had said that we would get to the summit of Adams if there were just 3 days of bad weather in a row. Unfortunately, we had 4 days of bad weather. But it was still fun!

More later!! Best regards, / rap

Technical Reports on - Equipment and Activities....

Our stove. Jon's old Optimus 111B (a 1950 design) needed its pump leather oiled and tweaked, and after that, it ran and started perfectly, whether on gas or alcohol. Its flame was not perfectly symmetrical, but it throttled up and down very nicely. We had plenty of flame. We left behind about 6 ounces of gasoline, and carried down a pint. The stove was steady and wonderful. We only needed a dozen matches for 4 days....

Crampons. MY crampons (1956 Army Surplus) worked. JUST plain worked.They went on easily, and did not fall off. They did not bend or break. Malcolm's good (forged) crampons (that we borrowed from Nancy) worked well, but we had to rig new straps. When we first tried to get them on, the old tired leather thong broke - and broke again. But after that, the leather thong did NOT break again, and was quite strong, and the combination of nylon and leather just worked well.

Jonathan's crampons (that I picked up for $21 in Kathmandu) did NOT fit well They were not quite big enough. We finally figured out how to add more straps. The first day, the right crampon fell off after 20 minutes. The second day, after 1 hour. We kept adding more straps, and the third day, they never fell off. It was still MUCH too much work to get them on, and too slow, but we felt it a minor triumph that we got them to hold on so well. (The left one never fell off. Not sure why not...) Refer to "What's All This Crampon Stuff, Anyhow?" in Electronic Design, Jan. 2006.

The crampon work at high altitude was good tough work. The wind was moderate, and did not really blow us over. But we knew we should turn around and descend, as we had no safety factor in the cool wind, about + 12 degrees, with 20 or 30 mph winds, and gusts near 40. We were correct to not try to force our way up. If a crampon had fallen off, we would have frozen our hands trying to fix it. We did see one young hiker, Jeff, who came up the trail, and went straight on up to the summit, and came down just as we were turning around. We were not in quite as good shape as he was.

Descending all the 3.5 miles to the road was really tough work. All that crunching on the frozen snow was VERY tough walking, even though any single step was not bad. Now back at Boston, as I type, I recognize my calves are quite tired and sore. After 10 hours of driving, today, I'm gonna be a basket case, trying to stand up and totter!

As we were descending, I was concerned that I'd get a big headache from all that crunching. (Didn't quite.) It was easy to step on a frozen knob of snow, or a rock, that tried to twist our ankles, and we could never really relax, even though the traction was good. All 3 crampons balled up occasionally with ice under the heel or instep, after we stepped into ice/water, running across the trail, but we gradually learned to avoid that, and knock off the ice.

Jackets, hats - all worked pretty well. Pants, Leggins (gaiters) - worked well.

Malcolm's boots were somewhat cold, as they got damp, but they were OK after he got them dried out. My Vasque boots I had just coated with shoe goo, and they seemed to stay dead dry. And comfy warm. I was wearing thin socks plus good Bridgedales, and I was prepared to double up on the warm socks, but I never had to.

Mittens were generally OK. We had good mittens, but our hands still got cold, especially during cooking at 12 degrees. We all tried those "Hand warmers", and we were surprised how long they heated - 9 to 12 hours, even for the "7.5 hour" ones. They made life liveable. We had several to spare.

Our sleeping bag "systems" were good. We each had a ~2-pound cheap knock-off down-and-feather bag that I bought in Kathmandu, AND we had home-made flannel inner bags, very important. And I insisted we wear flannel pajamas, to keep us warm. This was just about enough.

Snowshoes - we never even tried them on. I had run out of space inside my pack, so Jon carried several of my things, and I carried his snowshoes along with mine, lashed to the back of my pack. Malcolm carried the old rawhide ones - up AND down. We knew it was unlikely to get 20" of snow, but we did not want to get stuck up at Crag, with no snowshoes.

Food - we had enough at all meals, and plenty left over at a few. We learned not to cook a full pot, but just what we could eat. We had enough lunches for a week, and lots of gorp. ("Good Old Raisins and Peanuts (and chocolate bits))"

My camcorder tried to work, almost not at all. It seemed like the battery was refusing to connect to the camcorder. This had never happened before. By holding the battery down with a large force, I was sometimes able to get some video - and more often, NOT able to get it to run. Quite annoying. I finally got it working by shoving some tinfoil into the contact spaces.

Jon's cell phone worked well. He checked in with his wife every evening about 7 PM, and the signal strength was good, about 3 bars. (The antenna up on Pine Mt. had blown down, but their patch of the antenna seemed to be working fine.) Mostly we just said hello, and that we were OK, and confirmed that the weather was as bad as it seemed.

What am I forgetting? Not too much. The fingertips on my right hand got a little frosted, and are very slightly numb and painful, but when I get typing, they are not really noticeably uncomfortable. I'm sure they'll be OK in a while. But I did recognize, I had no safety factor in that cool weather. Especially while cooking at + 12 degrees F. Earworms: I got one song into my head - the sign-on theme from "Your Box At The Opera" on WTIC from 1946-1966 - and Jon and Mal told me what it was, the "fate" theme from Carmen. There was another one that came into my ahead every night (I suspect it was the sign-off theme for the same program) but I could not remember it in the morning. It will turn up! *** Got It!

Could we have gone up through a lot of fresh snow? Probably. If we had 6 or 8" of new snow, taking the snowshoes off our packs would have made our packs lighter, so that wouldn't have slowed us down much. We would have had good footing. If we had 14 or 20" of snow, and we had to bivouac in snow, we would have been OK. However, we really were not prepared for so much rain. Could we have bivouacked OK? What's all this Bivouac Stuff, Anyhow? Yes, there were adequate flat spots up to 3rd crossing - and not above there. When we saw there was only a little snow, and no new snow, we knew we would make it up, so we left our tarps and tube-tent down in the car. If we had our tube-tent, and it were to rain and blow, we would have been damp and miserable, but we would have made it.

Could we go back another year, and try for the summit? Yeah, we could, BUT in the words of a well-known politician - "It would be wrong". I think we can check some old weather reports, and see that the odds of finding good weather for one day out of 4, are just too thin. We had one good day, and we used that to get up to Crag, and then the next 4 days of weather were too cold and windy. I guess when we went up there in the past, we were pretty lucky to get such nice weather! If YOU live in the Boston area, and you want to climb Mt. Adams in winter - check the weather, and head up early, on a good day!

There is a report on the weather and trail conditions at nearby Gray Knob (for the last week or so).

The Weather Forecast for the Mt. Washington area is posted every morning.

All for now! /rap

(Jon and Malcolm can add comments as they wish.)

P.S. - Well, we DID get to visit our old 1955 hike leader Jack Williams in Mirror Lake NH. He seems to be quite healthy and happy, at 87. We visited for 1/2 hour, and then came down Route 11 from Alton to Rochester, to get to the NH pike to Boston. Mr. Williams has a handsome voice, as if from a barrel chest. I told him I loved to hear his voice - it reminded me of some other guy's voice - but I couldn't think of whose.

This report has been amended for people who have NOT been to Crag.

Snow fleas. We found some "dust" on the snow, as we approached Crag. Malcolm thought it was some kind of dust or industrial effluvia, but when I peered closely, I could see them move. The Caretaker didn't know much about these "snow fleas", but Jack Williams' wife said that they come up from the ground, as the spring weather warms up, and they jump around. She said they have a little claw. Total length about 1/32" long. They do tend to cluster in the footsteps! - and in our snow-melt water. We strained our melted snow through a clean handkerchief. Then we minimized their problems by using the spring water. We'll find some more info on them. Google up those snow fleas! (Are they a version of "springtail"? Yeah....)

Best wishes! / rap

Reading Material. We sat around in Crag, and read excerpts from a notorious book "Not Without Peril", about a lot of people who climbed up Mt. Washington and died of the horrendous cold weather - even in the summer, even in "good weather". Then, in the gathering gloom, at 12 degrees F, I pulled out and read a copy of Robert Service' "The Cremation of Sam McGee". Perfect poem for a cold evening!

Other significant topics: It is hard to buy reasonably-priced Sun-goggles that will go over glasses. Most sun-goggles are apparently for rich yuppy skiers who wear contacts. We found work-arounds: some old goggles, to keep the cold wind off our faces, in conjunction with balaclavas.

It's hard to buy good mitten INNERS. (The mitten shells are quite available at REI or EMS, but the inners are best found at local stores or at Campmor.com).

It's not easy to buy ski-poles with big baskets, as most modern ski-pole baskets are tiny for fastest schussing, but some large baskets can be added to small ski-pole baskets, or to hiking poles. So we wouldn't sink into deep snow.

Comments invited. / rap (Recipes for the classic one-pot meals are available on request.)

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THE BEST OF BOB PEASE

E.E. INSTRUCTORS

When you have a circuit demonstration all set up, and it doesn't quite work -- where do you go for help? When a student needs some help on a lab, and the capacitors look different from anything you've seen before -- is that a clue? How do you keep abreast of problems and solutions in the linear field, in the 1990s? Maybe that new book about linear circuit TROUBLESHOOTING will help you. After all, it's hard to get experience in everything, but when it comes to linear circuits, a little book-learning can't be bad ...

Back

ENGINEERS

If you still want to be able to solve all the tough, nasty problems, you will just have to buy this new book about TROUBLESHOOTING Analog Circuits. And you'll have to hide it, so the other engineers won't know where you get your troubleshooting techniques from. Lock it in your desk drawer. And especially, you will have to make sure the technicians don't see the book. Because if they want you to buy each of them a copy of the Troubleshooting book, they will be able to solve most of their problems without even bringing them to you. Hey, maybe that's not such a bad idea after all ...

Back

E.E. STUDENTS

Oh, it's great to get a lab project working. But it isn't always easy. The clues are not obvious. WHY won't the stupid thing work? Do we really think the problem was defined right? Maybe that new TROUBLESHOOTING book will help. Maybe if I show the book to my father, he'll spring for the money. He used to work with electronics -- maybe he can give me some tips on what the problems were like in the old days, and I'll get him so interested that he'll want to buy me that book ...

Back

TECHNICIANS

If you want to be the best trouble-shooter in your lab, you will just have to buy this new book about TROUBLESHOOTING analog circuits. And just leave it around on your bench, so people can see how smart you are. But, drill a hole in the book and keep it chained up, so it doesn't walk too far away. Then when your boss has to decide, who is the sharp, up-and-coming technician, this book will help remind him. Of course, the fact that you've been able to take on and solve some tough problems -- that is the biggest advantage. Why invest $28.95?? Because it will save you half of that, every time it saves you an hour in solving a nasty problem. Now, if you can't afford that much of an investment right now, just point out to your boss how good an investment it is for him to buy you a copy ...

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THE BEST OF BOB PEASE

Czar of Band-Gap References

Why did Bob Pease declare himself the Czar of Bandgaps??
Because a lot of people were repeating old mistakes in their new bandgap reference circuits. Pease has been able to cut down the repetition of old errors. From here on in, engineers have to make NEW errors. When we have the COLUMN on CZARS up on the web, we'll link it up to this page.

THE BEST OF BOB PEASE

Robert Widlar

Robert Widlar is considered the creator of the IC operational amplifier, which made millions for National. This photo was taken around 1977, judging by the LM10 circuit design at which he's looking. Widlar died on February 27, 1991. He was 53.

RAP's 1997 comments:
Maybe next year we can do a re-print of my old column on, "What's all this Widlar Stuff, Anyhow?" But I would really like to add a lot of additional stories about Widlar -- more of the things he did. Can you send me any? (rap@national.com)

THE BEST OF BOB PEASE

Sheep Mow Lawns

During "baaaaaaad" financial times National turned to sheep to mow the lawns. Robert Widlar was responsible.

RAP's 1997 comments:
Widlar drove down to Gilroy, and bought a sheep from a farmer, and brought the sheep back to Santa Clara, in the back of his Mercedes convertible. He then tethered the sheep out on the lawn.

It took only a few minutes for the photographer from the *San Jose Mercury News* to show up.

At the end of the day, Widlar went over to a nearby saloon, and tied up the sheep's rope to a barstool. At the end of the evening he gave the sheep to the bartender. What would YOU do?

Tom Chambliss, an NSC old-timer, claims the gal in the photo was Vickie Darst. Thanks for the info, Tom. We've been hoping to get that identification for years.

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THE BEST OF BOB PEASE

Away from the Office

Some people go backpacking to get away from their office... others seem to bring their office along with them...

Actually, that Xerox-paper Box is full of food. We brought in so much food by a pack train, that after 2 days of day-hiking and eating, we still had a lot of extra food. Bread. Pastries. Snacks. I could either leave the food behind, or carry it. So I filled up that box and carried it. The total was about 70 lb. Fortunately, we only had to go about 10 more miles before we stopped and ate more and got the weight down to a liveable amount. / rap

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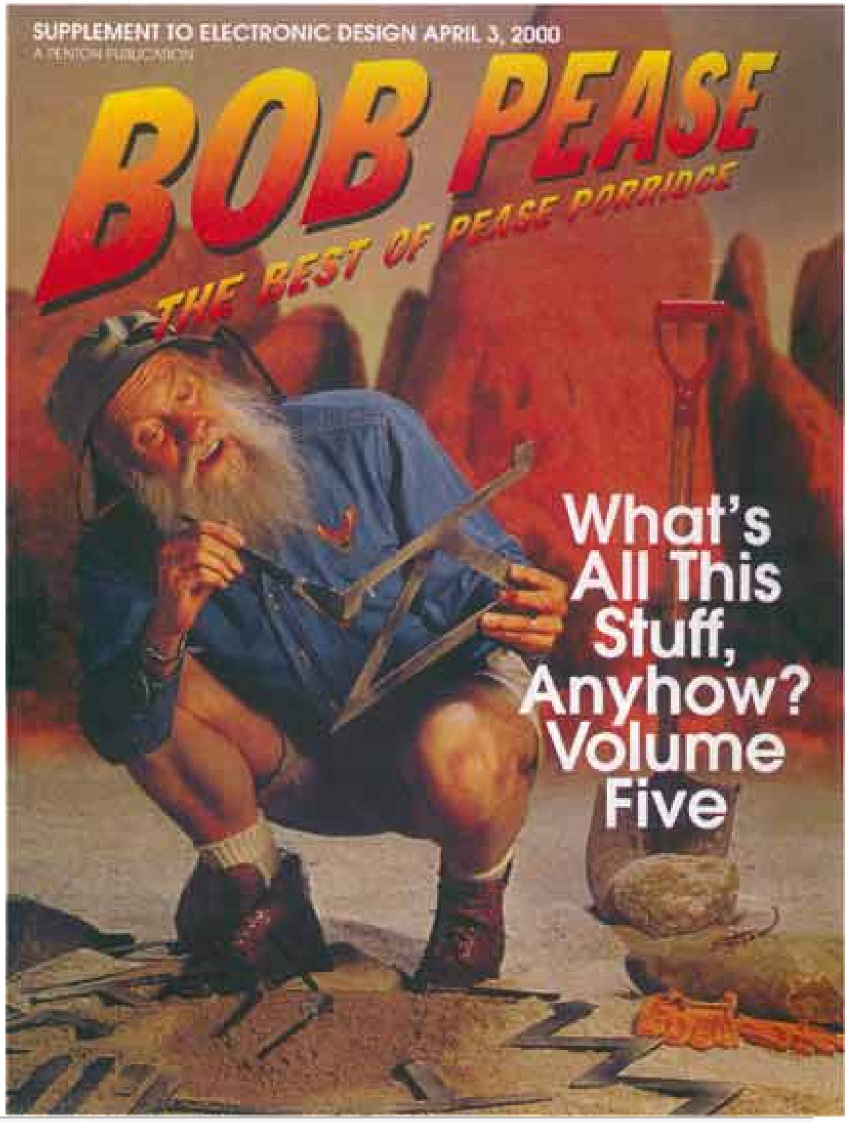
THE BEST OF BOB PEASE

Archeology?

This cover was used for the Bob Pease Re-run columns in Electronic Design, in April of 2000. Bob is delving for ancient op-amp artifacts.



THE BEST OF BOB PEASE

Abominable Snowman?

Will the real Abominable Snowman please stand up? (Bob Pease is using black yak fur for a disguise.)

THE BEST OF BOB PEASE

Too Fuzzy?

Bob Pease seems overwhelmed by Fuzzy Logic. All wrapped up on a cold morning in Nepal.

THE BEST OF BOB PEASE

Nancy and Bob and Friends

For a hundred rupees, YOU, TOO can get a big python wrapped around you, and your friends can take pictures....
Now, is my wife Nancy just laughing? or SCREAMING?
Or is she just ticklish?

THE BEST OF BOB PEASE

Friends, Close Up

- and why does Bob have that worried look in his eyes?

THE BEST OF BOB PEASE

More Friends

It's not the pythons that Bob is concerned about - but it may be the COBRAS.

THE BEST OF BOB PEASE

More Friends

Which of these people are wild and weird?
Which of these people are Don and Peggy?
Why do Don and Peggy allow themselves turn their backs on all these strange people?
Why are they smiling?
Maybe because there are no snakes around?

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RAP's List of Good Websites

Info on "How to Drive into ACCIDENTS and How NOT To":

http://www.transtronix.com

For vigorous hiking in Nepal, Peter Owens treks:

http://www.Instantweb.com/p/peterowens

Wilderness Travel for treks all around the world:

http://www.wildernesstravel.com

Doctor Science:

http://www.drscience.com

Kimmel-Gerke Associates (Experts on EMI and RFI):

http://www.emiguru.com

DAC/I Associates, for worst-case analysis of circuits:

http://www.daci-wca.com/daci001.htm

John Trudel for advice on business and Product planning:

http://www.trudelgroup.com

Don Lancaster for good ideas on engineering & publishing:

http://www.tinaja.com

Rich Hanson, purveyor of Model 102 Laptops:

http://www.the-dock.com/club100.html

Electronic Design:

http://www.elecdesign.com/

THE BEST OF BOB PEASE

RAP's Check List for Business Travel

1966; Revised 1986, 1996, & 1997

- Small Radio
- Photocopy of Driver's License
- Passport, vaccination forms
- Photocopy of passport
- Extra passport photos
- Sunglasses (for driving)
- Camera/Camcorder
- Tickets
- Frequent Flyer Numbers
- Credit Cards
- Traveller's checks
- $$$
- Maps

- Toothbrush, paste
- Scissors
- Camera, film, lenses
- Suitcase keys
- Duct tape
- Knapsack?
- Sleeping bag, tent?
- Suntan Lotion?
- Sun hat
- Precious card, choc. bar
- Iodine pills
- Water bottle
- Toilet paper

- Air Atlas
- Tickets
- Business Cards
- Expense Account Forms
- Quadrille paper, paper
- Pencils, lead, erasers
- Ball-point pens
- Whetstone
- Masking tape/Scotch tap
- Stapler
- Project files, test ckts.
- Talk/Lecture Notes
- Pointers
- Slides, foils
- Colored Pens
- Data Books, literature
- Envelopes, stamps
- Stationery, BIG envelopes
- Carbon paper
- Rubber bands
- Laptop computer
- Battery Charger
- Camcorder, tape recorder

- Swimsuit, towel (soap?
- Jack or Swiss-army knife
- Handkerchiefs
- Kleenex
- Aspirin or anacin
- Deodorant
- Brylcreem, comb
- Picnic Equipment, corkscrew
- Razor, blades
- Shoeshine kit
- Sewing kit, repair kit
- Diagonal Nippers

- Socks, Underwear
- Spare Shoes
- Pants, Hangers
- Shirts
- Ties
- Suits, Jackets

- Parka or Raincoat
- Hat for cold (or rain)
- Boots (vs. bad weather)

- **OVERSEAS:**
- RECONFIRM YOUR FLIGHTS!!!

- Mitts
- Check tires on Rental Car

- Int's Driver's License?
- Travel Guides, Books
- Maps
- Camera Receipts vs. Customs
- Line Cord Adapters
- No SUPERFLUOUS credit cards

Update in 1992; Credit: Anne W. Raphael, Compass Point Travel

Other Items to add:

- Swiss Army knife with corkscrew & can and bottle openers
- First Aid Kit with Moleskin, Band Aids, Talcum, Dental Floss, Large & Small Needle, aspirin or Ibuprofen
- Felt-tip pens
- Hair dryer
- Comfortable shoes for walking
- Water Heater, Tea bags
- Money-Machine cards
- Calculator
- Address/phone list

For Car Trips:

- Chains
- Vise Grips
- Screwdrivers
- Water
- Flares
- WD40
- Fire Extinguisher
- Oil
- Maps
- Jumper Cables

THE BEST OF BOB PEASE

RAP's Check List for Backpacking Trips and Summer Mountaineering

2002

"Experience will dicatate which items are essential;
Circumstances will determine which items are optional or not essential."

General Camping Gear:

- Sleeping bag
- Foam pad or air mattress
- Groundcloth, poncho, or rain shelter
- Tent & rain fly
- Heavy cord
- Packframe with belly band & chest strap
- Small day pack
- Small flashlight Spare bulbs and batteries or Plumber's Candle/candle lantern
- Guidebook & maps
- Hatchet /shovel/trowel
- Matches
- Walking Staff or poles
- Campfire permit"

Cooking Gear:

- Tin cup and/or plastic measuring cup
- Stove & Fuel & Fuel bottle
- Matches
- Waterproof Matches
- Fry pan

Personal Equipment & Clothing:

To Wear:

- COMFORTABLE boots or shoes (or, risking stone-bruises, sneakers)
- Cotton/nylon inner socks
- Wool outer socks
- Trousers or shorts (wool preferable)
- Underwear
- Shirt or shirts (wool?) !! Shirts with at least 27" side seams.
- Belt
- Sun hat and/or warm cap
- Jack-knife
- Pencil or pen & paper
- Compass
- Handkerchief or kleenex
- Comb
- Maps
- Identification (incl. blood type)
- Watch
- Dollar bills
- Coins for phone
- Thermometer

To Leave in Car:

- A full change of clothing incl.:

- Shoes, socks
- Trousers
- Shirts
- Cap
- Underwear
- Sweater or jacket
- Towel
- Pillow
- Spare sunglasses
- Foot powder
- Water
- Extra Car Keys
- Extra Eyeglasses
- Charcoal, Grill
- Bathroom scales

- Large & medium cooking pots
- Bowls and/or plates
- Paper bowls and/or plates
- Paper towels and/or dishtowel
- Large spoon
- Large sharp knife
- Brillo or scouring pad
- Soap
- Can-opener, corkscrew
- Forks, spoons, (knives)
- ot holder Spatula, whisk, rubber scraper
- Plastic bags

Food:

by your choice and opinions.

*** Put car keys with meat and refrig- erated food, in refrigerator when you are preparing the food

---

First Aid Kit - Including:

Aspirin, Ibuprofen or analgesic Band Aids, Paper Skin. Cipro, Immodium, Peptobismol, Ace Bandage, etc. etc.

To Carry:

- Camp shoes, moccasins, sneakers
- Socks (wool?)
- Underwear
- Wool sweater or shirt
- Spare shorts or trousers
- Parka or rain-gear
- Pajamas, pillow-case
- Mosquito netting, head net
- Toilet paper, trowel
- Insect repellent
- Canteens
- Water purifying pills or iodine AND Pump/filter
- Toothbrush, paste
- Adhesive tape
- Potassium pills for cramps
- Diagonal nippers
- Ear plugs
- Deodorant. Camera, film, lenses or, camcorder, tapes, batteries, chargers and solar panels
- Plastic bags & BIG plastic bags.

THE BEST OF BOB PEASE

The Design of Band-Gap Reference Circuits: Trials and Tribulations

ABSTRACT

This tutorial will briefly discuss the designs of various band-gap references, with an emphasis on technical problems that caused serious troubles. Practical solutions are shown for problems, and a methodology is shown for solving problems.

TUTORIAL

The band-gap reference has been a popular analog circuit for many years. In 1971, Robert Widlar introduced the LM113, the first band-gap reference.[1] It used conventional junction-isolated bipolar-IC technology to make a stable low-voltage (1.220 V) reference. This type of reference became popular as a stable voltage reference for low-voltage circuits, such as in 5-volt data acquisition systems where zener diodes are not suitable. Band-gaps are also used in digital ICs such as ECL, to provide a local bias that is not adversely affected by ambient noises or transients.

The principle of the band-gap circuit is well known and will be mentioned here in the briefest terms. The circuit relies on two groups of transistors running at different emitter current densities. The rich transistor will typically run at 10 times the density of the lean ones, and a factor of 10 will cause a 60 millivolt delta between the base-emitter voltages of the two groups. This delta voltage is usually amplified by a factor of about 10 and added to a Vbe voltage. The total of these two voltages adds up to 1.25 volts, typically, and that is approximately the band-gap of silicon.

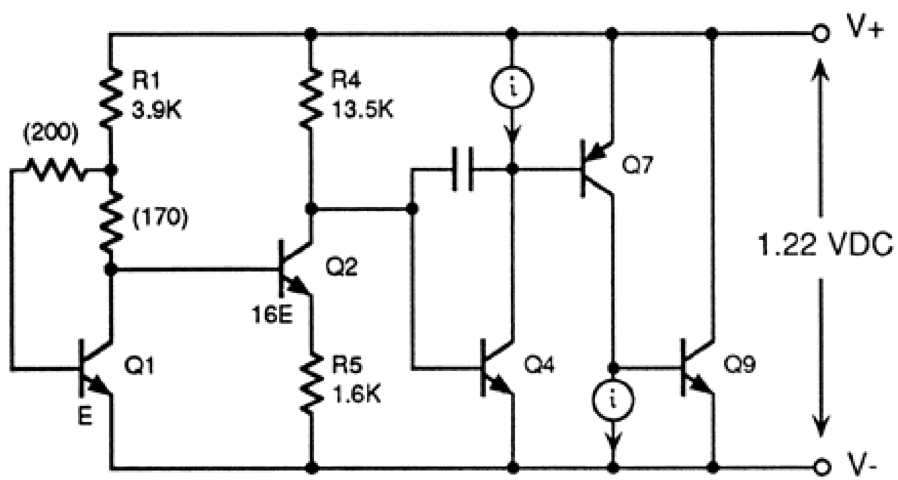


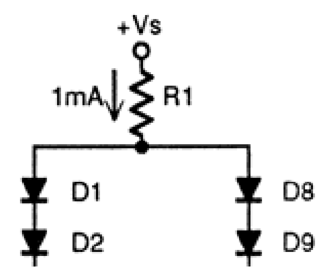
FIGURE 1
SCHEMATIC DIAGRAM, LM113 (SIMPLIFIED)

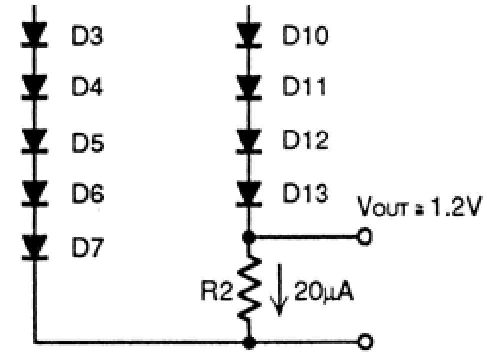
In figure 1, the LM113 schematic diagram shows a basic band-gap circuit. Q1 runs at a relatively high density, about 150 microamperes per square mil. Q2 is operated at a low density, about 10 microamperes per square mil, and so its Vbe is much less, about 70 millivolts. Now, Let's ASSUME that the circuit is at balance and the output is near 1.22 volts. Then the 70 millivolts across R5 is magnified by the ratio of R4 to R5, about 8:1, up to a level of 600 millivolts. This voltage is added to the Vbe of Q4 (about 620 millivolts at room temperature) to make a total of 1.22 volts, as required. Q4 then amplifies the error signal through Q7 and Q9, which provide enough gain to hold the V+ bus at 1.22 volts. The beauty of the band-gap reference is the summation of the Vbe term, which decreases at the rate of about -2 millivolts /°C, and the (delta-Vbe term) which grows at about + 2 millivolts /°C, to achieve an overall Temperature Coefficient (Tempco) that is substantially zero. All band-gaps employ this summation of a growing and a shrinking voltage, to make a stable low-tempco voltage. Further, it has been shown[2] that when a circuit has been trimmed to the correct voltage, the correct tempco will follow, despite process variations in parameters such as Vbe, beta, sheet resistivity, etc. Consequently, band-gap circuits are often trimmed to their ideal voltage so as to provide also a low tempco.

There are many other circuits that have been used for band-gap references, and each one has its own set of advantages and disadvantages. Figure 2 shows a simple brute-force scheme: the stack of Dl-D7 run at a rich current, and D8-Dl3 at a lean current, and the resultant output of 1.2 v has a low tempco. Unfortunately, this circuit is not very suitable for operation on low supply voltages, but its concept is clear!

The Brokaw cell (Figure 3), attributed to Paul Brokaw,[3] is often used for output voltages larger than 1.2 volts, as its Vout can be scaled by the ratio of two resistors, R3 and R4. A similar circuit is used in the LM117, an adjustable medium-power voltage regulator, which can be trimmed by two external resistors to any voltage in the range 1.25 to 57 volts. (Figure 4)

FIGURE 2
SCHEMATIC DIAGRAM
of SIMPLE BANDGAP





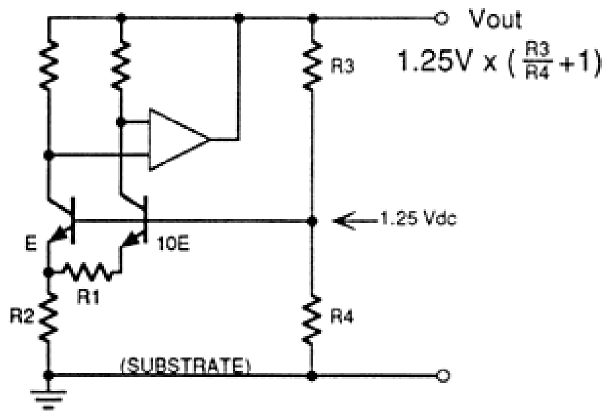


FIGURE 3
SCHEMATIC DIAGRAM, AD580 (SIMPLIFIED)

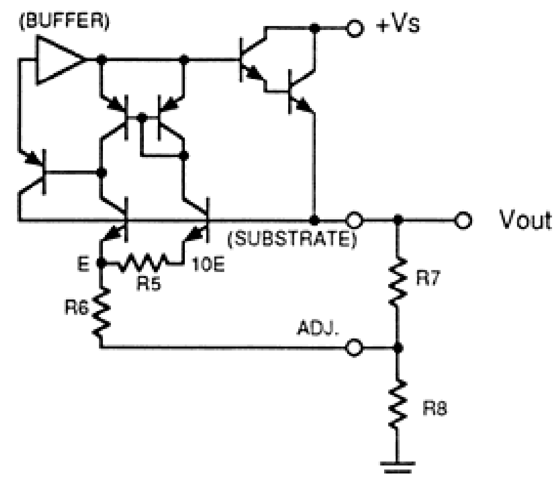


FIGURE 4
SCHEMATIC DIAGRAM, LM117 (SIMPLIFIED)

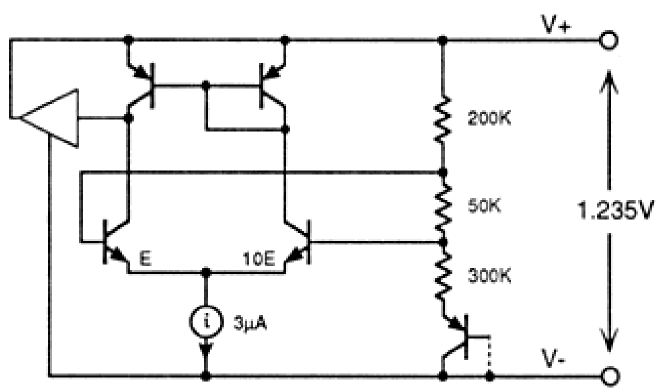


FIGURE 5
SCHEMATIC DIAGRAM, LM185 (SIMPLIFIED)

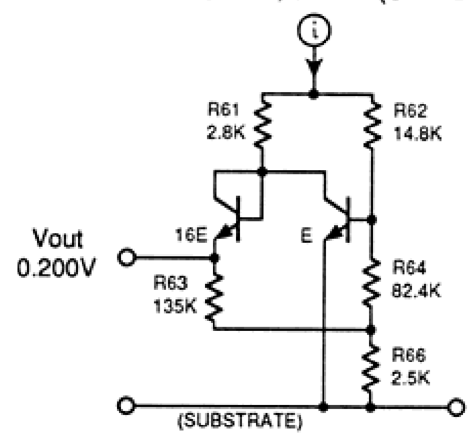


FIGURE 6
SCHEMATIC DIAGRAM, LM10 (SIMPLIFIED)

A different approach is shown in Figure 5, representing the LM136. The version shown is suitable for operation as a 1.2-volt shunt regulator. The circuit of Figure 6 is for the reference section of the LM10, which provides a reference voltage of 0.200 volts and operates on a supply voltage as low as 1.0 volts.

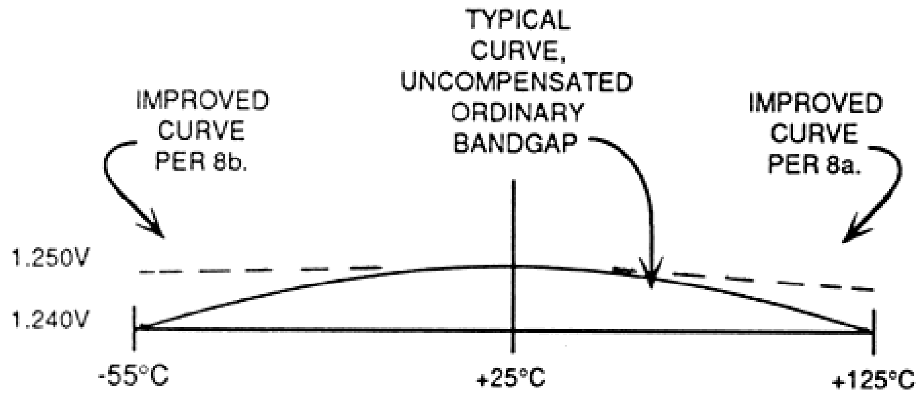


FIGURE 7
VREF VS. TEMPERATURE
BANDGAP REFERENCE

One of the major drawbacks of all these simple band-gaps is the curvature of their tempco. Ordinarily, all band-gaps have a negative tempco when hot, and a positive one when cold. See figure 7. Around room temperature, tempcos as good as 20 or 30 ppm/°C are typically attainable, but over a wide range, -1% shift is normal at hot and cold temperatures. Several techniques have been devised to neutralize this curvature. Figure 8a shows a little add-on circuit which can do a surprisingly effective improvement at warm temperatures. Sometimes 2 or more transistors are connected with slightly different biasses, for improved curvature correction. A circuit which can improve the tempco curvature at cold temperatures is shown in figure 8b.

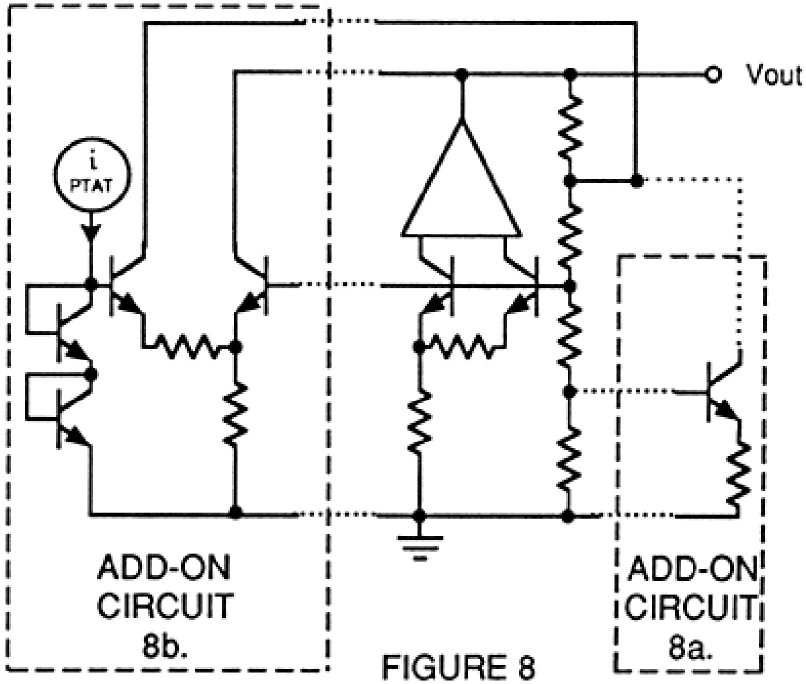


FIGURE 8
SIMPLE BANDGAP SHOWING
CURVATURE COMPENSATION

Other techniques rely on smoothly nonlinear techniques to cancel out the parabolic curvature. One example is shown in Figure 9. It is able to make an improvement of about 8:1. Other proprietary techniques and circuits are also used.

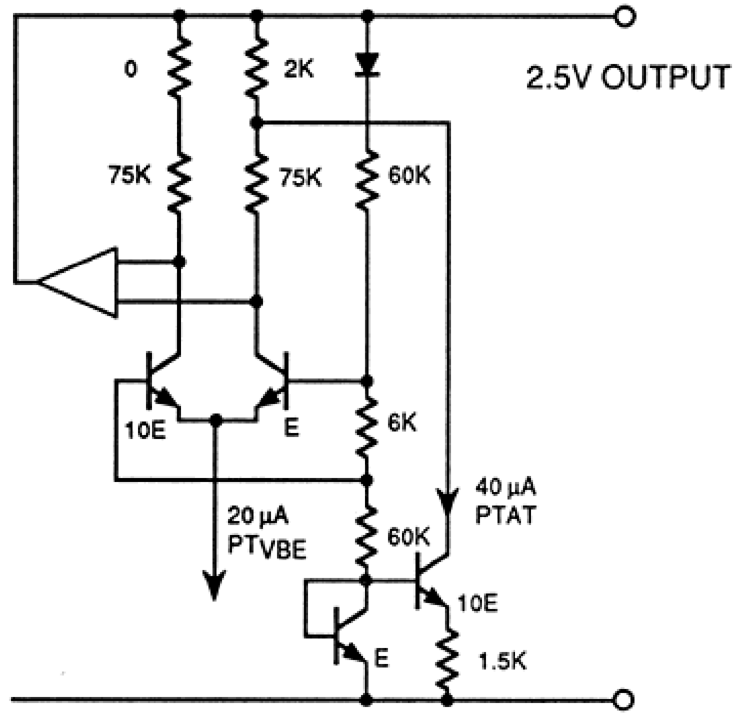


FIGURE 9
SMOOTH CURVATURE-CORRECTION CIRCUIT

Band-gap references are not normally thought of as low-noise devices, because of the high gains needed. Every 1.25 volt of output is made up of 0.6 volts of Vbe, plus a 60 mv signal magnified by a gain of 10. Consequently a 5-volt band-gap includes a 60 millivolt signal amplified by a gain of about 40. If you allow for a transistor running at 1 µA to have a theoretical amount of noise equal to 14 nv per square-root Hz, the output will have at least 800 nv per square-root Hz, and for a bandwidth of 10 kHz, about 80 µv rms, or 500 µv p-p. Obviously, a band-gap reference with 100 ppm of noise will not give good results with a 12-bit DAC. So although some band-gaps may claim advantages of low-power operation of only 11 µA total, for high-performance designs the circuits are more popular when biassed with 30 or 60 µA or more, for each group of emitters.

Many systems-on-a-chip depend on a bandgap to start up and bias all other circuits. Thus, the band-gap must be sure to start promptly under all conditions. It is not trivial to do this, as a band-gap that has not started may not have any bias currents to make sure it does start. Even the leakage of a junction capacitor may be sufficient to prevent the circuit from starting. A good solid sure-start circuit is advisable. If I can think of one, I'll present it. Figure 10, reserved.

FIGURE 10
SURE-START CIRCUIT for
BANDGAP REFERENCE

There are many other ways to design a band-gap reference that does not work well. There are two basic choices: with a computer, and without a computer.

If you rely on breadboards, you may trim to get a good tempco but the resistors may not be matched in their tempco if you just use RN55D or RN55Cs. If you actually get film resistors with a matched tempco, the tempco of your circuit may still not agree with your final circuit, due to the gross tempco of the actual diffused (or film) resistors in your circuit.

Example, diffused resistors have 1600 ppm per °C; implanted silicon resistors are even steeper. Some SiChrome resistors can have +300 ppm/°C, and they will give a completely different tempco than 50 ppm/°C. Also, diffused resistors sometimes have a different tempco depending on how many volts they are biassed below their tub's voltage, so the tempco of a voltage divider may not be as good as theoretical, unless each resistor sees about the same amount of tub bias; this can be done (in theory, if you have enough space) by giving each resistor its own tub.

The dynamic stability of a band-gap IC is often inferior to its breadboard due to stray capacitances in the breadboard. Consequently the use of SPICE and similar computer simulation schemes are becoming popular, as the capacitances can be well defined without false influences or strays. However, as with any other computer usage, a "sanity-check" is recommended to insure rational results in a known situation, before the computer can be trusted in unknown cases.

However, there are many ways to get false results in SPICE and other simulation schemes. Most transistor models do not accurately model the shape of the curve of Vbe vs. temperature. It is sometimes possible to tweak the characteristics of the model of a transistor until the tempco of the breadboard or analog model matches that of the computer model. However, after you have done this, it is not safe to assume that reasonable changes in the operating points will cause reasonable changes in the tempco. The actual changes may be different from the computed changes, even for a minor tweak. For example, a minor change of a resistor, which actually gives a change of +10 ppm per °C may be predicted by the computer to give a change of +5, with no plausible reason for the discrepancy. Often, a SPICE run will simply fail to converge at cold temperatures. If you take the observed operating points from a run at -34°C and insert them as the node-set voltages for a run at -35°C, don't be surprised if you still get no convergence. In a circuit, being close to the right answer helps, but in SPICE, convergence depends on the matrix yielding a valid answer, and that has almost nothing to do with the circuit or reality. For example, on a recent SPICE run, I had a resistor connected only to ground and to a capacitor which also went to ground. If I used an * to comment-out the resistor and capacitor, the circuit refused to converge, but if I put them back into the circuit, they somehow helped the matrix converge. So, in the future we may be able to insert useless meaningless resistors around the circuit, whose sole function is to help the matrix give good convergence.

Other practical examples will be given of how to make a band-gap work badly, and how to give it a chance of working well.

Advice to the Engineer

While it is not practical or suitable to show examples of How to Design a Good Band-gap Reference, it is possible to show examples of circuits that do not work well. By avoiding the thicket of bad design practices, a good design may be seen to be feasible. A list of examples of bad design will be given here, grouped in categories.

Layout Problems

- Bad cross-coupling. As in a good op-amp, the critical transistors should be laid out with cross-coupling -- example, 1/2 of Q1 on one side of Q2 and the other half on the other side of Q2, so the centroid of Q1 and of Q2 will be at the same place. Likewise, critical resistors should be arranged so that 1/2 of R1 is on one side of R2, and the other half on the other side -- again, common centroid. This is especially important in a power regulator where large temperature gradients can be expected. Also it is very advantageous to reject gradients in sheet rho, beta, etc. In a typical band-gap, this cross-coupling should be done for the delta-Vbe transistors and also for the PNP transistors that serve as their collector loads, unless you can prove it to be unnecessary.

- Layout of Delta-Vbe circuit vs. Vbe. In some circuits, the transistors that form the delta-Vbe are not the same ones that make the Vbe. These must be laid out to reject gradients from all expected directions.
- Thermal regulation errors. When a band-gap regulator or reference has a step change of dissipation, the thermal gradients across the die may cause significant errors. A good layout with adequate cross-coupling and attention to detail is normally required to keep these errors to acceptable levels. A good power regulator can do 0.005%/W; a good precision reference can do 0.002%/W. Thoughtful layout techniques as mentioned above are especially important for a library cell that will be used in an ASIC, because when it is used, you can never guess where the thermal gradients will come from; you have to lay the circuit out to reject gradients from all directions.
- Rejection of I x R drops in power busses. If some parts of a circuit are connected to a power bus at one point, and other parts at another point, significant errors can be caused when current flows through the bus. In some cases, you can specify that no such current can flow through the bus; in cases where the bus current must be expected to fluctuate, the connections to the power bus must be arranged to reject the I x R drops.
- Thermal stress in corners of the die. When a precision circuit is laid out far off the center-line of the die, near a corner, the thermal stresses can cause errors. For best results, avoid putting precision circuits in corners or far off-axis. This applies to ASIC cells, of course.

Start-up Circuit Problems

- Bad start-up. Normally applies only to series-mode circuits, not shunt-mode.
- Start-up circuit too weak. This often happens when the start-up current (high-value resistor or EPI-FET) puts out too little current. This problem is often exacerbated by high temperatures, leaky diodes, leaky capacitors, or excessive substrate currents if one of the terminals is pulled below the substrate. You can never absolutely be free of this, but you can avoid it if you have a good start-up test. Do not expect the computer to be of much help.
- Start-up circuit too strong. This can happen when the EPI-FET puts out too much current and overwhelms the start-up circuit. It's not easy to model this in SPICE, but you can think about this as a worst-case to be avoided.
- Dynamic start-up with no dc start-up. The circuit can start on the dv/dt of the input, but may not start if dv/dt is small. Use a start-up test.
- Start-up too slow. You may avoid this by good worst-case design and good modelling in SPICE or breadboarding.

Oscillations

- Oscillation due to capacitive load. You avoid this by good circuit design. Sometimes the condition can be helped by pre-load currents, or by a series R-C damper network to ground. Use Pease's Principle to make sure that ringing is not lurking nearby which will turn into oscillation when you turn your back. Check for ringing at all relevant temperatures.
- Oscillations at some temperatures and not others. Check for this by watching the Vout for ringing as the part's temperature is SWEPT from one extreme to the other. Note, monitoring the dc output voltage is not necessarily sufficient to insure freedom from oscillation.
- Oscillations due to improper start-up circuit. Make sure the start-up circuit is well-designed and well-behaved in all worst cases.
- Oscillations because the breadboard had enough strays but the IC does not. This is a matter of good modelling.

The breadboard can be expected to lie about this. SPICE may be helpful if applied thoughtfully.

- Obscure oscillations. The computer often lies badly about these. It may refuse to admit that they happen, and refuse to show them happening.

DC Output Voltage Errors (Room temp)

- Excessively broad distribution of Vref. When you expect a tolerance of ±3% and the observed distribution is excessive, the problem is usually either badly-matched resistors or transistors. The geometries must be identical as drawn and as masked. If your small resistor is short, your large resistor should be made of a group of short resistors. Sometimes it is advantageous to draw the Rs and Qs as cells, so that the mask-making process acts identically on each cell.
- Parts cannot be trimmed. Make sure that every voltage can be trimmed by at least one combination of trims; avoid any possible "holes" in your trim scheme.
- Interaction of trims. It is a good idea to make sure that in your plan, the size of each trim is (substantially) invariant of whether any of the previous trims have been done.
- Dependence of pre-trim Vref on beta. In general, a higher beta transistor has a lower Vbe. In some designs, a pinch resistor (whose resistance is a linear function of beta) is used to compensate for the shift of Vbe and improve the room-temp accuracy. In other cases, a pinch resistor is used to compensate for tempco, even as it degrades the room-temp accuracy.
- Band-gap "narrowing". With high-speed processes, the band-gap voltage (and the voltage for zero tempco) is decreased vs. ordinary transistors. A good breadboard can help determine the right place to operate. The computer cannot.

Tempco Errors

- Wrong "V-magic". Normally there is one value of Vref, which (if you trim to that voltage) gives the best tempco. But there may be circuit problems, masking problems, or process problems that can cause tempco to vary even when the Vref is well trimmed. The deviations are typically + or - 5 or 10 ppm/°C, but in a poor circuit can be considerably worse.
- Inability to trim to Vmagic. If there are "holes" in your trim scheme and you cannot get the Vref to trim to Vmagic with good precision, the tempco will be degraded by about 3 µv/°C per millivolt of error.
- Tempco curvature-correction circuit does not work well? MOST tempco curvature correction circuits do not work well the first time. Some are still bad after several tries. Computer models are of little help, or usually of much harm. Breadboards often are no better. Trial-and-error is usually needed.
- Leakages cause high-temp errors. You have to watch out for device leakages, tub leakages to substrate, and capacitor leakages. These are usually hard to model.
- Tempco does not agree with breadboard. If you used discrete low-tempco resistors in your breadboard instead of the monolithic (diffused or implanted) resistors, you can expect bad results.

Computer Modelling Problems

- Bad model of the Vbe versus temp. Most transistor models are poor. It is possible to tweak various parameters to get decent match of Vbe vs. temp, but the derivatives may not be realistic.
- Mis-typed data input. Be extremely meticulous about typing errors and copying errors. Strange results may occur otherwise.

- Failure to converge at cold temperatures. Yes, that is a problem...
- Failure to converge despite accurate "Node-set". Sometimes if Nodeset is TOO accurate, convergence is worse than if Nodeset is approximate.
- Failure to converge due to 35 volts across a diode (Vf) which does not conduct any current. Maybe you need a bigger diode...
- False current due to dv/dt across a hidden capacitance. When the collector voltage has a dv/dt, the "collector current" can show the current through the c-b junction, but the current through the c-substrate junction may not be included.
- False dv/dt due to .PLOT command truncating the .TRAN command. This has been observed to happen, when the end of the .PLOT is not at the same time as the end of .TRAN.

Miscellaneous Problems

- Low-voltage-lock-out problems. YOU must engineer carefully to get good results at low voltages, as the system may require good behaviour at very low supply voltages, and the reference may not want to give it. The breadboard works better than SPICE, here. Check at all temperatures.
- Thermal limit circuit works badly, poor errors, soft knee. Try to use a circuit that has been successful in the past. Hysteresis is often a good feature.
- High noise due to starvation. Be sure to check the breadboard. (Unless you are sure the computer gives good answers.)
- High noise due to high resistance. Check the breadboard carefully, and use realistic transistor samples. High-beta parts will have higher rbb' than low-beta ones.
- Bad matching due to buried layer. If the actual buried layer causes crystal growth to fall in the middle of a critical transistor, Vbe matching may suffer. Note, the crystal growth at the surface is shifted from where the buried layer appears to be.
- Saturation due to insufficient buried layer. Transistors do not run well at warm temperatures when asked to run near saturation, especially at high temp, when the buried layer has been omitted.
- Assembly shift. This is usually caused by stress sensitivity. A good layout can help minimize this.

Czardom

At National, we appointed a Czar to oversee the design of all band-gap circuits, and to monitor and to log all good and bad results. This has helped cut down on the number of repetitive foolish errors.

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THE BEST OF BOB PEASE

Third Thoughts on Fuzzy Logic

An ardent skeptic of fuzzy logic, Robert A. Pease presents a viewpoint opposing that of the theme articles in this issue. Pease is a staff scientist at National Semiconductor and writes the column "Pease Porridge." He has a BSEE from MIT. -- Ed.

I became an instant "expert" on fuzzy logic (FL) in May of 1993, after questioning[1] the advantages claimed for it -- too many were preposterous and made no sense. Now after writing five more columns on FL[2-6], lecturing, and receiving many thoughtful letters, I am not much more of an expert on doing FL than in 1993.

But, no problem: most people publishing papers touting FL as having great advantages over conventional systems know less about good conventional systems than I do about FL. And a lot of my bold statements about FL been confirmed. For example, when an FL system claims to show great advantages over a conventional system, the advantages arise because the conventional system was badly done, or because it was heavily nonlinear.

So-called experts make silly claims for FL: "An elevator not based on FL runs at constant speed until it reaches the destination, then comes to a rough stop."[7] Absurd! Then an FL "expert" on the radio[8] claimed that the 1993 Saturn automobile's automatic transmission was redesigned with FL. Daniel McNeill, author of a collection of platitudes and puffery about FL,[9] stated that on steep upgrades, the transmission used FL to cut out "hunting" and excessive shifting up and down. He said that ordinary automatic transmissions "always shift at the same speed," but by using FL, they can be made to shift at different speeds -- poppycock!! Well, the Saturn's transmission was improved, but it did not use FL to improve its behavior on upgrades.[10] Designers used FL only to provide downshifts on downgrades. Every example of FL included bad thinking and untrue statements -- which made me very suspicious!

Several people recommended the Sendai train as an excellent example of FL, providing smoother acceleration, faster speed, and better energy economy in a practical system. The Sendai train actually provides worse energy economy;[4] it only appeared to give better economy due to a flawed 1985 computer analysis. In addition, the only published research[11] about the train appeared before it began operation. So all FL enthusiasts must stop claiming that the Sendai train uses less energy. It is a very good, smooth train, and very well engineered, but it cannot travel faster between stations and still consume less energy. This is not because FL is bad, but just because the train provides smoother acceleration.

Several other people have pointed out that, even today, most technical papers on FL show trivial or "toy" examples, not real-world examples. Such papers still set up "straw men." Also, they are written in esoteric symbols and couched in obscure, scholarly phraseology -- and thus are incomprehensible to most serious students or practitioners of FL.

Most FL controllers respond only to proportional and derivative terms[5] and do not have integral response. So a true PID (proportional-integral-derivative) controller, whether analog, digital, or FL, can achieve better accuracy and better dynamic response. These days, few engineers know what PID control[6] is or why it is useful.

Some authorities (notably Bart Kosko) argue that when we go from two parameters to three, and use seven rules in each dimension, the number of fuzzy rules increases grossly, from 49 (7^2) to 343 (7^3), for example. In most cases, that are more or less linear, however, we can use three or five rules, rather than seven. if we add an integral term to the main (proportional) parameter, we may add a small number of new rules, while easily accommodating a third or fourth parameter. So, conversion of an FL to a full-PID controller may require only a few more rules, leading to greatly improved performance.

Dave Brubaker, a serious practitioner of FL, showed[12] the advantages of using PID control in FL. And Adaptive Logic (San Jose, California,) has new software that facilitates the design of PID FL controllers. This can be powerful: a full-PID controller that adds FL's ability to handle nonlinearities.

So what else are we learning about FL? For one, there is still a lot of hype. Ads insist that we'll prefer a $249.95 FL electric razor or a $99.99 FL electric toothbrush. Maybe; I'll wait to see what Consumer Reports says. Meanwhile, there are still many impractical promoters of FL -- balanced by a number of excellent, practical ones.

Such a case comes from Constantin von Altrock of Inform[13] (Oak Park, Illinois). A team from Inform built an autonomous racing car with a 1-hp electric motor for its 10 lbs. of weight, with a complete computer on board, plus an FL pattern recognition system. They put tape down on a parking lot to indicate a race track, so the car could sense its location on the track and when it was coming up to curves.

After a couple of hours writing software, the team got the car to move around the track -- but it performed poorly, skidding badly and driving stupidly. Yet, two weeks later, the software improved, and the car could really drift the corners and race competently. Impressive! Next, the team threw boxes (with tape on the edges, for visibility) onto the track, and the car dodged the boxes and kept racing! Bravo! This may not yet be useful, but it is a virtuoso performance, nontrivial, and not feasible with conventional computers. It can't even be done with op amps! Surely such capabilities will soon prove useful.

Enthusiasts make positive claims for process controllers using FL added to or instead of conventional PID controllers. However, people write saying that, despite these positive claims, FL controllers did not work as well as a good PID controller, in their particular application. Still, a marketeer at Omron Electronics, (Schaumburg, Illinois) pointed out that a good controller does cost extra with added FL; and these augmented controllers are selling pretty well. Why would people pay more? Because, in some applications, the ones with FL really do work better. This fact is compelling. As Jay Last (a Teledyne founder) says, "The only valid market survey is a signed purchase order."

At the 1994 Fuzzy Logic conference, the most impressive demonstration had a ping-pong ball floating atop a column of moving air in a vertical plastic cylinder. An FL controller moved the ball between three levels. This problem is fairly nonlinear and not easily controlled, even with a good detector to indicate the ball's location. (Most FL examples never mention the sensors used, or the sample rate, which can be very important.) Two of the movements were smooth, but the third overshot badly and oscillated. After a few hours, the third transition was alright, but the second one was poor. They never got all three transitions working correctly. So, while it is possible to optimize an FL system, doing so is difficult, despite some FL enthusiasts' claims that optimizing an FL system is easy. Claims that PID is difficult to use are similarly untrue.[14]

An article about balancing a ball on a tilting beam[15] claimed that an FL controller, using only a 486-based computer, was faster and settled better (compared to an untrained human operator). The published plot of the ball's motion was unbelievable because it showed that the ball sometimes did not accelerate after the beam tilted and sometimes accelerated when the beam did not tilt. In addition, the ball had a 100-percent overshoot five times before settling. And despite these poor results, the authors insisted that they got better performance using FL and did not have to provide a mathematical model for the system. When confronted,[16] the authors insisted their design was good,[17] but did not explain the erratic data.

I built my own ball-on-a-beam balancer and used a mathematical model. The ball's velocity is the integral of the tilt, and when a ball rolls, its position is the integral of its velocity. Thus, the ball's position is a double integration on the beam's tilt. I designed the controller in a couple of hours using scrap paper and pen -- not a computer. The design uses four op amps (LMC660) as integrators and differentiators.

This design ran on the first try. While its motion is not yet optimal, the ball still settles promptly without even 5 percent of overshoot, in about 6 seconds for a 20-in. motion. Thus, four op amps (costing less than $1) can, in a thoughtful application, outperform a $1,500 personal computer. This works because a good model exists for the rolling ball (rather than pretending to be better off without any model).

A while back, Lotfi Zadeh and I discussed ball-on-beam balancing. He thought he could make a ball roll on a lossy tilting surface (such as carpet) with humps to hinder the ball's free roll, and could even make it arrive on target at a particular time. I said that was possible with op amps, too, but he could surely do it better, because FL is very good for nonlinear cases.

Then Lotfi spoke of a colleague who still dislikes FL. This person said, "Lotfi, I hope I live long enough to see you invited to the White House, where the President will present you with a medal 'For fooling the Japanese into thinking that fuzzy logic is a good idea'." It was really charming that Lotfi had such a fine sense of humor, and could tell a joke on himself, on such a serious topic!

I invite your comments.

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THE BEST OF BOB PEASE

Understand Capacitor Soakage to Optimize Analog Systems

Dielectric absorption can cause subtle errors in analog applications such as those employing S/H circuits, integrating ADCs and active filters. But knowing how to measure this soakage and compensate for it helps you minimize its effects.

Veteran circuit designers often got a shocking introduction to dielectric absorption when supposedly discharged high-voltage oil-filled paper capacitors reached out and bit them. Indeed, the old oil-filled paper capacitors were notorious for what was once called soakage -- a capacitor's propensity to regain some charge after removal of a momentary short. Today, you won't find very many of these capacitors in use, but you will still encounter soakage. Do you know how to deal with it?

Nowadays, you're more likely to notice the effects of dielectric absorption in some more subtle way, perhaps in the performance of an integrator that can't be reset to zero or a sample/hold that refuses to work correctly. But whether you literally feel its effects or merely observe them in a circuit's behavior, dielectric absorption is an undesirable characteristic that every capacitor possesses to some degree. This characteristic is inherent in the dielectric material itself, although a poor manufacturing procedure or inferior foil electrodes can contribute to the problem.

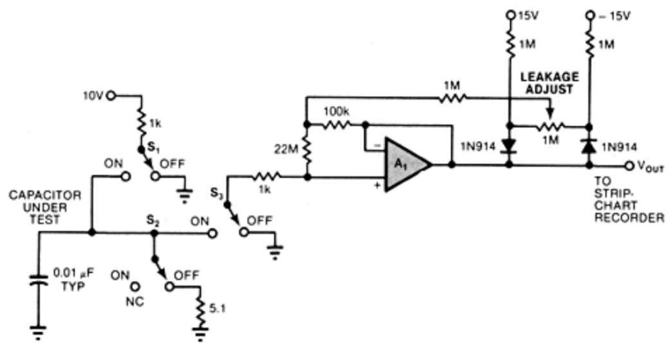


Fig 1 - A simple test fixture lets you evaluate dielectric absorption at low speeds. To use the one shown here, start with all switches off and throw S_1 and S_2 on for 1 min; throw S_1 and S_2 off and wait 6 sec, throwing S_3 on during the wait period. Next, turn S_2 on and watch V_{OUT} for 1 min. To compensate for leakage, leave all switches off for 1 min and then throw S_2 and S_3 on. Monitor V_{OUT} for 1 min and subtract this value from the V_{OUT} value obtained earlier. (View a larger version of the image.)

Indeed, soakage seems an apt term for dielectric absorption when you note what the capacitor seems to be doing. Consider a typical example: A capacitor charges to 10V for a long time T and then discharges through a small-value resistor for a short time t. If you remove the short circuit and monitor the capacitor terminals with a high-impedance voltmeter, you see the capacitor charge back to 0.1%, 1% or as much as 10% of the original voltage. For example, a 1-µF Mylar capacitor charged to 10V for 60 sec (T_{CHARGE}) and discharged for 6 sec ($T_{DISCHARGE}$) charges to 20 or 30 mV after 1 min (T_{HOLD}). Fig 1 shows a simple evaluation circuit for measuring this characteristic.

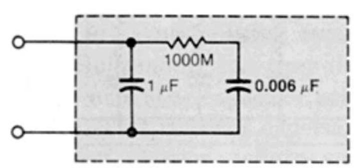


Fig 2 - To model the soakage characteristic of a 1-µF Mylar capacitor, consider a circuit that incorporates a 0.006-µF capacitor to represent the dielectric's charge-storage characteristics.

A capacitor exhibiting dielectric absorption acts as if during its long precharge time the dielectric material has soaked up some charge that remains in the dielectric during the brief discharge period. This charge then bleeds back out of the dielectric during the relaxation period and causes a voltage to appear at the capacitor terminals. Fig 2 depicts a simple model of this capacitor: When 10V is applied for 1 min, the 0.006-µF capacitor gets almost completely charged, but during a 6-sec discharge period it only partially discharges. Then, over the next minute, the charge flows back out of the 0.006-µF and charges the 1-µF capacitor to a couple of dozen millivolts. This example indicates that a longer discharging time reduces soakage error but that discharging for only a small fraction of that time results in a larger error. Illustrating this point, Fig 3 shows the results of conducting Fig 1's basic test sequence for 1-, 6- and 12-sec discharge times. Note that the capacitor tries to remember its old voltage, but the longer you hold it at its new voltage, the better it forgets -- in the Fig 3 case, soakage errors equal 31 mV at $t_{DISCHARGE}$=l sec, 20 mV at $t_{DISCHARGE}$=6 see and 14 mV at $t_{DISCHARGE}$=12 sec.

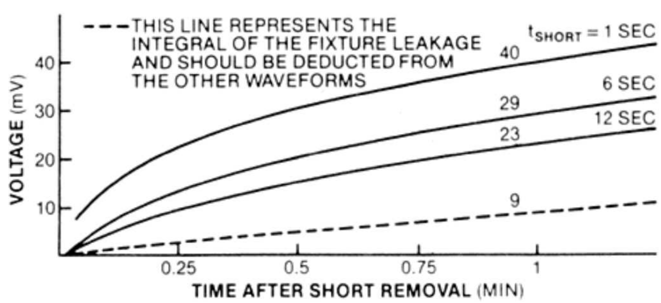


Fig 3 - Obtained using Fig 1's test circuit, these dielectric-absorption-measurement results for a 1-µF capacitor shown that longer $t_{DISCHARGE}$ times reduce soakage-caused errors.

High-speed tests predict S/H performance

You might now ask whether these low-speed tests have any bearing on a capacitor's suitability in fast millisecond or microsecond sample/hold applications. If you repeat the Fig 1 experiment for T_{CHARGE} = T_{HOLD} = 1000 µsec and $t_{DISCHARGE}$ = 100 µsec, you see very similar capacitor-voltage waveforms but with about 10-times-smaller amplitudes. In fact, for a constant T:t ratio, the resulting soakage error decreases only slightly in tests ranging in length from minutes to microseconds.

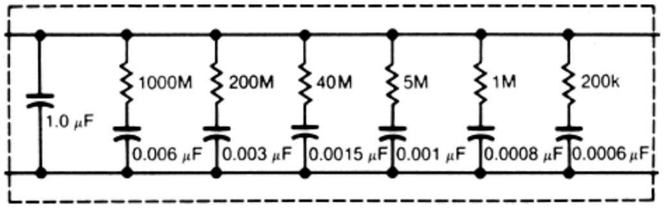


Fig 4 - More precise than Fig 2's equivalent circuit, a capacitor model employing several time constants proves valid for a wide range of charge and discharge times. This model approximates a Mylar capacitor.

Fig 4's circuit approximates this capacitor characteristic, which you can observe on actual capacitors by using Fig 5's test setup. Here, a sample/hold IC exercises the capacitor under test at various speeds and duty cycles, and a limiter amplifier facilitates close study of the small residual waveforms, without over-driving the oscilloscope when the capacitor is charged to full voltage.

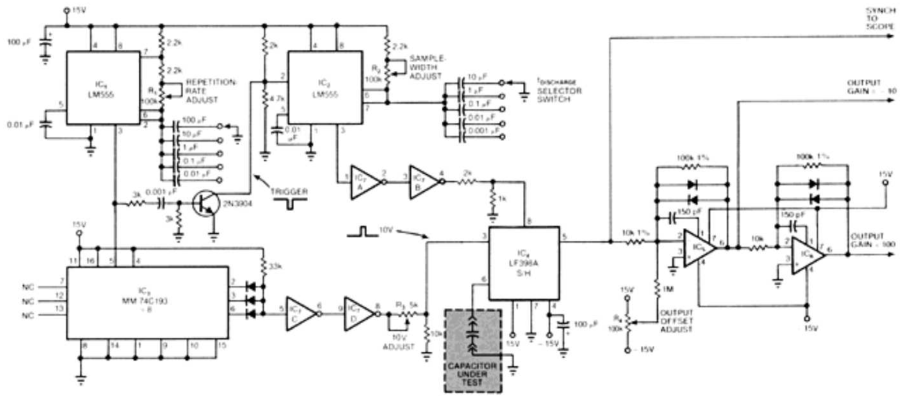


Fig 5 - Capable of automatically sequencing the dielectric-absorption tests, a circuit employing timers, a sample/hold and limiting stages allows you to make measurements for a wide range of T_{CHARGE}, T_{HOLD}, and $t_{DISCHARGE}$ values. Fig 7 shows the results obtained using the circuit shown here. (View a larger version of the image.)

Notes:

1. ALL DIODES = 1N914
2. IC5, IC6 = LM301A
3. IC7 = MM74C04
4. USE R4 OR -10 GAIN TO KEEP SCOPE WAVEFORM BELOW 200mV SO AS TO AVOID DISTORTION OR FALSE ATTENUATIONS

Such experiments illustrate that if you put a certain amount of charge into a less-than-ideal capacitor, you will get out a different amount of charge, depending on how long you wait. Thus, using low-soakage capacitors proves important in applications such as those involving high-resolution dual-slope integrating ADCs. And sure enough, many top-of-the-line digital voltmeters do use polypropylene (a low-soakage dielectric) devices for their main integrating capacitors.

But dielectric-absorption characteristics are most obviously detrimental in applications involving sample/holds. Manufacturers guarantee how fast these devices can charge a capacitor in their Sample mode and how much their circuits' leakage causes capacitor-voltage droop during the Hold mode, but they don't give any warning about how much the capacitor voltage changes because of soakage. This factor is especially important in a data-acquisition system, where some channels might handle small voltages while others operate near full scale. Even with a good dielectric, a sample/hold can hurt your accuracy, especially if the sample time is a small fraction of T_{HOLD}. For example, although a good polypropylene device can have only 1-mV hysteresis per 10V step if T/t=100 msec/10 msec, this figure increases to 6 mV if the T/t ratio equals 100 msec/0.5 msec. Because most sample/hold data sheets don't warn you of such factors, you should evaluate capacitors in a circuit such as Fig 5's, using time scaling suited to your application.

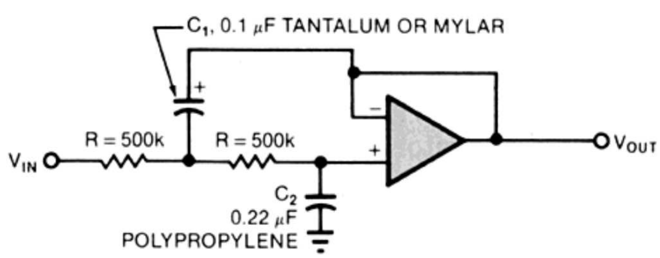


Fig 6 - Soakage can present problems when you're designing a fast-settling amplifier or filter. In the circuit shown here, for example, C_1 can be a Mylar or tantalum unit, but making C_2 a polypropylene device improves performance.

Other applications in which soakage can degrade performance are those involving fast-settling ac active filters or ac-coupled amplifiers. In Fig 6's circuit, C_1 can be a Mylar or tantalum unit because it always has 0V dc on it, but making C_2 polypropylene instead of Mylar noticeably improves settling. For example, settling to within -0.2 mV for a 10V step improves from 10 to 1.6 sec with the elimination of Mylar's dielectric absorption. Similarly, voltage-to-frequency converters benefit from low-soakage timing capacitors, which improve V/F linearity.

Some dielectrics are excellent at all speeds

Fortunately, good capacitors such as those employing polystyrene, polypropylene, NPO ceramic and Teflon dielectrics perform well at all speeds. Fig 7 shows the characteristics of capacitors using these dielectrics and others such as silver mica and Mylar. In general, polystyrene, polypropylene or NPO-ceramic capacitors furnish good performance, although polystyrene can't be used at temperatures greater than 80℃. And although NPO cera mic capacitors are expensive and hard to find in values much larger than 0.01 µF, they do achieve a low temperature coefficient (a spec not usually significant for a S/H but one that might prove advantageous for precision integrators or voltage-to-frequency converters). Teflon is rather expensive but definitely the best material to use when high performance is important. Furthermore, only Teflon and NPO ceramic capacitors suit use at 125℃.

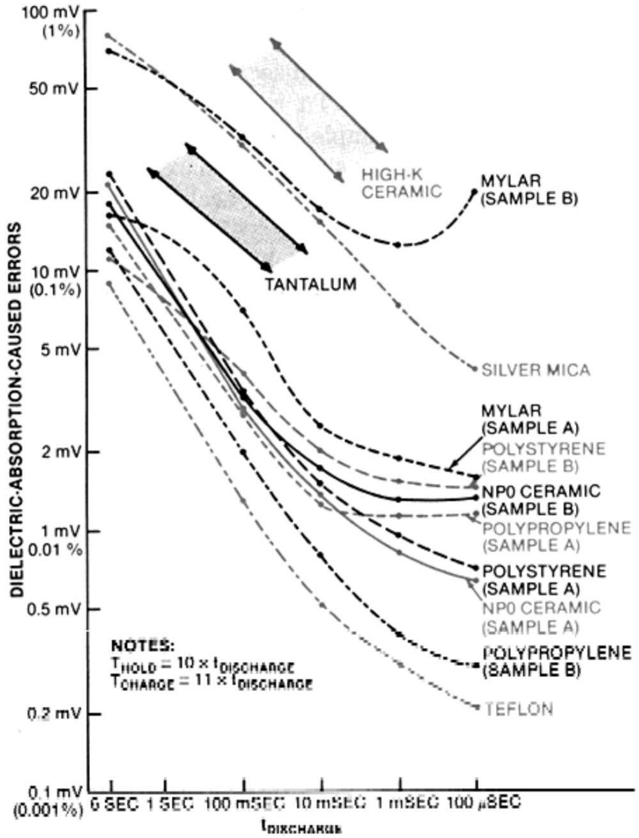


Fig 7 - Soakage-measurement results for a variety of capacitors illustrate the effects of $t_{DISCHARGE}$ values on dielectric-absorption-caused errors. Note the curves for two different samples of NP0 ceramic capacitors intersect.

If you look at Fig 7's dielectric-absorption values, you can see wide differences in performance for a given dielectric material. For example, polypropylene sample A is about as good as B at t=6 see, but B is four times better at high speeds. Similarly, NP0-ceramic sample A is slightly worse than NP0-ceramic sample B at low speeds, but A is definitely better at high speeds. And some Mylar capacitors (sample A) get better as speed increases from 1000 to 100 µsec, but others (sample B) get worse. So if you want consistently good performance from your capacitors, evaluate and specify them for the speed at which they'll be used in your application. Keep in mind that because most sample/holds are used at much faster speeds than those corresponding to the 1- or 5-min ratings usually given in data sheets, a published specification for dielectric absorption has limited value.

In addition, other dielectrics furnish various levels of performance:

- Because any long word that starts with poly seems to have good dielectric properties, how about polycarbonate or polysulfone? No -- they are about as bad as Mylar.
- Does an air or vacuum capacitor have low soakage? Well, it might, but many standard capacitors of this type are old designs with ceramic spacers, and they might give poor results because of the ceramic's hysteresis.
- If a ceramic capacitor is not an NP0 device, is it any good? Most of the conventional high-K ceramics are just terrible -- 20 to 1000 times worse than NP0 and even worse than tantalum.
- Is silicon dioxide suitable for small capacitances? Although Fig 5's test setup, used in preparing Fig 7's chart, only measures moderate capacitances (500 to 200,000 pF), silicon dioxide appears suitable for the small capacitors needed for fast S/Hs or deglitchers.

Cancellation circuit improves accuracy

A practical method of getting good performance with less-than-perfect capacitors is to use a soakage-cancellation circuit such as one of the form shown in Fig 8, in which a capacitor of the type modeled in Fig 4 serves as an integrator. (Only the first two soakage elements are shown.) The integrator's output is inverted with a scale factor of -0.1, and this voltage is then fed through one or more experimentally chosen RC networks to cancel the equivalent network inherent in the capacitor's dielectric material.

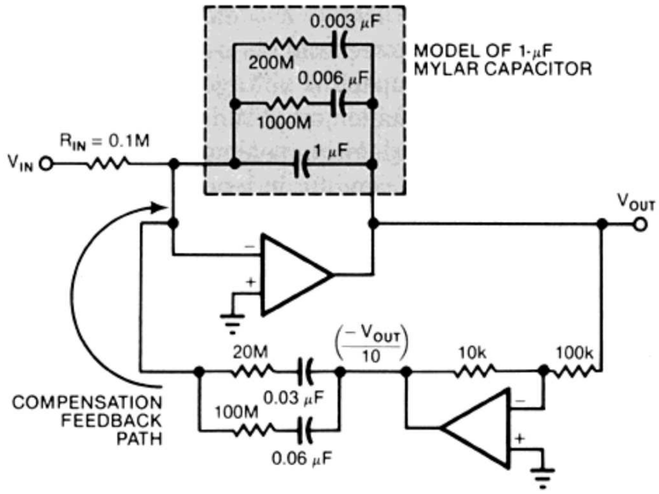


Fig 8 - You can compensate an integrator for dielectric absorption by feeding its inverted output back to the input through one or more experimentally chosen RC networks, which cancel the equivalent network inherent in the capacitor's dielectric material.

Fig 9 shows a practical sample/hold circuit with an easily trimmed compensator. This network provides about a 10-fold improvement for sample times in the 50- to 2000-µsec range (Fig 10). Although this compensation is subject to limitations at very fast or slow speeds, the number of RC sections and trimming pots employed can be extended.

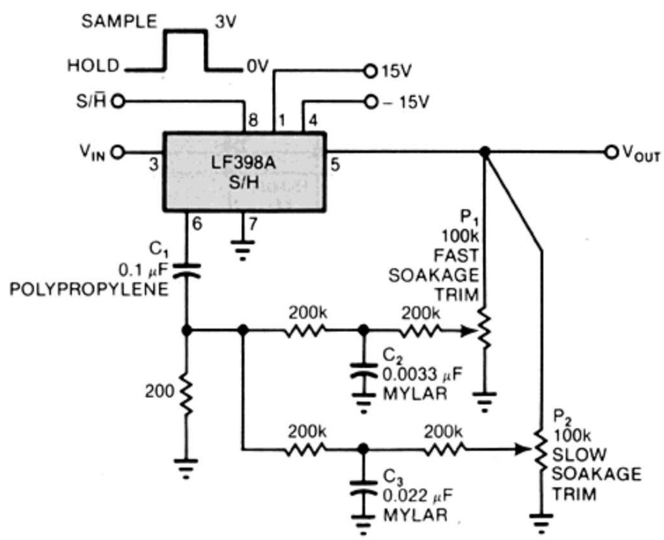


Fig 9 - Adding compensation circuitry to a sample/hold yields better-than-Teflon performance with a polypropylene capacitor. Using Teflon capacitors in such circuits can yield a 15- to 17-bit dynamic range.

Simple circuits similar to Fig 9's or Fig 8's have been used in production to let inexpensive polypropylene capacitors provide better-than-Teflon performance. In turn, using these compensator circuits with a good Teflon capacitor furnishes a dynamic range of 15 to 17 bits.

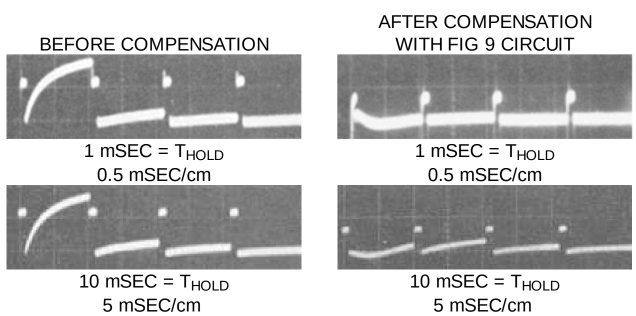


Fig 10 - Adding Fig 9's compensation network to a sample/hold circuit yields a 10-fold performance improvement for sample times of 50 to 2000 µsec; additional RC networks and trimming pots can extend the time range. The short pulses represent normal S/H jumps and occur during the sample time. The exponentially rising waveform during the hold time results from soakage. Note that soakage effects are still visible during the second hold period.

Notes:

1. Dielectric absorption errors with good polypropylene capacitor
2. All waveforms at 1mV/cm; T_{SAMPLE}/T_{HOLD} = 1/10

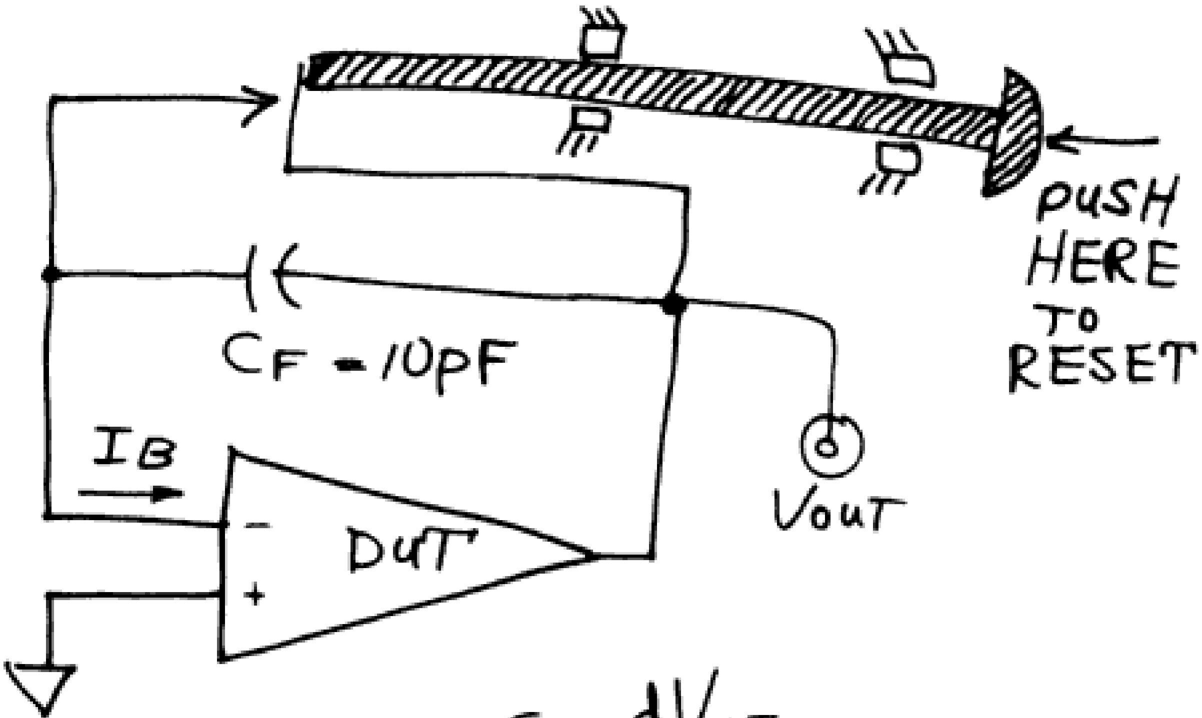
Originally published in EDN,
October 13, 1982.

RAP Update: *FIFTEEN years ago, back in 1982, when I wrote this, I had never seen any study of capacitors and their "soakage" -- nor of the kind of circuits you could use to shrug off the effects of soakage. Nobody ever talked about this, at high speed.*

To this day, I have not seen any other articles that covered either subject. So this is still about the prime source of info on how to evaluate capacitors for soakage, AND how to build good Sample-and-Hold circuits, so as to NOT get hurt by that soakage.

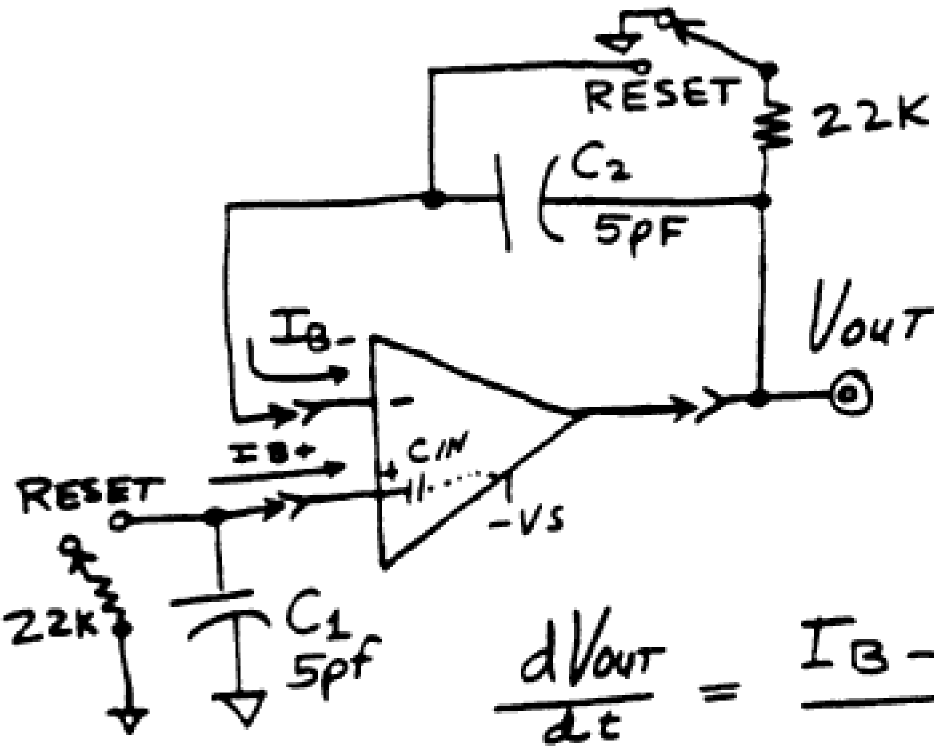
Your comments are invited! / RAP


NOR-CAL



- $-I_B = C_F \frac{dV_{OUT}}{dt}$
- BUT BEWARE OF ERRORS INCASE OF A TEFLON PUSH ROD!

RAP ≈ 12 xii 90



$$\frac{dV_{OUT}}{dt} = \frac{I_{B-} + I_{lkg}}{C_2}$$

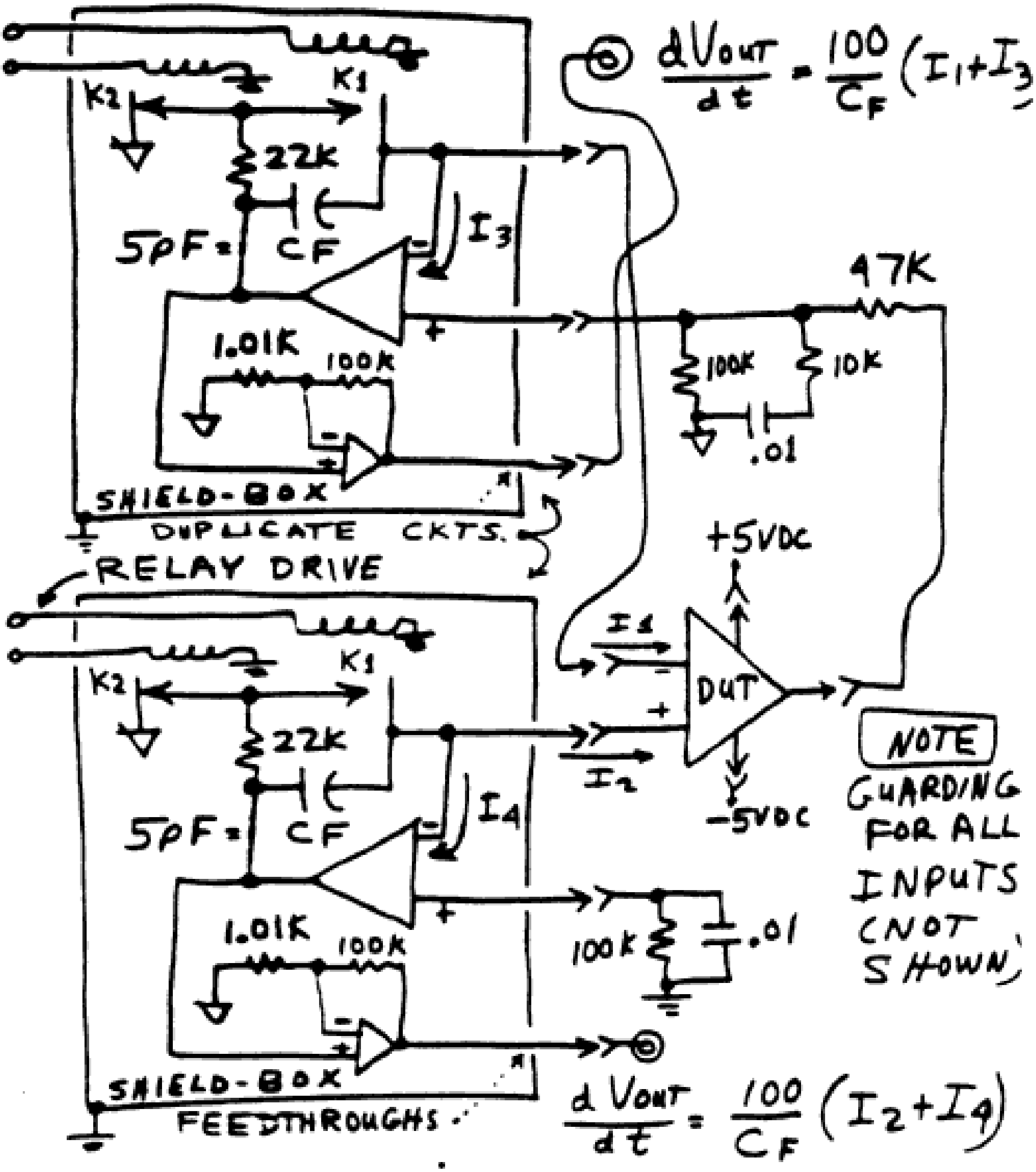
OR

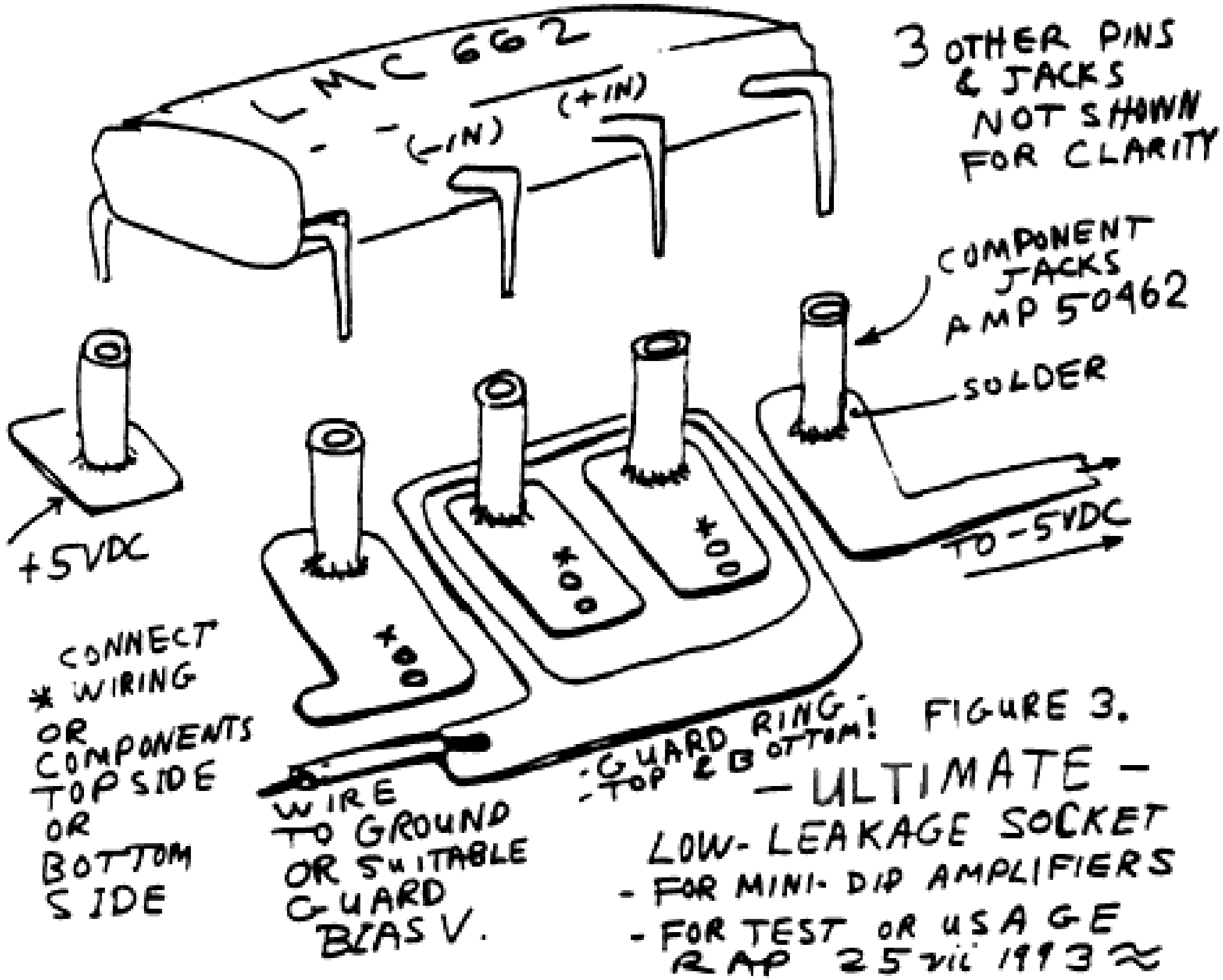
$$\frac{dV_{OUT}}{dt} \cong \frac{I_{B+} + I_{lkg}}{C_1 + C_{IN}}$$

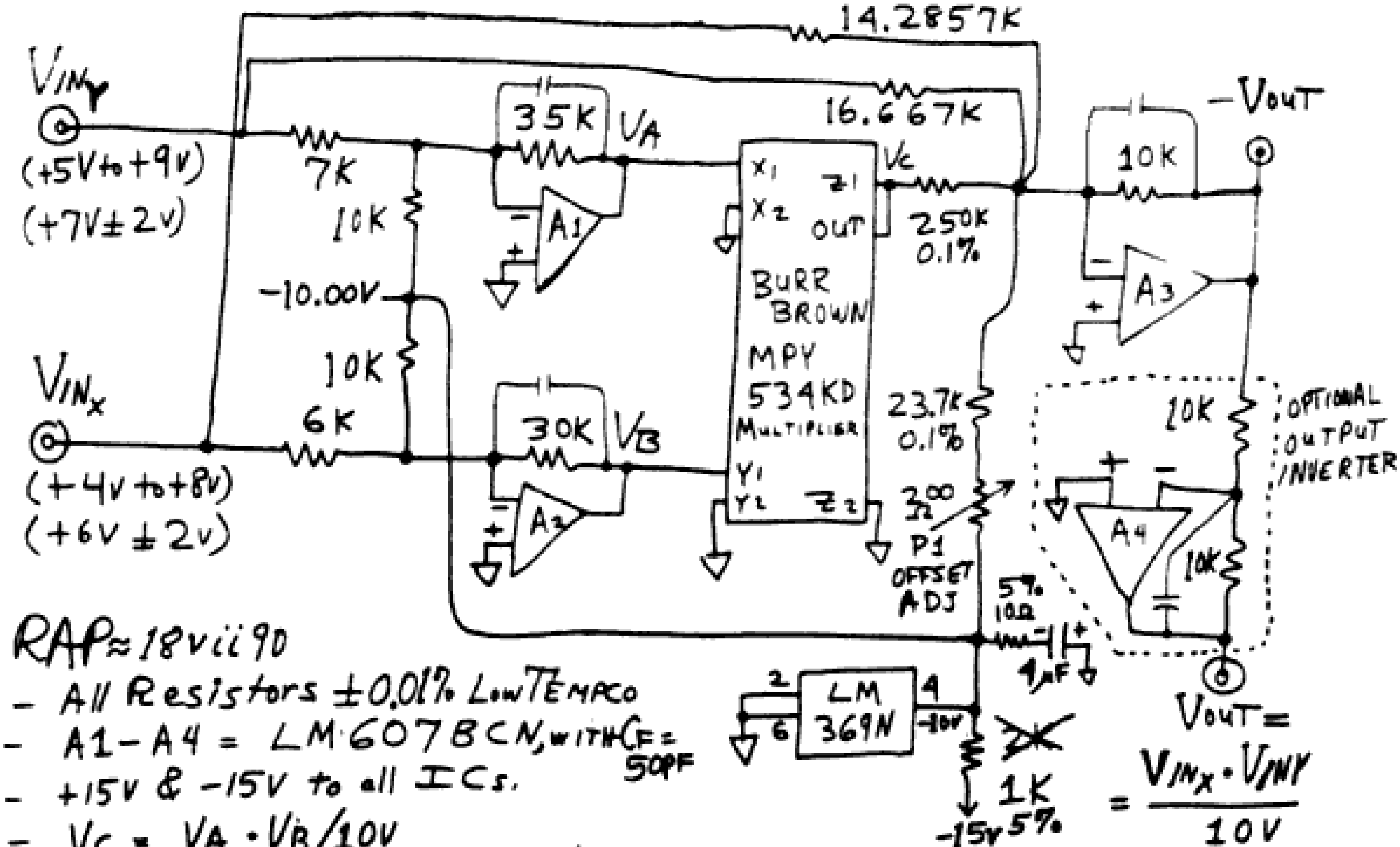
Figure 1 Basic Test for Sub-picoampare currents

FIGURE 2. PRECISION FEMTOAMPERE INTEGRATOR

RAP ≈ JULY 1993




LMC 662
(−IN)
(+IN)
3 OTHER PINS & JACKS NOT SHOWN FOR CLARITY
COMPONENT JACKS AMP 50462
SOLDER
TO −5VDC
+5VDC
CONNECT * WIRING OR COMPONENTS TOP SIDE OR BOTTOM SIDE
WIRE TO GROUND OR SUITABLE GUARD BIAS V.
GUARD RING: TOP & BOTTOM!
FIGURE 3.
— ULTIMATE —
LOW-LEAKAGE SOCKET
- FOR MINI-DIP AMPLIFIERS
- FOR TEST OR USAGE
RAP 25 vii 1993



RAP ≈ 18vii90

- All Resistors ±0.01% Low TEMPCO
- A1–A4 = LM607BCN, with CF = 50PF
- +15V & −15V to all ICs.
- $V_C = V_A \cdot V_B / 10V$
- TRIM P1 for 4.200V output, at V_{INY} = 7.000V, V_{INX} = 6.000V.

– What do we want from our MULTIPLIER?

– We want $V_{OUT} = \frac{V_{INX} \cdot V_{INY}}{10V} \pm 0.02\%$

but only in a limited range, $4V \leq V_{INX} \leq 8V$ and $5V \leq V_{INY} \leq 9V$.

– Let's define new VARIABLES:

– Let $(-V_A) = (V_{INY} - 7V) \cdot 5$
Let $(-V_B) = (V_{INX} - 6V) \cdot 5$
and then multiply $V_A \cdot V_B$.

Then $V_C = \frac{(-V_A)(-V_B)}{10V} = \frac{V_A \cdot V_B}{10V} = \frac{25(V_{INX} - 6V)(V_{INY} - 7V)}{10V}$

So $\left[\frac{V_A \cdot V_B}{10V \cdot 25}\right] = \left(\frac{V_{INX} \cdot V_{INY}}{10V}\right) - \frac{6V}{10V} V_{INY} - \frac{7V \cdot V_{INX}}{10V} + \frac{42V^2}{10V}$

REARRANGING –

$\left(\frac{V_{INX} \cdot V_{INY}}{10V}\right) = \left(\frac{V_A \cdot V_B}{10V \cdot 25}\right) + 0.6 V_{INY} + 0.7 V_{INX} - 4.2V$

– So all we have to do is generate V_A & V_B, feed them to a multiplier, and take a summation:

$V_{OUT} = \left(\frac{V_{INX} V_{INY}}{10V}\right) = \frac{V_C}{25} + 0.6 V_{INY} + 0.7 V_{INX} - 4.2V$

That is easy to do –

A3 sums all these voltages with the required gains – the gain from V_C to V_{out} is $\frac{1}{25}$;

– the gain from V_{INY} to V_{OUT} is $\frac{6}{10}$;

– the gain from V_{INX} to V_{OUT} is $\frac{7}{10}$;

– and the 23.7K adds in a 4.2VOLT offset, which is trimmed for best accuracy:

When $V_{INY} = 7.000V$,
$V_{INX} = 6.000V$,
$V_A \cong V_B \cong V_C \cong 0$,
so just trim V_{OUT} to 4.200V using offset ADJUST P1.

A4 lets you have an inverted POLARITY.

RAP 2 iii 91

Vin Y	Vin X	Vout	Column 5	Verror
5.0000	4.0000	-1.999399	-2.000000	0.000601
6.0000	4.0000	-2.399693	-2.400000	0.000307
7.0000	4.0000	-2.799666	-2.800000	0.000334
8.0000	4.0000	-3.199520	-3.200000	0.000480
9.0000	4.0000	-3.599620	-3.600000	0.000380
5.0000	5.0000	-2.499626	-2.500000	0.000374
6.0000	5.0000	-2.999929	-3.000000	0.000071
7.0000	5.0000	-3.499720	-3.500000	0.000280
8.0000	5.0000	-3.999440	-4.000000	0.000560
9.0000	5.0000	-4.499300	-4.500000	0.000700
5.0000	6.0000	-2.999830	-3.000000	0.000170
6.0000	6.0000	-3.600000	-3.600000	0.000000
7.0000	6.0000	-4.199930	-4.200000	0.000070
8.0000	6.0000	-4.799750	-4.800000	0.000250
9.0000	6.0000	-5.399350	-5.400000	0.000650
5.0000	7.0000	-3.500170	-3.500000	-0.000170
6.0000	7.0000	-4.200100	-4.200000	-0.000100
7.0000	7.0000	-4.900130	-4.900000	-0.000130
8.0000	7.0000	-5.600000	-5.600000	0.000000
9.0000	7.0000	-6.299500	-6.300000	0.000500
5.0000	8.0000	-4.000470	-4.000000	-0.000470
6.0000	8.0000	-4.800290	-4.800000	-0.000290
7.0000	8.0000	-5.600360	-5.600000	-0.000360
8.0000	8.0000	-6.400360	-6.400000	-0.000360
9.0000	8.0000	-7.200230	-7.200000	-0.000230

Ideal Output V

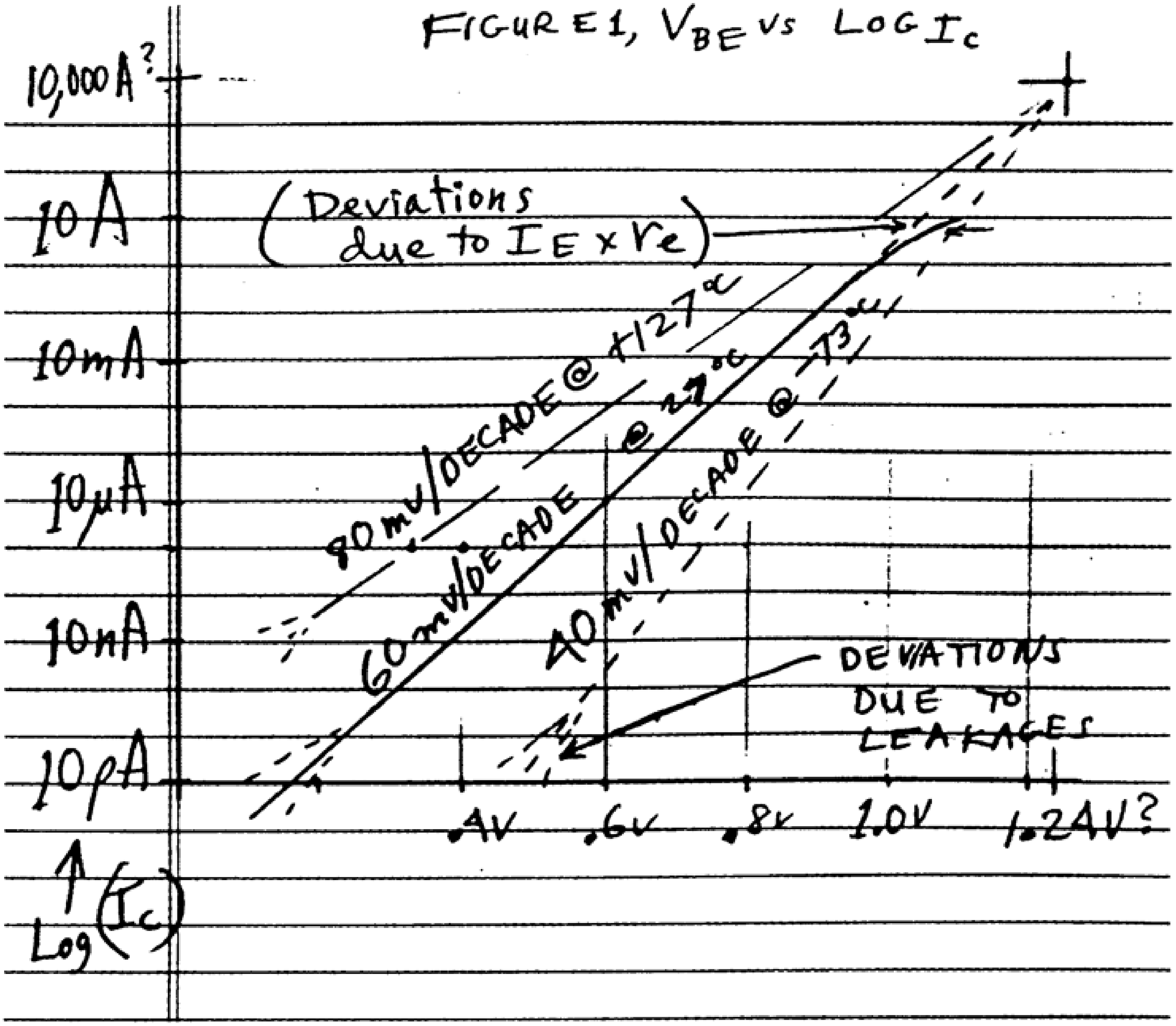
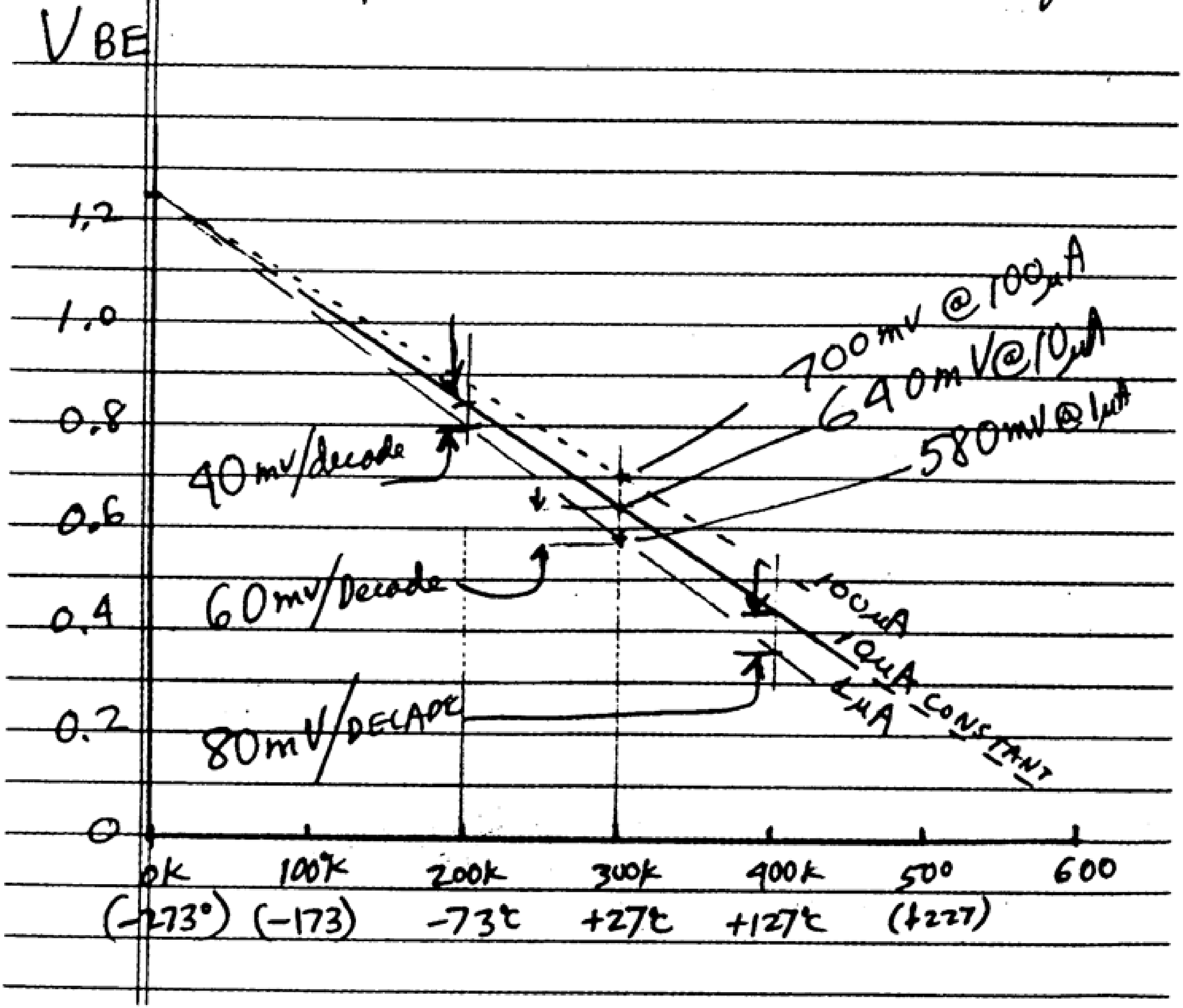


FIGURE 1, VBE vs LOG Ic
10,000 A?
10 A
10mA
10µA
10nA
10pA
Log (Ic)
(Deviations due to IE x re)
80mv/DECADE @ +127°C
60mv/DECADE @ 27°C
40mv/DECADE @ -73°C
DEVIATIONS DUE TO LEAKAGES
.4V
.6V
.8V
1.0V
1.24V?

FIGURE 2 - Vbe VS. Temp



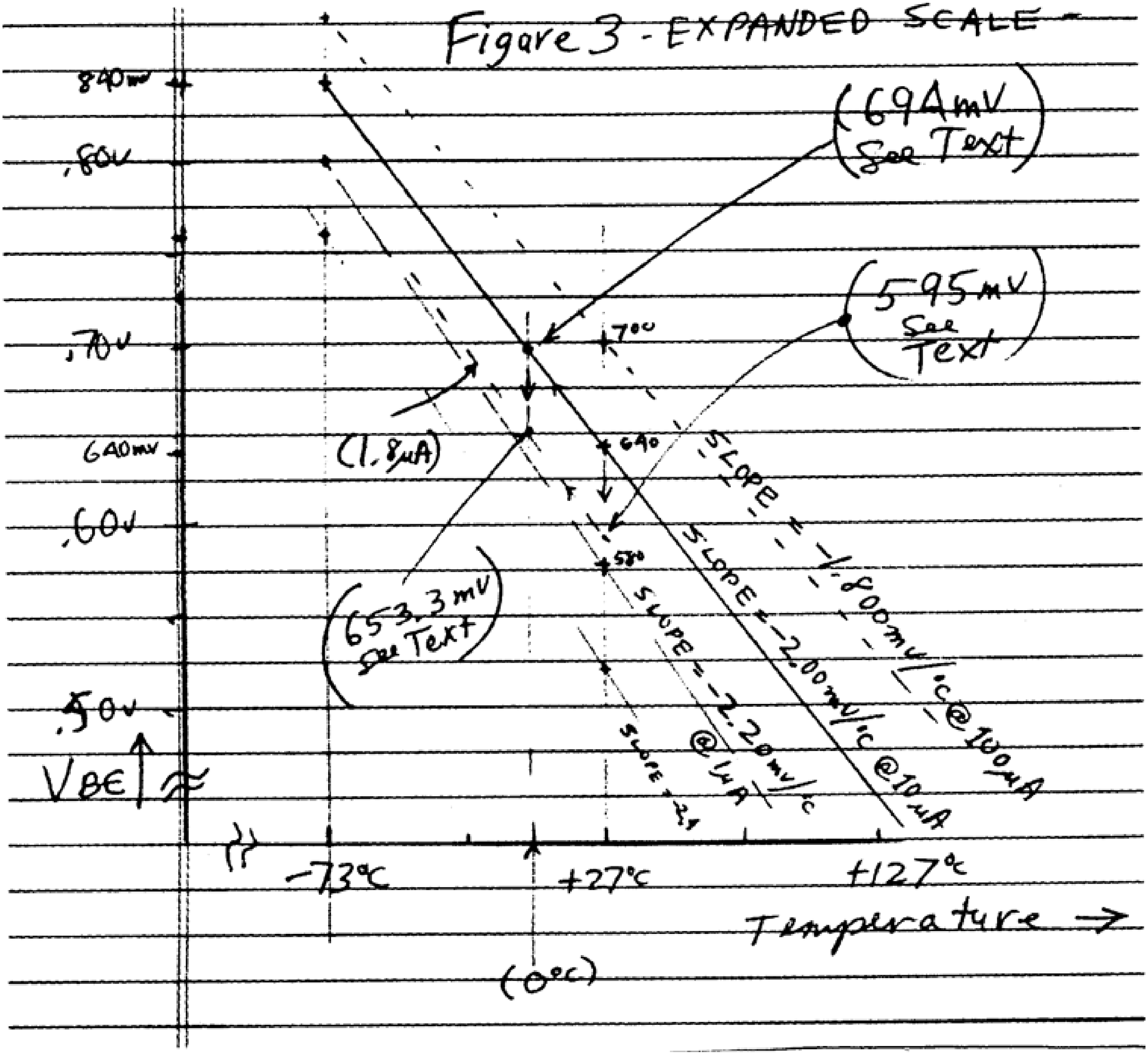


Figure 3 - EXPANDED SCALE -
840mv
.80v
.70v
640mv
.60v
.50v
VBE
(694mV See Text)
(595mV See Text)
(653.3mV See Text)
(1.8μA)
700
690
580
SLOPE = -1.800mv/°c @ 100μA
SLOPE = -2.00mv/°c @ 10μA
SLOPE = -2.20mv/°c @ 1μA
-73°C
+27°C
+127°C
(0°C)
Temperature

THE BEST OF BOB PEASE

What's All this Trekking Stuff, Anyhow? - Maxi-Report

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[Back to Equipment and Photography] [Back to Diary]

Manang (center) was the last town before the pass at Thorong La. We spent just half an hour shopping and wandering around town; then we continued on up the trail. We are looking out over the valley of the Marsyangdi Khola, the river we had been following 9 days. Slide by John Cordes, 20 November 1997.

THE BEST OF BOB PEASE

What's All this Trekking Stuff, Anyhow? - Maxi-Report

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[Back to Peter Owens' Staff] [Back to Equipment and Photography]

It was a grey day as we ascended to the 17,771' pass at Thorong La, but we didn't complain, because the winds were nearly calm and the temperature was warming up to about 15 degrees. We were hiking just fast enough to keep warm, at a conservative pace, not in any hurry. Fortunately, the trail was easy and the grade shallow, as you can see. Two porters are coming up the trail, about 16,500 ft. This is the view toward the Northeast. We are leaving these mountains behind and climbing west to the pass. This is not exactly the same view as the calendar picture that inspired us to take this trek, but similar. Those mountains are just right of center. Photo by John Cordes, 22 November 1997.

THE BEST OF BOB PEASE

What's All this Trekking Stuff, Anyhow? - Maxi-Report

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Yesterday was cloudy and snowy, but the 5 AM skies were crystal clear, and we knew that when the light came we should be up and about with our cameras ready at 6:15 AM. This is the view of Annapurna III (25,770') south from our camp at Braga (about 11,000'), 20 November, 1997, about 6:25 AM. Photo by John Cordes; film was Fuji Velvia ASA100; Camera was Canon EOS Elan with Sigma 24-50mm lens.

THE BEST OF BOB PEASE

What's All this Trekking Stuff, Anyhow? - Maxi-Report

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Taken from Braga shortly after breakfast, around 7:15 AM, this scene shows the fluting that was so fascinating. Not to mention the ice-fall, and the clouds blowing over 24,560' Gangapurna. Photo by John Cordes.

THE BEST OF BOB PEASE

What's All this Trekking Stuff, Anyhow? - Maxi-Report

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Every day around 10:30 the cooks and kitchen boys would start preparing lunch. Here we are a couple hundred feet above the last bridge over the Jhargeng Khola, about 14,000 feet. Soon we will go around the corner to reach Thorong Phedi, at the foot of the pass, and lose these great views of Annapurna III. But in this sheltered spot, the Annapurna massif looms above, as the hiss of the pressure-cookers rises from below. Photo by John Cordes, 21 November 1997.

THE BEST OF BOB PEASE

What's All this Trekking Stuff, Anyhow? - Maxi-Report

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I am always impressed by Nepali children. Even at a very young age, they have learned to say Namaste. And they are good hikers and climbers, too. Photo by Sharon Prehn.

THE BEST OF BOB PEASE

What's All this Trekking Stuff, Anyhow? - Maxi-Report

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[Back to Adventure]

I Am always impressed with the dignity of old people - men and women too - in Nepal. Photo by Sharon Prehn.

PUDDING	Rs.
RICE PUDDING HONEY	125
RICE PUDDING BANANA	125
CHOCOLATE PUDDING	110
CHOCOLATE PUDDING BANANA	125
CUSTARD PUDDING HONEY	125
CUSTARD PUDDING BANANA	125
MIXED PUDDING	150
MIXED PUDDING BANANA	165

PIE	Rs.
APPLE PIE	150
APPLE PIE CHOCOLATE SOUCE	180
BANANA PIE	170
BANANA PIE CHOCOLATE SOUCE	180
MIXED PIE	190
MIXED PIE CHOCOLATE SOUCE	195

ROLL	Rs.
MARS BAR ROLL	180
SNICKERS BAR ROLL	180
MIXED BAR ROLL	195

HARD DRINKS	Rs.
BEER	180
XXX KHUKURI RUM	180
BAGPIPER	185
ROYAL STAG WHISKY	200
LOCAL WINE	45
MUSTANG COFFEE	55

CURRY	Rs.
VEG. POTATO CURRY	90
MIXED CURRY	95
VEG. POTATO CURRY RICE	160
MIXED CURRY RICE	165

SANDWICH	Rs.
TOMATO, ONION, CHEESES SANDWICH	150
TOMATO, CHEESE, TUNA SANDWICH	170
MIX SANDWICH	180

BREADS	Rs.
CORN BREAD PLAIN	55
CORN BREAD JAM/HONEY	65
TIBETAN BREAD PLAIN	55
TIBETAN BREAD JAM/HONEY	65
PAN-CAKE PLAIN	55
PAN-CAKE JAM/HONEY	65
BANANA PAN-CAKE	70
APPLE PAN-CAKE	70
MIX PAN-CAKE	80
CHAPATI PLAIN	35

POTATOES	Rs
BOILED POTATO	90
POTATO CHIPS	110
MASHED POTATO	110
FRIED POTATO EGG	120
FRIED POTATO EGG CHEESE	130
POTATO ROSTY VEG CHEESE	145
POTATO ROSTY VEG. CHEESE EGG	155
MIX ROSTY	160

FRITTER	Rs
APPLE FRITTER	150
APPLE FRITTER HONEY	160
BANANA FRITTER	150
BANANA FRITTER HONEY	160
MIXED FRITTER	165
MIXED FRITTER HONEY	175

SALAD	Rs
VEG. TOMATO SALAD	135
VEG. TOMATO TUNA SALAD	185
MIXED SALAD	190

RICE	Rs
PLAIN RICE	70
RICE DAL VEG.	150
VEG. TOMATO FRIED RICE	125
VEG. TOMATO CHEESE FRIED RICE	135
VEG. EGG FRIED RICE	130
VEG. EGG CHEESE FRIED RICE	135
MIXED FIRED RICE	150

CEREALS	Rs
MUESLI MILK	90
MUESLI FRUIT	100
PORRIDGE MILK	90
PORRIDGE FRUIT	100
CORN PORRIDGE WITH MILK	90
CORN PORRIDGE WITH FRUIT	100

COLD DRINKS	Rs
COCA-COLA/FANTA/SPRITE	50
MINERAL WATER	60
BOILED WATER	35

SOUPS	Rs
VEG. TOMATO SOUP	75
TOMATO NOODLE SOUP	80
VEG. TOMATO NOODLE SOUP	80
EGG VEG. SOUP	75
ONION, TOMATO SOUP	75
GARLIC SOUP 70	70
POTATO GARLIC	75
TOMATO SOUP	75
MIX SOUP	90
MUSHROOM SOUP GARLIC	100

SPAGHETTI	Rs.
VEG. TOMATO SPAGHETTI	160
VEG. TOMATO CHEESE SPAGHETTI	170
VEG. CHEESE EGG SPAGHETTI	180
MIXED SPAGHETTI	190
VEG. TUNA SPAGHETTI	180

MACARONI	Rs.
VEG. TOMATO MACARONI	160
VEG. TOMATO CHEESE MACARONI	175
VEG. EGG CHEESE MACARONI	180
MIXED MACARONI	185

PAKAUDA	Rs.
VEG. POTATO PAKAUDA	110
VEG. EGG PAKAUDA	110
MIXED PAKAUDA	125
VEG. TUNA PAKAUDA	150

HOT DRINKS			Rs.
	CUP	S.POT	B.POT
BLACK TEA	20	90	110
MILK TEA	25	110	140
BLACK COFFEE	40	150	180
MILK COFFEE	45	150	195
HOT CHOCOLATE	45	150	195
HOT LEMON	25	110	140
LEMON TEA	25	110	140
MINT TEA	25	110	140
GINGER TEA	25	110	140
MASALA TEA	35	140	180
HOT MILK	40		

MOMO	Rs.
VEG. TOMATO MOMO STEAMED	130
VEG. TOMATO MOMO FRIED	140
VEG. TOMATO CHEESE MOMO STEAMED	155
VEG. TOMATO CHEESE MOMO FRIED	165
CHEESE MOMO STEAMED	140
CHEESE MOMO FRIED	150
TUNA CHEESE MOMO STEAMED	170
TUNA CHEESE MOMO FRIED	180
MIX MOMO STEAMED	190
MIX MOMO FRIED	200

POP-CORN	Rs.
POPCORN PLATE	70

NOODLES	Rs
VEG. TOMATO FRIED NOODLES	95
VEG. TOMATO CHEESE FRIED NOODLE	135
VEG. EGG CHEESE FRIED NOODLE	140
VEG. EGG CHEESE TUNA FRIED NOODLE	180
MIXED FRIED NOODLE	185

SPRING ROLL	Rs
VEG. TOMATO SPRING ROLL	145
VEG. EGG SPRING ROLL	155
VEG EGG CHEESE SPRING ROLL	165
MIX SPRING ROLL	180

HASHED BROWN	Rs
ONION CHEESE HASHED BROWN	130
VEG. CHEESE ONION HASHED BROWN	145
VEG. CHEESE EGG HASHED BROWN	150
MIXED HASHED BROWN	180

EGG	Rs
BOILED EGG	45
FRIED EGG	45
OMLATE EGG	45
POCHED EGG	45
CHEESE OMLATE	70
VEG. ONION, CHEESE OMLATE	80
VEG. POTATO CHEESE OMLATE	80
MIXED OMLATE	85
VEG. TOMATO CHEESE OMLATE	80
SCRAMBLE EGG	65

PIZZA	Rs
TOMATO ONION CHEESE PIZZA	150
TOMATO ONION CHEESE TUNA PIZZA	195
MIXED PIZZA	200
MUSHROOM CHEESE PIZZA	195

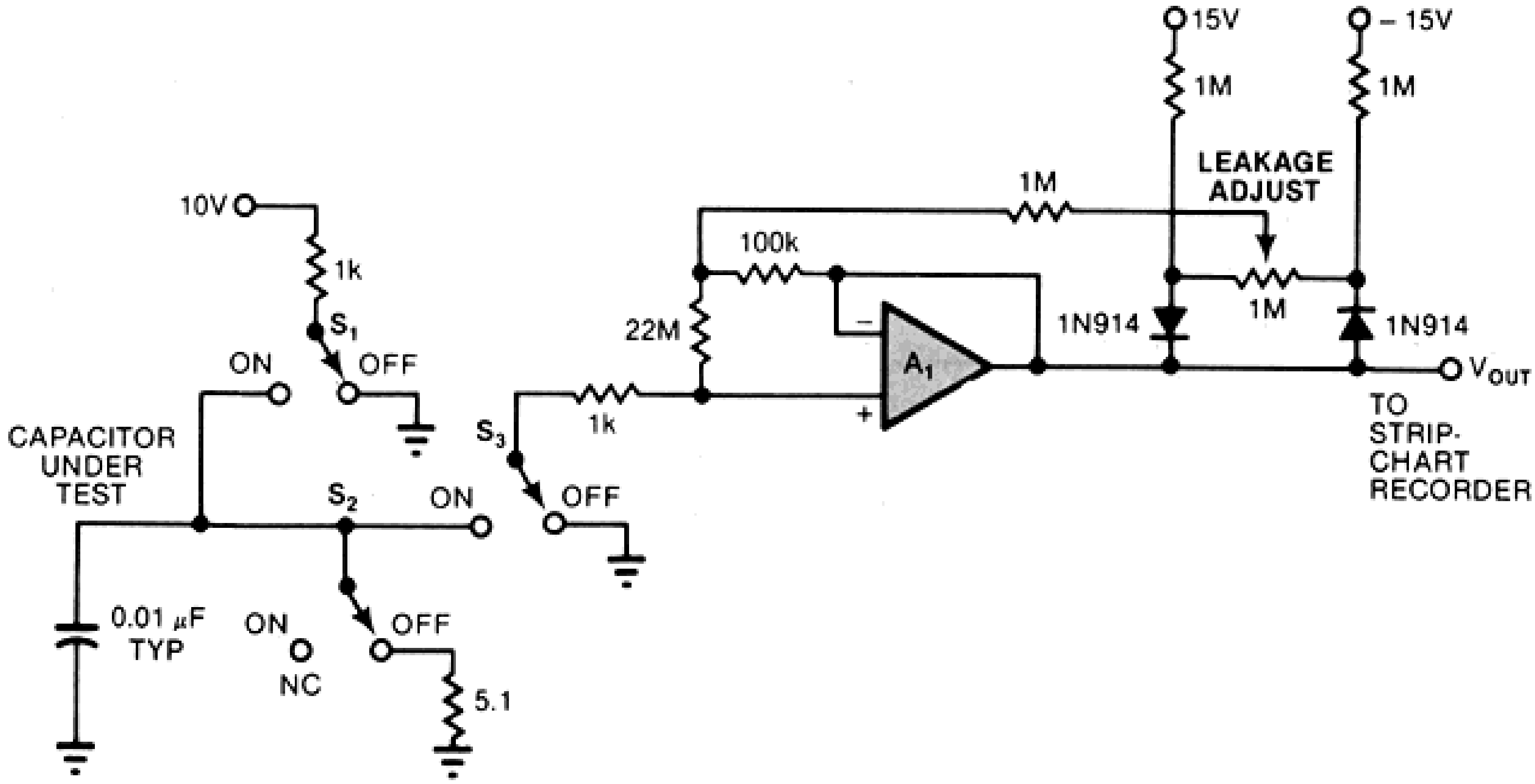
ROOM CHARGE	Rs
SINGLE BEDROOM	90
DOUBLE BEDROOM	145
TRIPPLE BEDROOM	200
ROOM CHARGE CAMPING GROUP	300
CAMPING CHARGE PER TENT	35
KITCHEN CHARGE	180
HOT SHOWER	50

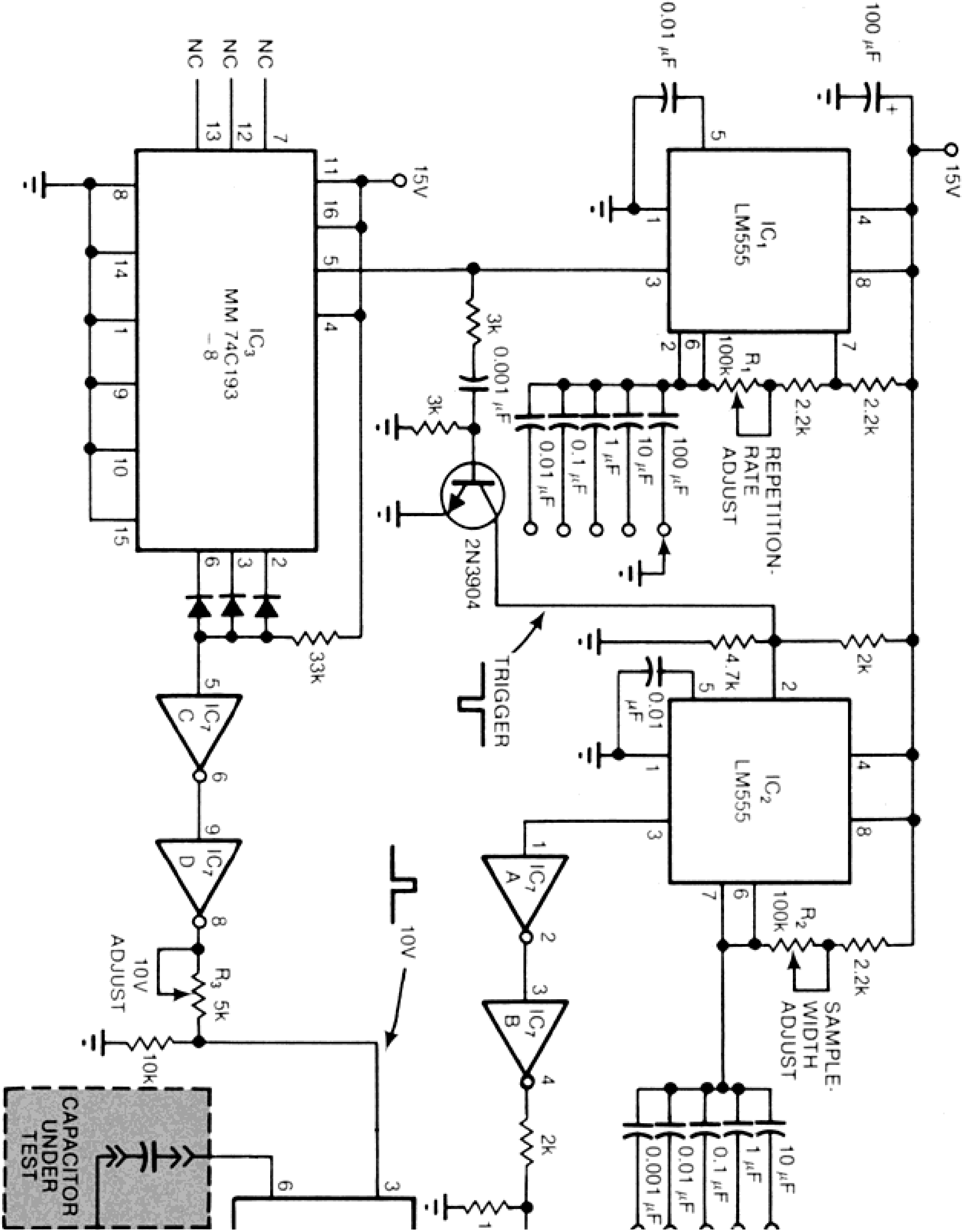
CHAPATI JAM/ HONEY	45	MUSHROOM TOMATO SOUP	100

THE BEST OF BOB PEASE

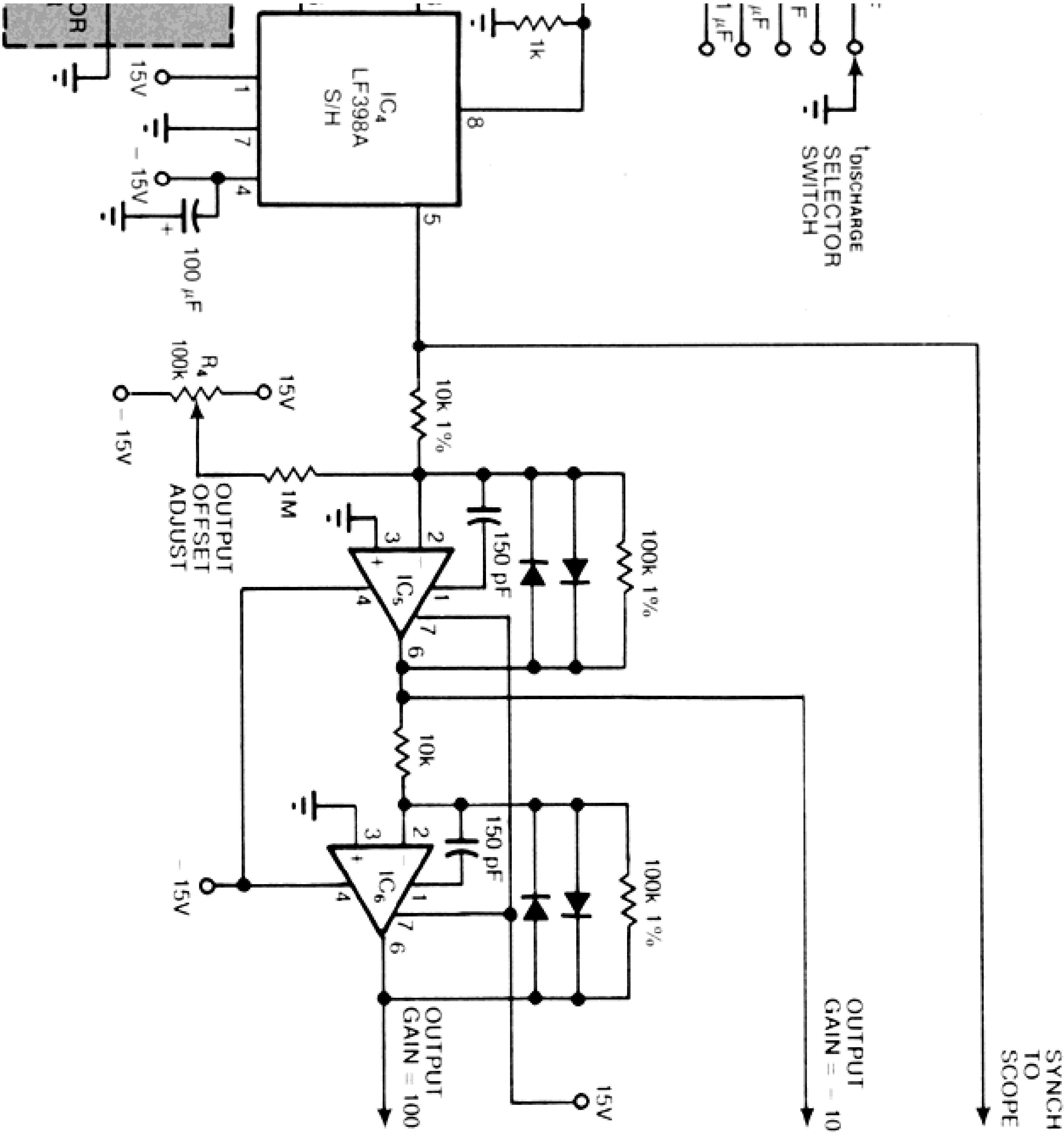
Horrible Pictures

- Bob Pease - Czar of Band-Gap References
- Robert Widlar - Creator of the IC Op Amp
- Sheep - At Work
- Hiking - Away from the Office
- Archeology?
- Abominable Snowman?
- Too fuzzy?
- - The following pictures were taken at Pashupatinath in Kathmandu, Nepal:
  - Nancy and Bob and friends
  - Friends, close up
  - More friends
  - More friends


10V
1k
S1
ON
OFF
CAPACITOR
UNDER
TEST
S2
ON
0.01 μF
TYP
ON
NC
OFF
5.1
S3
1k
OFF
22M
100k
1M
A1
15V
1M
-15V
1M
LEAKAGE
ADJUST
1M
1N914
1N914
VOUT
TO
STRIP-
CHART
RECORDER



IC1
LM555
IC2
LM555
IC3
MM 74C193
-8
IC7 A
IC7 B
IC7 C
IC7 D
15V
0.01 μF
100 μF
R1
100k
2.2k
2.2k
REPETITION-
RATE
ADJUST
100 μF
10 μF
1 μF
0.1 μF
0.01 μF
3k
0.001 μF
3k
2N3904
TRIGGER
33k
NC
NC
NC
4.7k
2k
0.01 μF
R2
100k
SAMPLE-
WIDTH
ADJUST
10 μF
1 μF
0.1 μF
0.01 μF
0.001 μF
2k
10V
R3 5k
10V
ADJUST
10k
CAPACITOR
UNDER
TEST


IC4
LF398A
S/H
1k
15V
– 15V
100 μF
tDISCHARGE
SELECTOR
SWITCH
1 μF
μF
F
R4
100k
10k 1%
OUTPUT
OFFSET
ADJUST
1M
150 pF
100k 1%
IC5
10k
IC6
OUTPUT
GAIN = 100
OUTPUT
GAIN = – 10
SYNCH
TO
SCOPE