HEWLETT PACKARD
COMPANY

STANDARDS CALIBRATION PROCEDURES

APPLICATION NOTE 39

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STANDARDS
CALIBRATION
PROCEDURES

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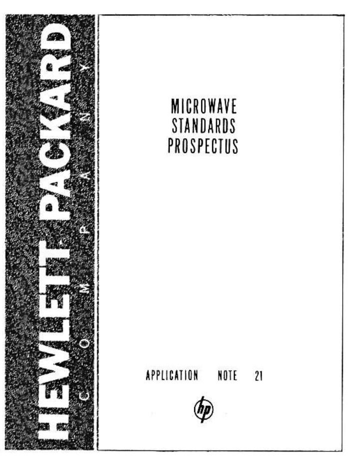
SECTION I
GENERAL

This Application Note describes calibration procedures for some of the -hp- instruments commonly found in test departments or calibration laboratories. The procedures are useful wherever instruments are frequently calibrated and the necessary equipment is available. Since, in general, each procedure provides enough checks to insure that an instrument is operating within specifications, they will also be useful as a guide to groups responsible for incoming inspection.

In addition to calibration, the procedures allow the determination of the optimum range of operation for some of the instruments. For example, the procedure for the X485B Detector Mount explains a step-by-step method for determining the square law response of the barretters. Knowing this response permits the maximum range of operation.

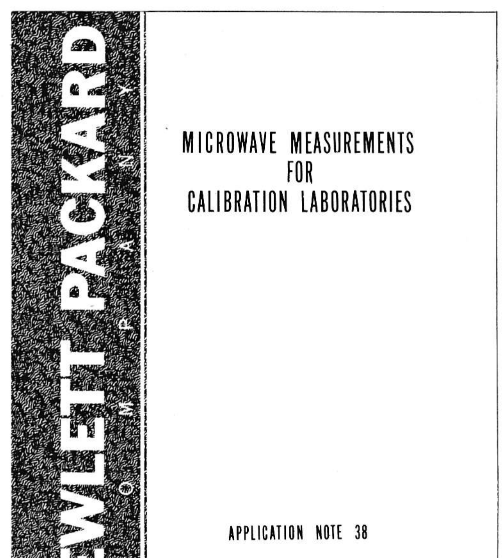
The procedures also permit achieving the maximum inherent accuracy of the instruments. If desired, calibration curves may be plotted for some of the instruments. Thus, the accuracy of instruments such as the X752A Directional Coupler and the X382A Variable Attenuator can be increased considerably. Also, known calibration permits a more realistic evaluation of system errors.



Application Note 21 is a tabular list of equipment (with costs) to make standard measurements of frequency attenuation, impedance, and power over various frequency ranges in coax or waveguide systems. Instrumentation shown is a good compromise between accuracy and cost.

The procedures were originally developed by Hewlett-Packard for the Air Force for calibrating equipment used in the standards laboratories at military bases, and they are presented in step-by-step form. All settings and adjustments are explicitly stated.

Although in many cases they do not cover all frequencies and ranges as do the factory tests, they provide enough calibration to insure satisfactory operation. Generally, enough procedural information is provided to extend the measurement to other ranges or frequencies.



Application Note 38 entitled "Microwave Measurements for Calibration Laboratories" will also be helpful for test instrument calibration. It includes sections describing frequency, attenuation, impedance, and power measurements in detail. Each section includes such topics as definitions, theory, possible errors, and measurement technique.

SECTION II
X752A DIRECTIONAL COUPLER

2-1 SPECIFICATIONS

Frequency Range:	8.2 to 12.4 kmc
Coupling:	3 db
Mean Coupling Accuracy:	±0.4 db
Coupling Variation:	±0.5 db
Directivity:	40 db

2-2 PRELIMINARY NOTES

The Model X752A Directional Coupler is calibrated for coupling factor and directivity. Coupling factor is defined as the ratio of the power entering the primary arm to the power flowing in the forward secondary arm. Directivity is the ratio of the power flowing in the forward direction in the secondary arm to the power flowing in the reverse direction in the secondary arm when power is flowing only in the forward direction in the main guide.

2-3 COUPLING FACTOR CALIBRATION

1) To check the coupling factor of the X752A, connect the equipment as shown in Figure 2-1. Connect the X485B Detector Mount and the X870A Slide Screw Tuner directly to the X532A Frequency Meter.

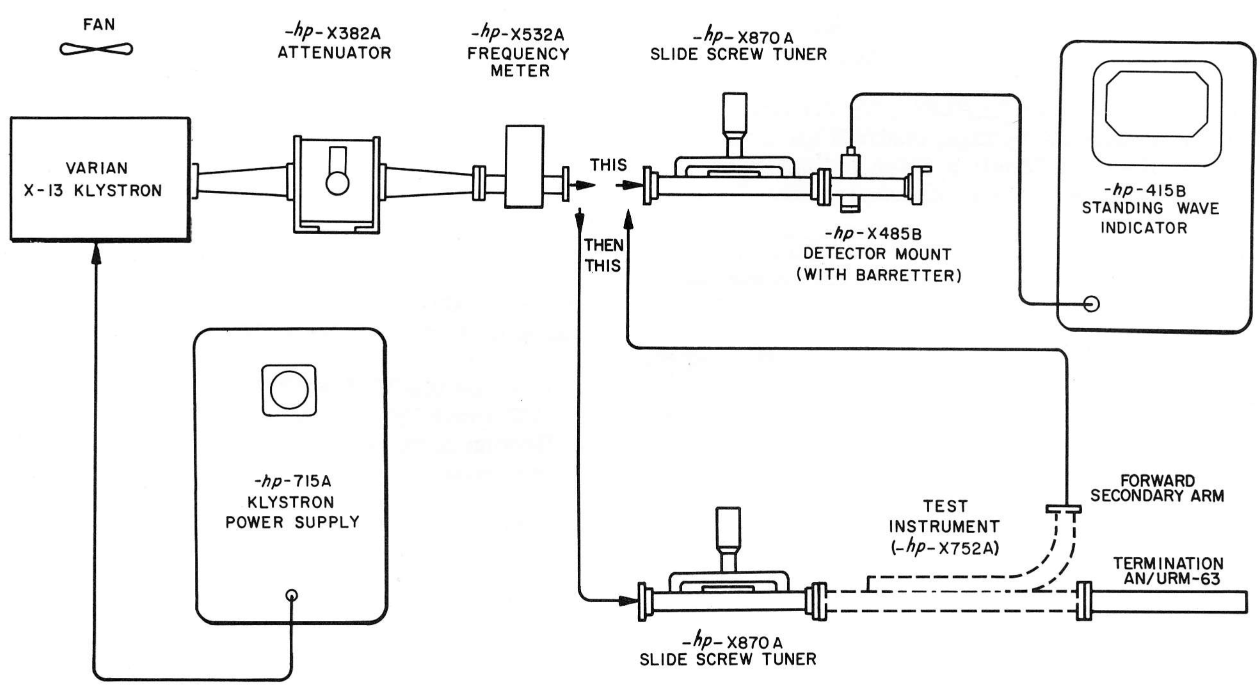


Figure 2-1. X752A Direction Coupler Coupling Factor Calibration

2) Set the Klystron Power Supply beam and reflector voltages to off. Both voltages on the 715A Klystron Power Supply may be turned off with the MOD. SELECTOR switch.

3) 415B Standing Wave Indicator Control Settings:
INPUT SELECTOR switch to BOLO
BOLO BIAS CURRENT switch to HIGH
RANGE switch to 30
METER SCALE switch to NORMAL
GAIN control fully clockwise

4) Set the X382A Variable Attenuator to 30 db.

5) Connect the equipment to a source of 115V ac power. Turn on the klystron fan. Turn on all equipment and allow it to warm up for 10 minutes.

6) Set the X-13 Klystron micrometer to 12.4 kmc.

7) Adjust the Klystron Power Supply beam, reflector and modulation voltage to operate the klystron with 1000-cps modulation. A beam voltage of about 380 volts and reflector voltage between 600 and 900 volts provide good operation with the X-13 Klystron. A jump in the cathode current indicates that the klystron is operating.

8) If necessary vary the X382A Variable Attenuator to obtain a deflection on the meter of the 415B Standing Wave Indicator.

9) Adjust the 715A Klystron Power Supply MOD. FREQ. (1000-cycle modulation frequency) for a maximum deflection on the 415B Standing Wave Indicator.

10) Adjust the 715A REFLECTOR VOLTS and MOD. VOLT. (modulation voltage) controls for a maximum deflection on the Standing Wave Indicator, varying the X382A attenuation as necessary.

11) Tune the X485B Detector Mount for a maximum deflection on the 415B, varying the X382A attenuation as necessary.

12) Check the klystron frequency by adjusting the X532A Frequency Meter until a dip occurs on the 415B. Read the frequency and reset the klystron frequency adjustment to 12.4 kmc if necessary. Turn the knob one-quarter turn to set the X532A off resonance.

13) Adjust the X382A for a full-scale meter deflection (0 db).

14) Insert the X752A between the X382A and the X485B as shown in Figure 2-1. Read the 415B and record the coupling factor.

15) Repeat and record the coupling factor measurement at frequencies of 12, 11.35, 10.3, 9.25, and 8.2 kmc.. An accurate calibration curve for the directional coupler is useful for power measurements.

2-4 DIRECTIVITY CALIBRATION

1) To check the directivity of the X752A, connect the equipment as shown in Figure 2-2. Place the X920A Short on the end of the X752A.

2) Set the Klystron Power Supply beam and reflector voltages to off. Both voltages on the 715A Klystron Power Supply may be turned off with the MOD. SELECTOR switch.

3) 415B Standing Wave Indicator Control Settings:
INPUT SELECTOR switch to BOLO.
BOLO BIAS CURRENT switch to HIGH.
RANGE switch to 30.
METER SCALE switch to NORMAL.
GAIN control fully clockwise.

4) Set the X382A Variable Attenuator to 30 db.

5) Connect the equipment to a source of 115V ac power. Turn on the klystron fan. Turn on all equipment and allow it to warm up for 10 minutes.

6) Set the X-13 Klystron micrometer to 12.4 kmc.

7) Adjust the Klystron Power Supply beam, reflector, and modulation voltages to operate the klystron with 1000-cps modulation. A beam voltage of about 380 volts and a reflector voltage between 600 and 900 volts provide good operation with the X-13 Klystron. A jump in the cathode current indicates that the klystron is operating.

8) If necessary vary the attenuation of the X382A to obtain a deflection on the 415B meter.

9) Adjust the 715A Klystron Power Supply MOD. FREQ. (1000-cycle modulation frequency) for a maximum deflection on the 415B.

10) Adjust the 715A REFLECTOR VOLTS and MOD. VOLT. (modulation voltage) controls for a maximum deflection on the 415B, varying the X382A attenuation as necessary.

11) Tune the X485B Detector Mount for a maximum deflection on the 415B.

12) Check the Klystron frequency by adjusting the X532A Frequency Meter until a dip occurs on the 415B. Read the frequency and reset the klystron frequency adjustment for 12.4 kmc if necessary. Turn the Frequency Meter knob one-quarter turn to set the Frequency Meter off resonance.

13) Adjust the X382A for a full-scale deflection (0 db).

14) Replace the X920A Adjustable Short with the X914B Moving Load.

15) Adjust the 415B RANGE switch for a meter deflection. If necessary decrease the attenuation of the X382A for a reading and note the decrease.

16) Adjust the X914B for a maximum deflection on the Standing Wave Indicator and note the reading (D max). Then adjust the X914B for a minimum deflection and note the reading (D min). Record both maximum and minimum readings, taking into consideration the decrease of the X382A attenuation.

17) Convert the maximum and the minimum readings from db to numerical ratios and solve for the reflection coefficient of the X914B and the directivity of the X752A with the following formulas: (Reflection coefficient, ρ, is the ratio of reflected voltage to incident voltage.)

$$D \text{ or } \rho = \frac{D_{max} + D_{min}}{2}$$

$$D \text{ or } \rho = \frac{D_{max} - D_{min}}{2}$$

The directivity of the X752A could be either value of "D or ρ" determined above. To uniquely determine the directivity of the X752A under test, make the same measurement on another directional coupler. Since the same termination is used for both measurements, the reflection coefficient will be common to both measurements. The other value is then the directivity of the X752A under test. (The Signal Separation Chart, Figure 2-3, may also be used to determine the directivity and reflection coefficient.)

Example:

Suppose that the maximum and minimum readings are -30.6 and -36.3 db respectively. Then, the voltage ratios are:

$$\text{Antilog} \frac{(-30.6)}{20} = 0.0295$$

$$\text{Antilog} \frac{(-36.3)}{20} = 0.0153$$

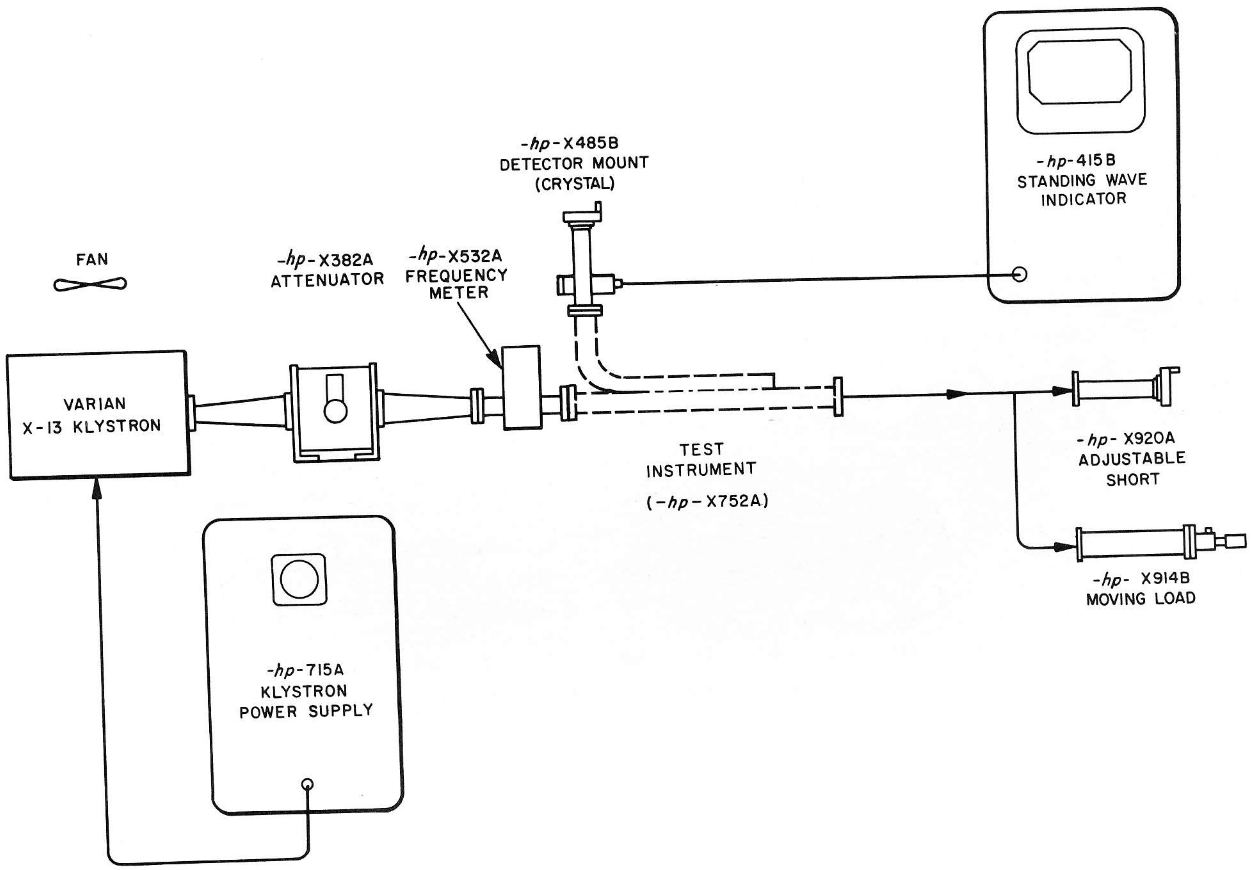


Figure 2-2. X752A Directional Coupler Directivity Calibration

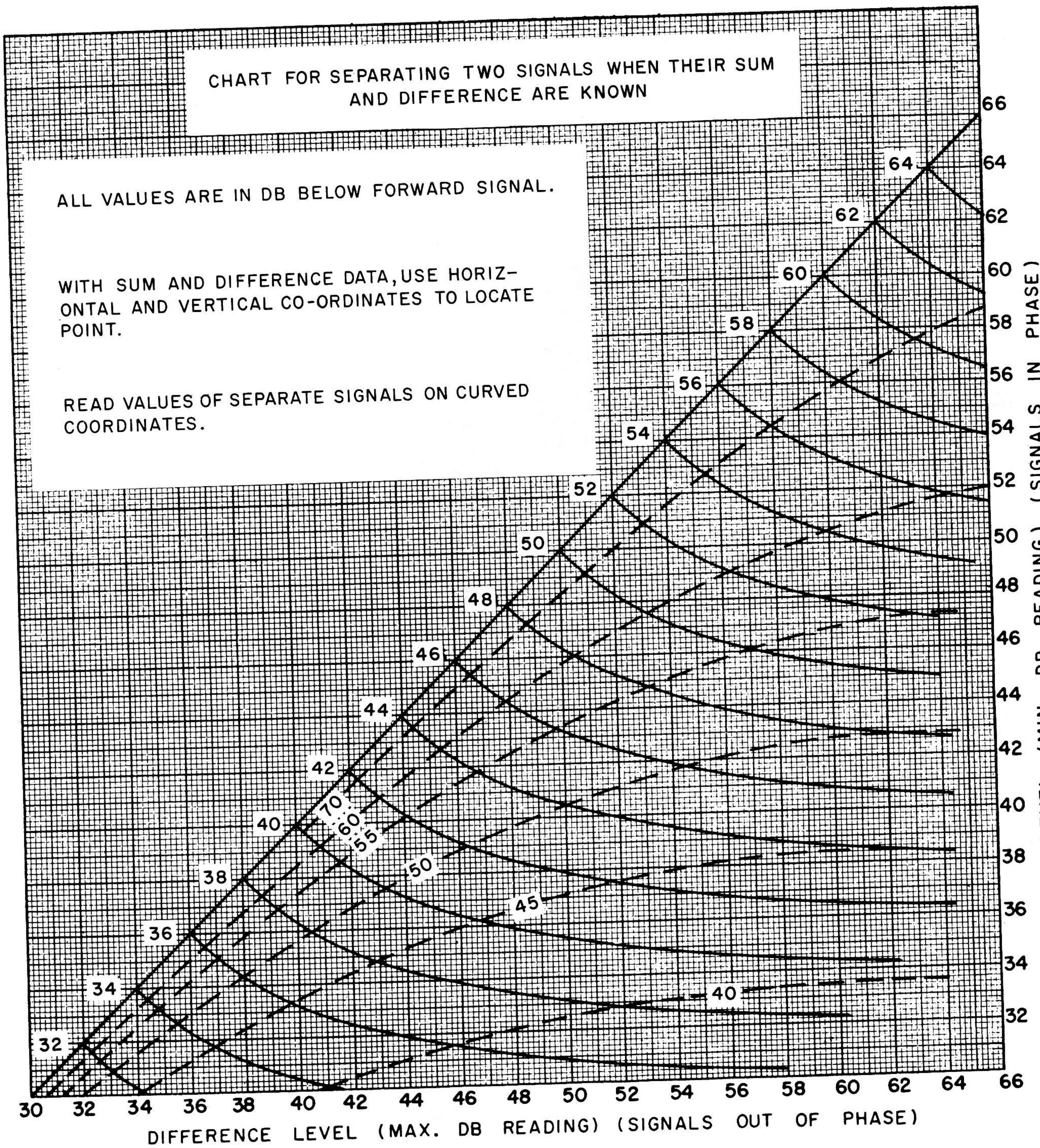


Figure 2-3. Signal-Separation Chart

Substituting into the formulas and solving,

$$D \text{ or } \rho = \frac{0.0295 + 0.0153}{2}$$

$$= 0.0224$$

In db $= 20 \log (0.0224)$

$= -33\text{db}$

$$D \text{ or } \rho = \frac{0.0295 - 0.0153}{2}$$

$$= 0.00706$$

In db $= 20 \log (0.00706)$

$= -43$ db

When another directional coupler was used D and ρ were -33 db and -46 db. Hence, since -33 db is common to both, it is the reflection coefficient of the termination. Therefore the directivity of the X752A under test is -43 db. (The Signal Separation Chart provides the same results.)

18) Repeat the measurement at other frequencies and record the directivity. The directivity should be at least -40 db at all frequencies.

SECTION III
X382A VARIABLE ATTENUATOR

3-1 SPECIFICATIONS

Attenuation Range:	0 to 50 db
Attenuation Accuracy:	±2% of reading in db or 0.1 db, whichever is greater
Attenuation at Zero Setting:	Less than 1 db
SWR:	Less than 1.15

3-2 PRELIMINARY NOTES

This procedure describes the calibration of the Model X382A Variable Attenuator. It includes rapid dial adjustment check which generally indicates proper calibration over the entire range. If desired, the dial may be checked at other points and frequencies to insure proper calibration. The attenuation at 0 db may also be checked. Throughout this procedure, the X382A being calibrated will be referred to as the "X382A under test". The X382A mounted between the X-13 Klystron and the X532A Frequency Meter will be referred to as the "calibrating X382A". For highest accuracy, the 415B Standing Wave Indicator should be calibrated. Section VIII describes a suitable calibration procedure.

3-3 DIAL CALIBRATION

1) Set up the equipment as shown in Figure 3-1.

2) 715A Klystron Power Supply Control Settings:
REFLECTOR RANGE switch to 600-900.
MOD. SELECTOR switch to OFF.
BEAM VOLTS control to approximately 380.
REFLECTOR VOLTS control fully clockwise.
MOD. VOLT. partially clockwise.

3) 415B Standing Wave Indicator Control Settings:
INPUT SELECTOR switch to BOLO.
BOLO BIAS CURRENT switch to HIGH.
METER SCALE switch to EXPAND.
RANGE switch to 40.
GAIN control to nearly maximum.

4) Set the calibrating X382A to 20 db.

5) Connect the equipment to a 115V ac power source. Turn on the klystron fan. Turn on the equipment and allow it to warm up for 10 minutes.

6) Set the X-13 Klystron micrometer control to 10.3 kmc.

7) Set the 715A MOD. SELECTOR control to 1000 ∿ . Decrease the REFLECTOR VOLTS setting until the klystron starts oscillating, as indicated by a jump in the cathode current. If necessary, adjust the REFLECTOR RANGE switch to 300-600. If necessary, change the calibrating X382A setting to obtain an upscale reading on the 415B meter.

CAUTION

Do not reduce the attenuation of the calibrating X382A below 10 db or the barretter might be destroyed. If desired, a 10 db pad may be inserted between the X382A and X-13 Klystron to prevent damage to the barretter. For highest accuracy, operate the X485B with an rf power input of less than 0.2 mw.

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8) Adjust the 715A MOD. FREQ. control for a maximum deflection on the 415B meter, adjusting the X382A as necessary.

9) Adjust the 715A REFLECTOR VOLTS and MOD. VOLT. controls for a maximum deflection on the 415B, adjusting the X382A as necessary.

NOTE

An oscilloscope and a detector mount equipped with a crystal provide a convenient method of monitoring klystron operation. Adjust the Klystron Power Sup-

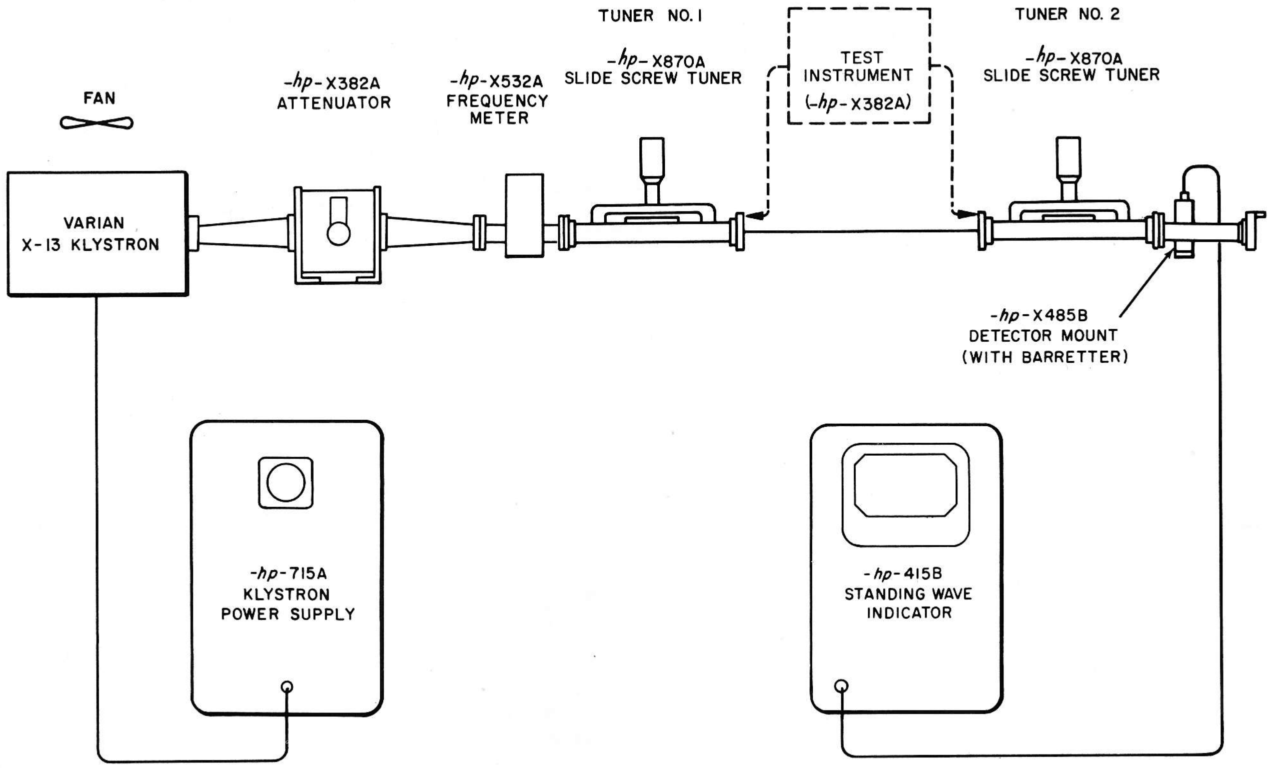

Figure 3-1 X382A Variable Attenuator Calibration.

ply REFLECTOR VOLTS and MOD. VOLT. controls so that a clean square wave of maximum amplitude appears on the oscilloscope.

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10) Check the klystron frequency by adjusting the X532A Frequency Meter until a dip occurs on the 415B meter. Adjust the klystron as necessary. Read the frequency and then adjust the X532A to a point off resonance.

11) Insert the X382A under test between the two tuners and withdraw both tuner probes.

12) Rotate the dial of the X382A under test until the dial dot, located between 45 and 55 db, appears under the index line. Approach the dot from the MAX side.

13) Adjust the calibrating X382A Variable Attenuator and 415B GAIN controls to obtain a convenient reading on the meter. Tune the X485B for a maximum deflection and note the reading.

14) Turn the dial of X382A under test so that the dot to the right of MAX appears under the index line and note the reading. Approach the dot from the MAX side. This eliminates the effects of any backlash.

15) If the 415B reading is not the same as that of step 14, loosen the dial shaft screws and turn the dial so that the meter readings are the same at both dot positions. The meter is now calibrated.

16) To check the calibration, set the 415B RANGE switch to 30 and increase the attenuation of the calibrating X382A Variable Attenuator.

17) Decrease the attenuation of the X382A under test to 0 db.

18) Set the calibrating X382A for an upscale meter reading.

19) Tune the X485B and then the No. 2 X870A for a maximum indication on the 415B meter.

20) Set the 415B GAIN control and calibrating X382A attenuation for a 1-db reading on the 415B EXPANDED scale.

21) Set the X382A under test to 10 db.

22) Set the 415B RANGE switch to 40 db. The attenuation of the X382A under test is 10 db plus the deviation of the needle from the 1-db mark. (A deviation to the right will be minus and to the left will be plus.) For greatest accuracy, apply the correction factors

obtained from the 415B calibration. If desired, a correction curve may be plotted. The final calculated attenuation should be between 9.8 and 10.2 db.

23) Set the X382A under test to 20 db and the 415B RANGE switch to 50. The attenuation of the X382A under test should be between 19.6 and 20.4 db.

24) To calibrate the X382A under test at 30 db, set the 415B RANGE switch to 30.

25) Adjust the calibrating X382A Variable Attenuator for the same meter reading on the 415B as in step 24.

26) Increase attenuation of the X382A under test to 30 db.

27) Set the 415B to 40 db. The attenuation of the X382A under test is 30 db plus the deviation of the needle from the 1-db mark. For greatest accuracy, apply the 415B correction factors. The final calculated attenuation should be between 29.4 and 30.6 db.

28) Calibrate the X382A under test at 40 and 50 db. The limits are 39.2 and 40.8 db, and 49 and 51 db.

29) Calibration at 10.3 kmc usually indicates proper calibration over the entire frequency band. However, if desired, the X382A under test may be calibrated at 8.2, 9.25, 11.35, 12.0 and 12.4 kmc.

3-4 ATTENUATION AT 0 DB

1) Connect the equipment as shown in Figure 3-1 with the two tuners connected together.

2) Set the equipment following steps 2 through 10 of 3-2.

3) Withdraw the probe of both Slide Screw Tuners. Tune the X485B Detector Mount for maximum deflection on the 415B. Then tune Slide Screw Tuner No. 2 for maximum deflection.

4) Set the 415B GAIN control or X382A Attenuator for a 0-db meter reading on the EXPANDED scale.

5) Insert the X382A under test between the two Slide Screw Tuners.

6) Tune both Slide Screw Tuners for a maximum deflection on the 415B meter. Read the attenuation of the X382A under test on the 415B. It should be less than the rated specification of 1 db. Record the reading.

7) Repeat the measurement for frequencies of 8.2, 9.25, 11.35, 12.0 and 12.4 kmc and record.

SECTION IV
X532A FREQUENCY METER

4-1 SPECIFICATIONS

Frequency Range:	8.2 to 12.4 kmc.
Accuracy:	0.08% of reading.

4-2 PRELIMINARY PROCEDURE

1) Connect the equipment as shown in Figure 4.1.

Set the 524D Electronic Counter power-switch to the STANDBY position and allow it to warm up. Throughout this procedure, the X532A being calibrated will be referred to as the "X532A under test". The X532A directly connected to the X382A will be referred to as the "calibrating X532A".

2) Set the X382A Variable Attenuator to 10 db.

3) Turn on the klystron fan.

4) 715A Klystron Power Supply Control Settings:
MOD. SELECTOR switch to OFF.
REFLECTOR RANGE switch to OFF.
BEAM VOLTS control to approximately 380.
REFLECTOR VOLTS control to 900.

5) Turn on all the instruments and allow them to warm up for 10 minutes.

6) 130B Oscilloscope Control Settings:
VERT. SENSITIVITY control to 0.1 v/cm.
AC/DC switch to AC.
SWEEP MODE switch to LINE.
TRIGGER SLOPE switch to +.
Sweep speed to 0.5 millisecond/cm.

7) 524D Electronic Counter and 525B Frequency Converter Control Settings:
FUNCTION SELECTOR switch to FREQUENCY.
FREQUENCY UNIT switch to 0.01.
DISPLAY TIME control to desired display time, which is usually counterclockwise.
MIXING FREQUENCY control to 190 mc.
MIXER-DIRECT-WAVEMETER switch to MIXER.

8) 540B Transfer Oscillator Control Settings:
LOW FREQ, GAIN, and HIGH FREQ controls fully clockwise.

4-3 FREQUENCY CALIBRATION

1) Mechanically check the frequency adjust knob of the X532A under test by turning it from one stop to the other to see that it does not bind. If it binds, correct this defect before proceeding.

2) Turn the frequency adjust knob of the X532A under test to the stop above 12.4 kmc.

3) Set the 540B frequency dial to 200 mc. Monitor the 540B frequency with the 524D Electronic Counter and adjust the 540B COARSE and FINE VERNIER controls to set the frequency exactly to 200 mc. The Electronic Counter will then read 10000.0.

4) Set the calibrating X532A Frequency Meter to 12.4 kmc.

5) Set the 715B Klystron Power Supply REFLECTOR RANGE switch to 600-900. Set the MOD. SELECTOR switch to 60 ∼ .

6) Starting from the high end, adjust the 715A REFLECTOR VOLTS control to obtain a sweep mode on the oscilloscope screen. Adjust the MOD. VOLT. control fully clockwise so that the best mode pattern is obtained. Adjust the 60 ∼ PHASE control for best display.

7) Adjust the X382A Variable Attenuator or the Oscilloscope VERT. SENSITIVITY control to keep the trace on the oscilloscope screen.

8) Adjust the X-13 Klystron micrometer so that the notch from the calibrating X532A Frequency Meter appears on the mode resonance curve. A zero-beat pip representing the test frequency should also appear on the mode. When both appear on the mode response curve, the klystron is adjusted to 12.4 kmc.

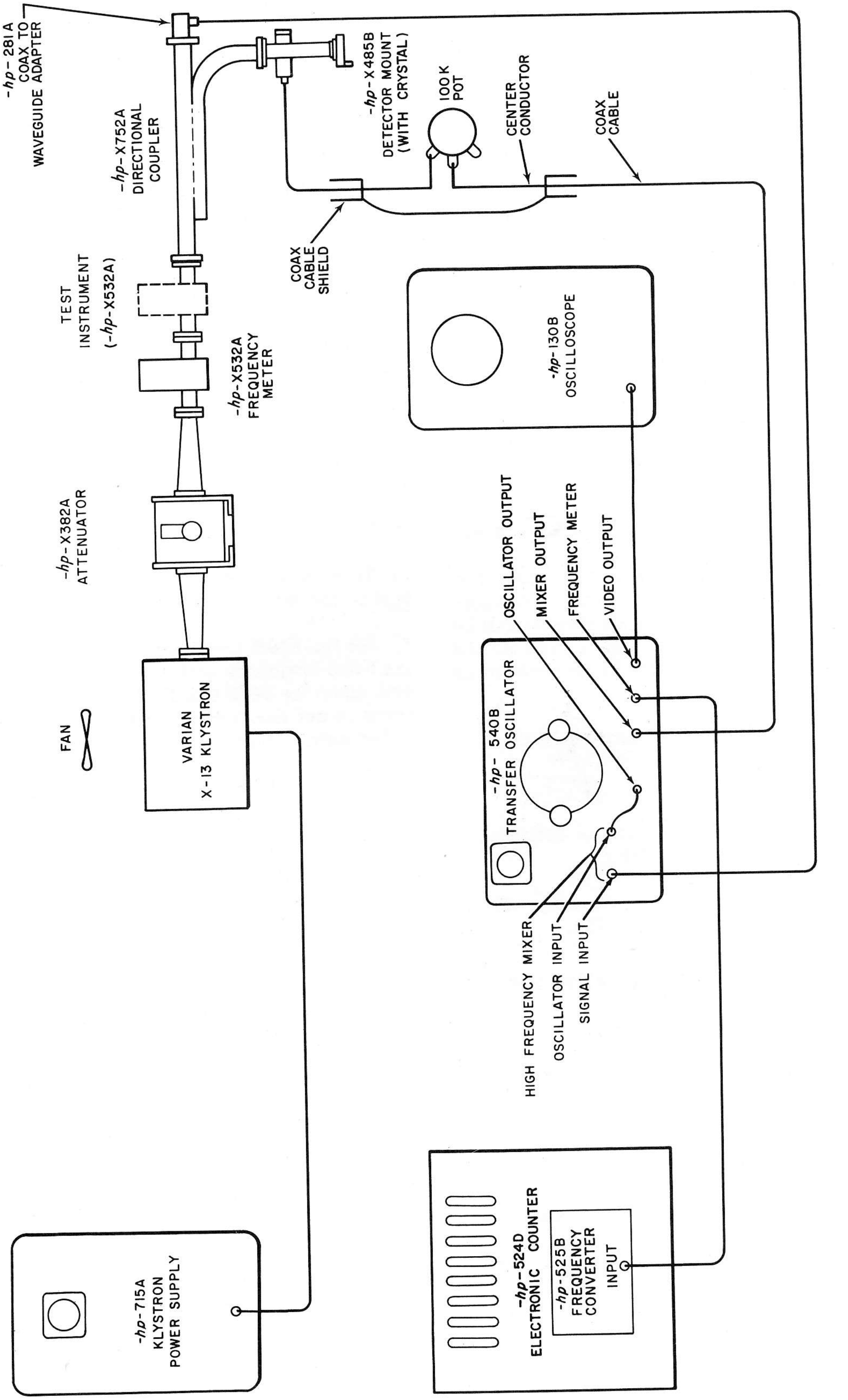

Figure 4-1. X532A Frequency Meter Calibration

9) Adjust the 715A REFLECTOR VOLTS, MOD. VOLT. and 60~ PHASE controls to produce the best oscilloscope trace. The trace on the oscilloscope should appear as in Figure 4-2.

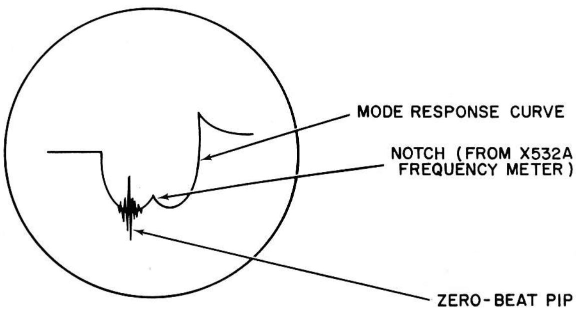

Figure 4-2. Oscilloscope Trace Showing the Klystron Mode Response Curve and Test Frequency Pip

10) Turn the 540B Transfer Oscillator HIGH FREQ control counterclockwise to reduce the width of the zero beat to a fine line. The pip represents 12.4 kmc.

11) Adjust the calibrating X532A Frequency Meter to 12.2 kmc to move the notch from the screen.

12) Position the zero-beat pip on the mode response peak by adjusting the klystron micrometer.

13) Tune the X485A Detector Mount for maximum display on the oscilloscope. Reduce the height of the mode resonance curve for a good presentation on the oscilloscope by increasing the 100 K potentiometer attenuation. If necessary increase the attenuation of the X382A.

14) To check for backlash, adjust the frequency of the X532 under test to 12.4 kmc and note the position of the notch on the oscilloscope screen. Turn the X532A under test past this position and then turn it back towards 12.4 until the new notch is located at the same position as the first notch. The meter should read 12.4. The maximum allowable difference is ± one division.

15) To check for mechanical looseness, press down slightly on the knob of the X532A under test and note if shifting of the notch occurs. It should remain fixed. Shifting indicates improper seating of the nut bushing. Check for dirt or excess grease in the bearing surface.

16) To calibrate the X532A under test at 12.4 kmc turn the knob of the X532A under test towards 12.4 until the notch coincides with the zero-beat pip. Note the indication on the X532A under test. If it does not indicate 12.4, as it should, remove the knob from the X532A under test and slightly loosen the three screws underneath the knob. Holding the shaft stationary, so that the zero-beat pip and notch remain superimposed on the oscilloscope, turn the gray dial until 12.4 lines up with the hairline. Tighten the three screws slightly in sequential fashion until they are tight. Tightening each screw completely, one at a time, may cause the gray dial to bind on the clear plastic sleeve.

17) Set the klystron frequency to 12.2 kmc by adjusting the micrometer counterclockwise until the notch from the X532A Frequency Meter appears on the oscilloscope. The zero-beat pip should be in the immediate vicinity of this notch. Adjust the klystron frequency until the zero-beat pip appears at top of the mode response curve.

18) Adjust the 715A REFLECTOR VOLTS control and the X485B for a maximum display.

19) Adjust the calibrating X532A Frequency Meter to 12.0 kmc to move the notch from the screen.

20) To check the X532A under test at 12.2 kmc, adjust the X532A under test until the notch coincides with the zero-beat pip. Note the dial reading on the X532A under test. It must not be more than ±1 division from the 12.2 kmc reading.

21) Continue to check the calibration of the X532A under test down to 8.4 kmc at 200-mc intervals; e. g., 12.4, 12.2, 12.0, 11.8 and so on.

22) If the X532A under test is not within specification upon reaching the 8.2 kmc frequency, note the error and return the X532A under test to the 12.4 kmc setting. Remove the knob, loosen the screws and reset the dial at one-half the error noted at 8.2 kmc. The frequency meter dial will then be slightly off at 8.2 and 12.4 kmc but should be within specifications throughout the middle of the band. If the dial is reset because of an error at 8.2 kmc, recheck the calibration at 12.4, 12.2, and 12.0 kmc. Satisfactory performance at these points generally indicates favorable calibration throughout the rest of the band. If more accuracy is desired, a correction curve for the instrument may be plotted.

SECTION V
X485B DETECTOR MOUNT
(WITH BARRETTER)

5-1 SPECIFICATIONS

Frequency Range:	8.2 to 12.4 kmc.
Maximum SWR:	1.25.

Uses Sperry 821 or Narda N821 barretter; or 1N21 or 1N23 crystal.

5-2 SWR CALIBRATION

1) Connect the equipment as shown in Figure 5-1.

2) 715A Klystron Power Supply Control Settings:
   REFLECTOR RANGE switch to 600-900.
   MOD. SELECTOR switch to OFF.
   BEAM VOLTS control to approximatley 380.
   REFLECTOR VOLTS control fully clockwise.
   MOD. VOLT. control partially clockwise.

3) 430C Power Meter Control Settings:
   BIAS CURRENT control to OFF.
   COARSE and FINE controls fully counterclockwise.
   RES switch to 200.
   COEF switch to POS.
   POWER RANGE switch to 10 mw.

4) 415B Standing Wave Indicator Control Settings:
   INPUT SELECTOR switch to CRYSTAL 200Ω.
   RANGE switch to 30.
   METER SCALE switch to NORMAL.
   GAIN control fully clockwise.

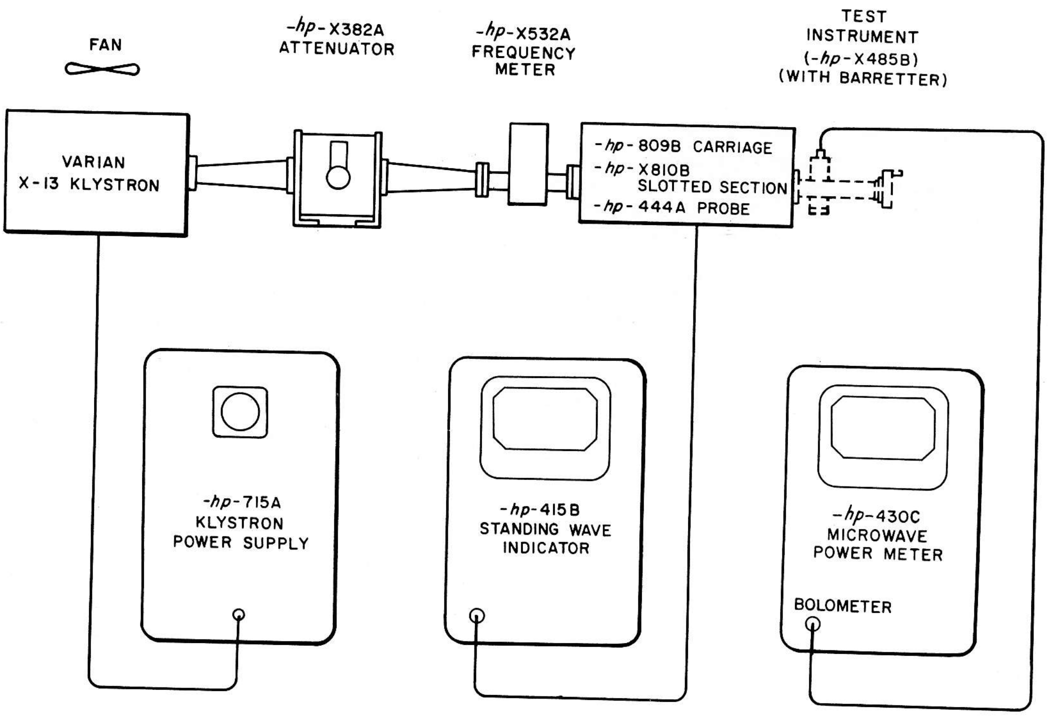

Figure 5-1 X485B Detector Mount SWR Calibration.

5) Set the X382A Variable Attenuator to 20 db.

6) Connect the equipment to a 115V ac power source. Turn on the klystron fan. Turn on the equipment and allow it to warm up for 10 minutes.

7) Set the 430C BIAS CURRENT and COARSE and FINE controls to obtain an approximate zero set reading.

8) Set the X-13 Klystron micrometer to 12.4 kmc.

9) Set the 715A MOD. SELECTOR control to 1000 ∿ . Decrease the REFLECTOR VOLTS control setting until the klystron starts oscillating as indicated by a jump in the cathode current.

10) If necessary, switch the RANGE switch on the 415B to obtain an upscale deflection.

11) Adjust the 715A MOD. FREQ. control for maximum deflection on the 415B, adjusting the RANGE switch as necessary.

12) Adjust the 715A REFLECTOR VOLTS and MOD. VOLT. controls for maximum deflection on the 415B, adjusting the RANGE switch as necessary.

13) Check the klystron frequency by adjusting the X532A Frequency Meter until a dip occurs on the Standing Wave Indicator. Note the frequency, then turn the frequency meter knob at least a quarter-turn from the resonance setting.

14) Move the probe along the slotted section to obtain a peak deflection on the 415B.

15) With the 415B GAIN control nearly maximum and the RANGE switch on 40, vary the 444A Probe penetration to obtain a reading of nearly "1" on the SWR scale. Adjust the 415B GAIN control for a reading of "1". The crystal in the Slotted Line probe now has the proper rf power input. After this adjustment has been completed, the 415B switches and probe carriage may be moved to any position during the measurement without overloading the crystal.

16) Move the probe carriage along the slotted section to obtain a minimum deflection on the 415B. Adjust the X485B tuning control for a minimum SWR. Use the expanded scale control of the 415B for more resolution. The maximum permissible SWR is 1.25.

17) Check the SWR at 8.2, 9.25, 10.3, 11.35 and 12.0 kmc.

5-3 SQUARE LAW CALIBRATION

1) Connect the equipment as shown in Figure 5-2.

2) 715A Klystron Power Supply Control Settings:
REFLECTOR RANGE switch to 600-900.
MOD. SELECTOR switch to OFF.
BEAM VOLTS control to approximately 380.
REFLECTOR VOLTS control fully clockwise.
MOD. VOLT. control partially clockwise.

3) 415B Standing Wave Indicator Control Settings:
INPUT SELECTOR switch to BOLO.
BOLO BIAS CURRENT switch to HIGH.
RANGE switch to 30.
METER SCALE switch to EXPAND.

4) Set the X382A Variable Attenuator No. 1 to 20 db; the No. 2 X382A to 10 db.

5) Connect the equipment to a 115V ac power source. Turn on the klystron fan. Turn on the equipment and allow it to warm up for 10 minutes.

6) Set the X-13 Klystron micrometer control to 11.35 kmc.

7) Set the 715A MOD. SELECTOR control to 1000 ∿ . Decrease the REFLECTOR VOLTS setting until the klystron starts oscillating, as indicated by a jump in the cathode current. If necessary switch the REFLECTOR RANGE switch to 300-600. If necessary change the No. 1 X382A setting to obtain an upscale reading on the 415B meter.

CAUTION

Do not reduce the attenuation of the No. 1 X382A below 10-db or the barretter might be destroyed. For highest accuracy, operate the X485B with an rf power input of less than 0.2 mw. If desired a 10 db pad may be inserted between the X382A and the X-13 to prevent barretter damage.

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8) Adjust the 715A MOD. FREQ. control for a maximum deflection on the 415B meter, adjusting the No. 1 X382A as necessary.

9) Adjust the 715A REFLECTOR VOLTS and MOD. VOLT. controls for a maximum deflection on the 415B, adjusting the No. 1 X382A as necessary.

NOTE

An oscilloscope and a detector mount equipped with a crystal provide a convenient method of monitoring klystron operation. Adjust the Klystron Power Supply REFLECTOR VOLTS and MOD. VOLT. controls so that a clean square wave of maximum amplitude appears on the oscilloscope.

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10) Adjust the X485B tuning control for a maximum meter reading.

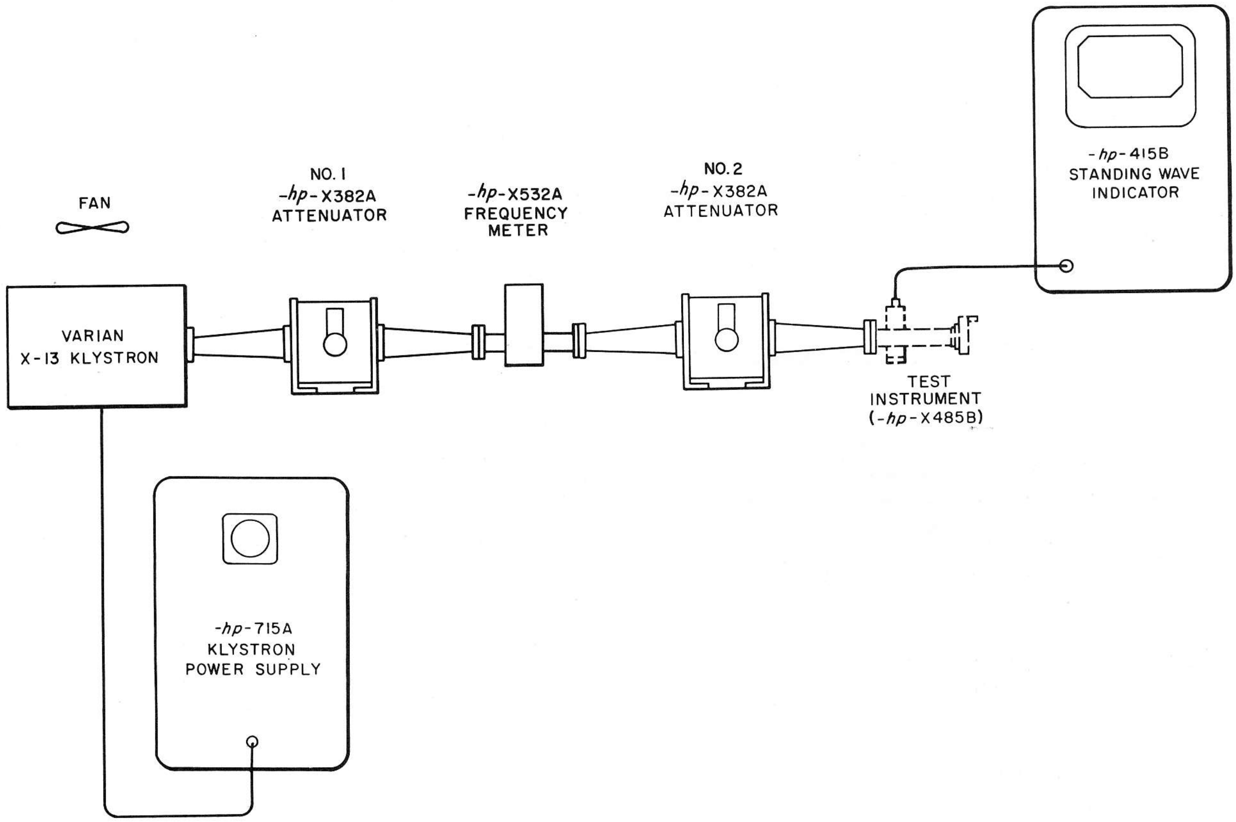

Figure 5-2 X485B Detector Mount Square Law Calibration

11) Check the klystron frequency by adjusting the X532A Frequency Meter until a dip occurs on the 415B meter. Adjust the klystron as necessary. Note the frequency and then adjust the X532A to a point off resonance.

12) Adjust the 415B GAIN or No. 1 X382A for a meter reading of 0.5 db. Use this point as a reference.

13) Decrease the No. 2 X382A to 0 db. Set the 415B RANGE switch to 20. Note the deviation from reference (0.5 db) and add to the RANGE switch setting. (A deviation to the left is regarded as positive and one to the right as negative.) Record the reading.

14) Increase the No. 2 X382A attenuation to 10 db and increase the output by adjusting the No. 1 X382A for the same meter reading as in step 13.

15) Repeat step 13 with the 415B RANGE switch set to 10 and record. If it is desired to plot the 415B readings versus power input to the X485B, the power input should be measured with a 430C at this setting. The power levels at the rest of the points are then known since it is varied in 10 db steps.

16) Set the 415B RANGE switch back to 30, the No. 2 X382A to 0 db and the No. 1 X382A for a 0.5-db reading on the 415B.

17) Increase the No. 2 X382A attenuation to 10 db and set the 415B RANGE switch to 40. Record the 415B setting.

18) Reduce the No. 2 X382A to 0 db and reset the No. 1 X382A for the same reading as in step 17.

19) Repeat step 17 with the 415B RANGE switch on 50 and record.

20) Repeat steps 17, 18, and 19 for a reading on the 60 range and record.

21) Plot the 415B readings versus power input. The straight line portion of the curve represents the useful region for the barretter. It should be linear over 30 db of power input. If it is not, replace the barretter.

SECTION VI
H01 872A SLIDE SCREW TUNER

6-1 SPECIFICATIONS

Frequency Range:	500 to 4000 mc
Characteristic Impedance:	50 ohms
Connectors:	Type N

6-2 OPERATIONAL CHECK

1) Connect the equipment as shown in Figure 6-1. Throughout this procedure, the H01 872A being calibrated will be referred to as the "H01 872A under test." The H01 872A used in the test set-up will be referred to as the "calibrating H01 872A."

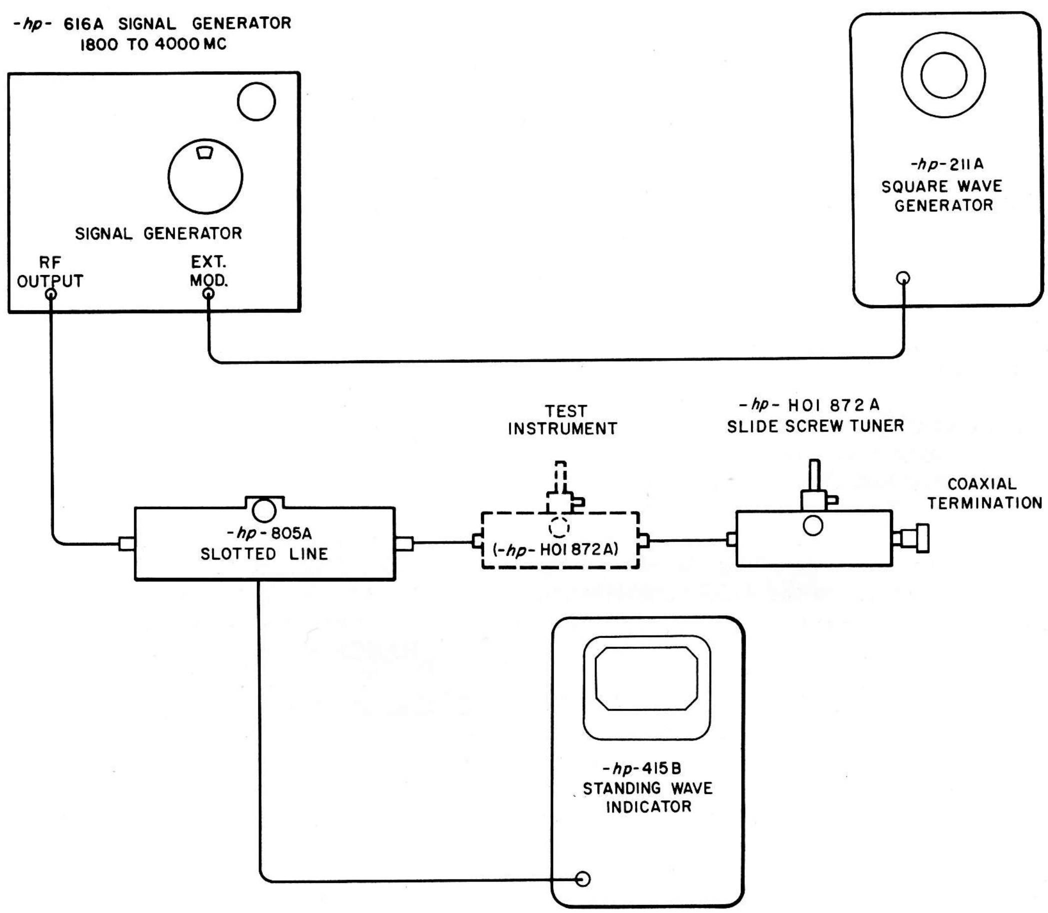

Figure 6-1. H01 872A Slide Screw Tuner Check.

2) 211A Square Wave Generator Control Settings:
RANGE switch to X100.
FREQUENCY control to 10.
AMPLITUDE control fully clockwise.

3) Signal Generator Control Settings:
Adjust the SIGNAL FREQUENCY control to any frequency between 1800 and 4000 mc.
Set the FM-CW-OFF switch to OFF.

4) 415B Standing Wave Indicator Control Settings:
RANGE switch to 30.
INPUT SELECTOR switch to CRYSTAL 200KΩ.
GAIN control fully clockwise.
METER SCALE switch to NORMAL.

5) Connect the equipment to a 115V ac power source. Turn on all the equipment and allow it to warm up for 15 minutes.

6) Remove the probe of the H01 872A under test.

7) Signal Generator Control Settings:
ZERO SET control for a ZERO SET reading on the meter.
FM-CW-OFF switch to CW.
POWER SET control for a POWER SET reading on the meter.
OUTPUT ATTENUATION control to -10 dbm.
FM-CW-OFF switch to EXT NEG.

8) Adjust the RANGE switch on the 415B to obtain an indication on the meter.

9) Adjust the 211A FREQUENCY control and SYMMETRY control for maximum deflection on the 415B, adjusting the 415B RANGE switch as necessary. A deflection occurs when the pointer moves to the right.

10) Adjust the tuning knob on the top of the 805A Slotted Line for maximum deflection on the 415B. Adjust the 415B RANGE switch to keep the pointer on the scale.

11) Move the probe carriage along the slotted line for maximum deflection on the 415B, adjusting the RANGE switch as necessary.

12) With the 415B RANGE switch at 30, METER SCALE switch to NORMAL, and GAIN control to almost maximum gain, adjust the 805A probe penetration for a full scale meter deflection ("1" on the SWR scale). The crystal in the 805A will have the proper rf power input when the 415B meter indicates full scale with the switches set as indicated above. After this adjustment has been made the 415B switches and 805A probe carriage may be moved to any position during the measurement without overloading the crystal.

13) Move the probe carriage for minimum deflection on the 415B. Note the SWR. If the SWR is greater than 3, adjust the RANGE switch and read on the 3 to 10 scale. Adjust the calibrating H01 872A Slide Screw Tuner for an SWR between 3 and 10.

14) Adjust the probe of the H01 872A under test to obtain minimum SWR. Use the scale expansion control on the 415B for more resolution.

15) The H01 872A under test is operating properly if the SWR, as adjusted by the calibrating H01 872A Slide Screw Tuner, can be reduced to 1.05 or less.

6-3 TUNER LOSS CALIBRATION

1) Connect the H01 872A under test to the 805A Slotted Line as shown in Figure 6-1. Omit the calibrating H01 872A Slide Screw Tuner from the setup.

2) Set the 616A Signal Generator, 211A Square Wave Generator, and 415B Standing Wave Indicator controls as described in 6-2. Set the probe of the H01 872A under test for an SWR of 1.1 at 2200 mc using the technique described in 6-2.

3) Connect the equipment as shown in Figure 6-2 to measure the tuner loss. Do not connect the 415B Standing Wave Indicator to the 627A Detector Mount at this time.

4) Set the 616A FM-CW-OFF switch to OFF.

5) No. 1 415B Standing Wave Indicator Control Settings:
INPUT SELECTOR switch to BOLO.
BOLO BIAS CURRENT switch to LOW.
RANGE switch to 40.
GAIN control to nearly maximum.
METER SCALE switch to EXPAND.

6) No. 2 415B Control Settings:
INPUT SELECTOR switch to CRYSTAL 200Ω.
METER SCALE switch to EXPAND.
GAIN control to nearly maximum.
RANGE switch to 30.

7) Connect all equipment to a 115V ac power source, turn on the equipment, and allow 10 minutes for warm up.

8) 211A Square Wave Generator Control Settings:
RANGE switch to X100.
FREQUENCY dial to 10.
AMPLITUDE control completely clockwise.

9) Connect the PRD 627A Bolometer Mount to the No. 1 415B.

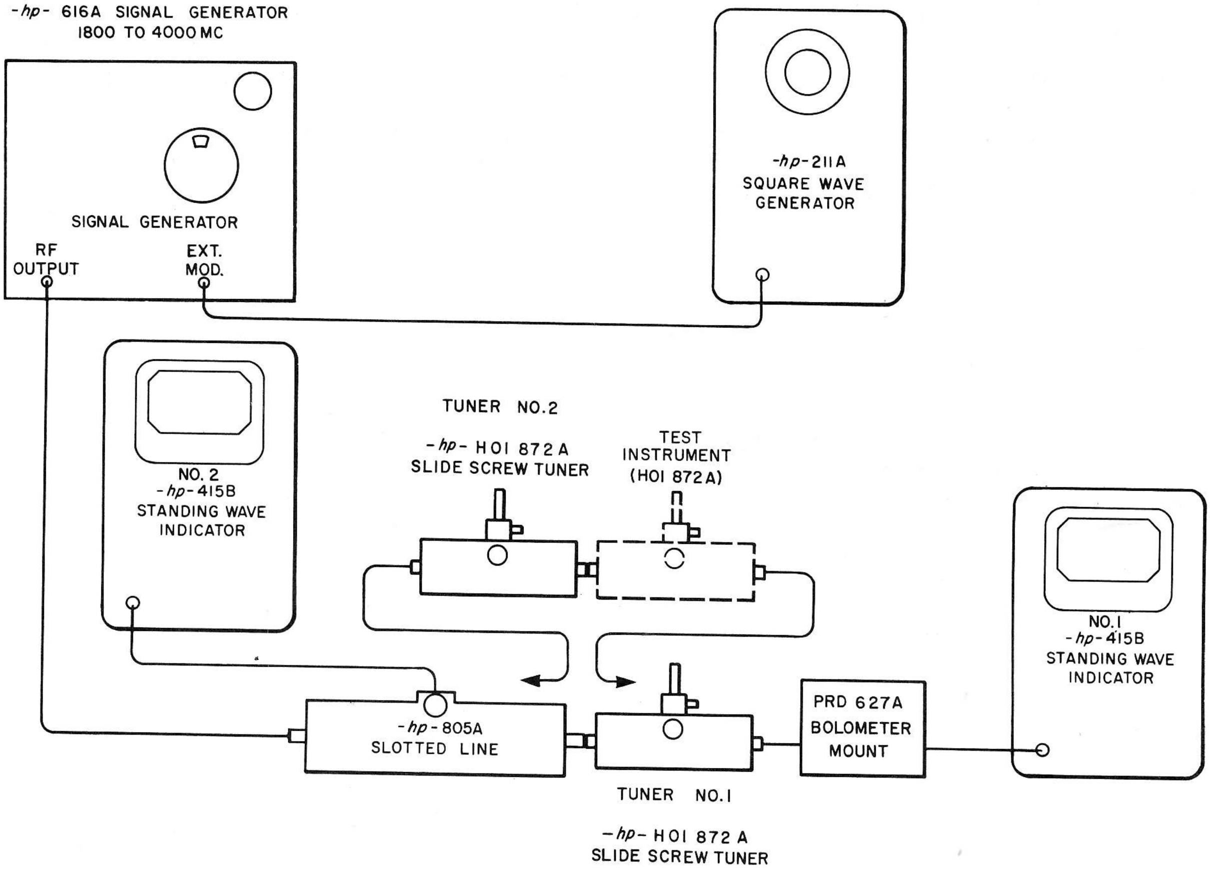

Figure 6-2. Checking H01 872A Slide Screw Tuner Loss

10) 616A Control Settings:
SIGNAL FREQUENCY control to 2200 mc.
ZERO SET control for a ZERO SET indication on the meter.
FM-CW-OFF switch to EXT. NEG.
OUTPUT ATTEN. control for an upscale reading on the No. 1 415B.

CAUTION

Do not exceed 0 dbm (1 mw) into the PRD 627A Bolometer Mount. Excessive power will burn out the bolometer. If desired, insert a pad between the Signal Generator and 805A to prevent damage to the barretter.

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11) Adjust the 211A Square Wave Generator FREQUENCY control and SYMMETRY control for a maximum indication on the No. 1 415B.

12) Tune the No. 1 calibrating H01 872A for a maximum indication on the No. 1 415B.

13) Set the No. 2 415B RANGE switch for an upscale deflection. Slide the 805A Slotted Line probe carriage over the slotted line. The No. 1 415B meter pointer should not fluctuate more than ±1%. If it does, reduce the probe penetration. Note the position of the carriage.

14) Set the No. 1 415B GAIN controls for a 0-db meter reading.

15) Insert the H01 872A under test and the No. 2 calibrating H01 872A Slide Screw Tuner between the 805A Slotted Line and the No. 1 H01 872A.

16) Tune the No. 2 H01 872A for a maximum deflection on the No. 1 415B meter.

17) Slide the 805A probe carriage for a maximum deflection on the No. 2 415B. Adjust the No. 2 415B RANGE switch and GAIN control for a full scale deflection ("1" on the EXPANDED SWR scale).

18) Slide the probe carriage for a minimum No. 2 415B deflection. Adjust the No. 2 calibrating H01 872A for a SWR less than 1.01. Return the probe carriage to the position in step 13.

19) Read the No. 1 415B. This is the attenuation of the H01 872A under test and the No. 2 calibrating H01 872A. The loss of the H01 872A under test is approximately one-half of the measured attenuation.

20) Repeat the measurement for SWR's of the H01 872A under test of 1.3, 1.5, 2.0, and 3.0. Plot the loss versus SWR for the H01 872A under test at 2200 mc. If desired it may be repeated at other frequencies. Graphs of tuner loss are useful for correcting power measurements.

SECTION VII
X870A SLIDE SCREW TUNER

7-1 SPECIFICATIONS

Correctable SWR:	20
Insertion loss at maximum correctable SWR:	2 db

7-2 OPERATIONAL CHECK

1) Connect the equipment as shown in Figure 7-1. Throughout this procedure, the X870A being calibrated will be referred to as the "X870A under test". The X870A used in the test setup will be referred to as the "calibrating X870A".

2) 715A Klystron Power Supply Control Settings:
REFLECTOR RANGE switch to 600-900 volts.
MOD. SELECTOR switch to OFF.
BEAM VOLTS control to approximately 380 volts.
REFLECTOR VOLTS control fully clockwise.
MOD. VOLT. control clockwise.

3) 415B Standing Wave Indicator Control Settings:
INPUT SELECTOR switch to CRYSTAL 200Ω.
RANGE switch to 30.
METER SCALE switch to NORMAL.
GAIN control fully clockwise.

4) Adjust the X382A Variable Attenuator to 20 db.

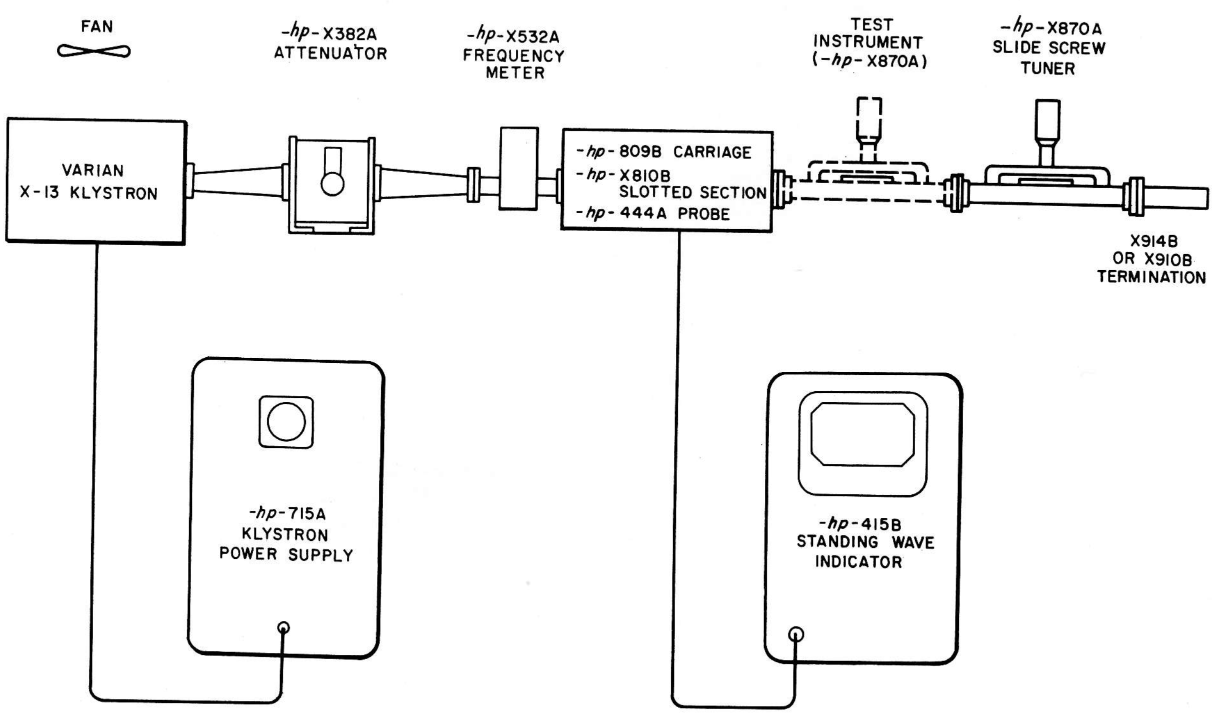

Figure 7-1. X870A Slide Screw Tuner Check

5) Withdraw the probe of the X870A under test.

6) Connect the equipment to a 115V ac power source. Turn on the klystron fan. Turn on all equipment and allow it to warm up for 10 minutes.

7) Adjust the X-13 Klystron micrometer to any frequency between 8.2 and 12.4 kmc.

8) Set the 715A Klystron Power Supply MOD. SELECTOR control to 1000 ∿ . Decrease the REFLECTOR VOLTS control setting until the klystron starts oscillating as indicated by a jump in the cathode current.

9) If necessary, adjust the 415B RANGE switch for an upscale deflection.

10) Adjust the 715A MOD. FREQ. control for maximum deflection on the 415B, adjusting the RANGE switch as necessary.

11) Adjust the 715A REFLECTOR VOLTS and MOD. VOLT. controls for maximum deflection on the 415B, adjusting the RANGE switch as necessary.

12) Check the klystron frequency by adjusting the X532A Frequency Meter until a dip occurs on the 415B. Note the frequency, then rotate the frequency meter knob a quarter-turn from the resonance setting.

13) Move the probe carriage along the slotted section to obtain a peak deflection on the 415B.

14) With the 415B GAIN control at nearly maximum gain and the RANGE switch at 30, adjust the probe penetration to obtain a reading of "1" on the SWR scale. The crystal in the Slotted Line probe will then have the proper rf power input. After this adjustment has been completed, the 415B switches and the probe carriage may be adjusted to any position during the measurement without overloading the crystal.

15) Move the probe carriage along the slotted section for a minimum deflection on the 415B. Note the SWR. If the SWR is greater than 3, adjust the RANGE switch to the next position and note the indication on the 3 to 10 SWR scale. Adjust the calibrating X870A Slide Screw Tuner probe for an SWR between 3 and 10.

16) Adjust the probe of the X870A under test for a miminum SWR. Use the scale expansion control on the 415B for more resolution. Decrease the Slotted Line probe insertion and repeat the SWR measurement until consecutive readings are within 1% of each other.

17) The X870A under test is operating properly if the SWR set by the calibrating X870A Slide Screw Tuner can be reduced to a value less than 1.02.

7-3 TUNER LOSS CALIBRATION

1) Connect the X870A under test to the X810B Slotted Section as shown in Figure 7-1. Omit the calibrating X870A Slide Screw Tuner from the setup.

2) Set the 715A Klystron Power Supply and 415B Standing Wave Indicator controls as described in 7-3. Set the probe of the X870A under test for an SWR of 1.1 at 10.3 kmc using the technique described in 7-2.

3) Connect the equipment as shown in Figure 7-2 to measure the tuner loss.

4) 715A Control Settings:
- REFLECTOR RANGE switch to 600-900.
- MOD. SELECTOR switch to OFF.
- BEAM VOLTS control to approximately 380.
- REFLECTOR VOLTS control fully clockwise.
- MOD. VOLT. control partially clockwise.

5) No. 1 415B Standing Wave Indicator Control Settings.
- INPUT SELECTOR switch to BOLO.
- BOLO BIAS CURRENT switch to HIGH.
- RANGE switch to 40.
- GAIN control to nearly maximum.
- METER SCALE switch to EXPAND.

6) Set the X382A Variable Attenuator to 20 db.

7) No. 2 415B Control Settings:
- INPUT SELECTOR switch to CRYSTAL 200Ω.
- METER SCALE switch to EXPAND.
- GAIN control to nearly maximum.
- RANGE switch to 30.

8) Connect the equipment to a 115V ac power source. Turn on the klystron fan. Turn on all equipment and allow it to warm up for 10 minutes.

9) Set the X-13 Klystron micrometer control to 10.3 kmc.

10) Set the 715A MOD. SELECTOR control to 1000 ∿ . Decrease the REFLECTOR VOLTS setting until the klystron starts oscillating which is indicated by a jump in the cathode current. If necessary switch the REFLECTOR RANGE switch to 300-600. If necessary change the X382A setting to obtain an upscale reading in the No. 1 415B meter.

CAUTION

Do not reduce the attenuation of the X382A below 10-db or the barretter might be destroyed. For highest accuracy, operate the X485B with rf power input less than 0.2 mw. If desired a 10 db pad may be inserted

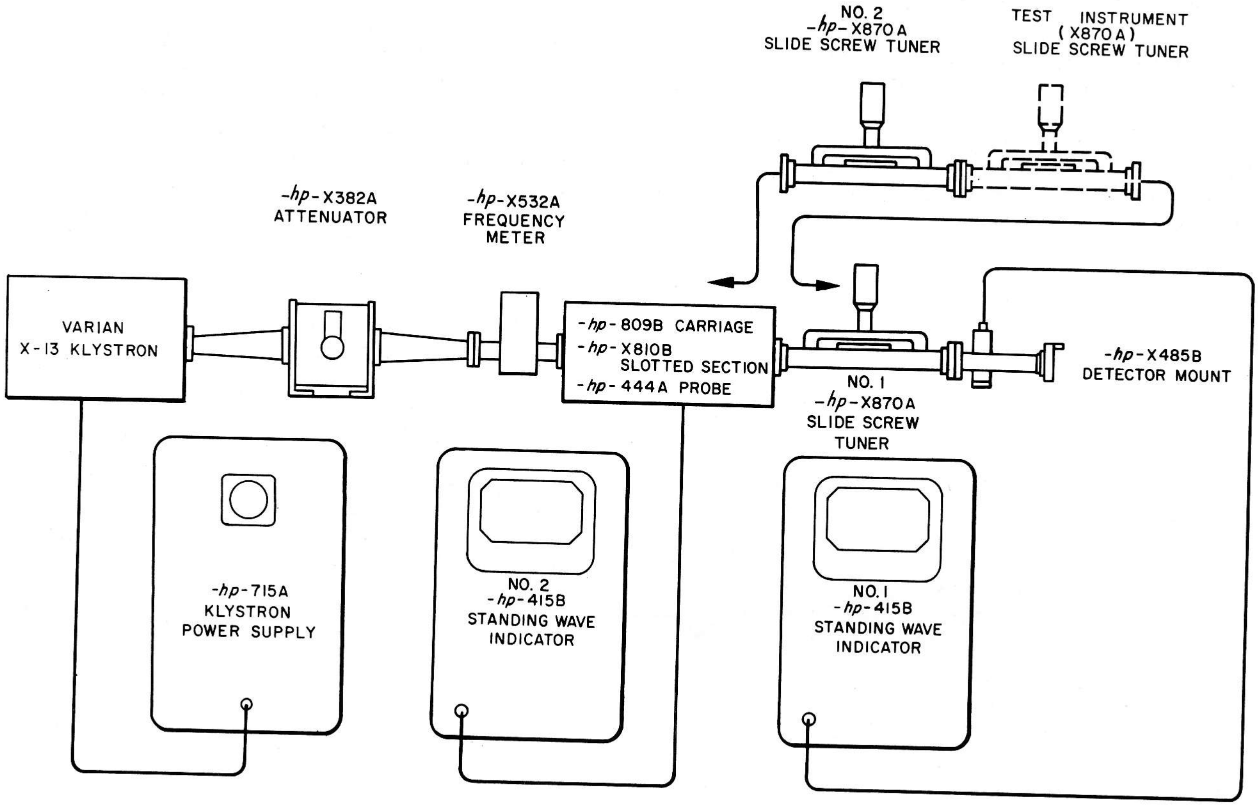

Figure 7-2. Checking X870A Slide Screw Tuner Loss

between the X382A and X-13 to prevent barretter damage.

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11) Adjust the 715A MOD. FREQ. control for a maximum deflection on the No. 1 415B meter, adjusting the X382A as necessary.

12) Adjust the 715A REFLECTOR VOLTS and MOD. VOLT. controls for a maximum deflection on the No. 1 415B, adjusting the X382A as necessary.

NOTE

An oscilloscope and a detector mount equipped with a crystal provide a convenient method of monitoring the klystron for optimum operation. Adjust the Klystron Power Supply REFLECTOR VOLTS and MOD. VOLT. controls so that a clean square wave of maximum amplitude appears on the oscilloscope.

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13) Check the klystron frequency by adjusting the X532A Frequency Meter until a dip occurs on the No. 1 415B meter. Adjust the klystron as necessary. Read the frequency and then adjust the X532A off resonance.

14) Withdraw the probe of the No. 1 calibrating X870A Slide Screw Tuner. Tune the X485B for maximum indication on the No. 1 415B. Then tune the No. 1 calibrating X870A for maximum indication.

15) Set the No. 2 415B RANGE switch for an upscale reading. Slide the 809B Probe Carriage over the slotted line. The No. 1 415B meter pointer should not fluctuate more than 1%. If it does, reduce the probe penetration. Note the position of the carriage.

16) Adjust the GAIN control for a 0 db reading on the No. 1 415B. If necessary adjust the X382A.

17) Insert the X870A under test and the No. 2 calibrating X870A between the No. 1 calibrating X870A Slide Screw Tuner and the Slotted Line.

18) Tune No. 2 calibrating X870A for a maximum deflection on the No. 1 415B meter.

19) Slide the Slotted Line probe carriage for a maximum deflection on the No. 2 415B. Adjust the No. 2 415B RANGE and GAIN controls for a full scale reading ("1" on the EXPANDED SWR scale).

20) Slide the probe carriage for a minimum No. 2 415B deflection. Adjust the No. 2 calibrating X870A Slide Screw Tuner for a SWR less than 1.01. Return the probe carriage to the position in step 16.

21) Read the No. 1 415B. This is the attenuation of the X870A under test and the No. 2 calibrating X870A Slide Screw Tuner. The loss of the X870A under test is approximately one-half of the measured attenuation.

22) Repeat the measurement for SWR's of the X870A under test of 1.3, 1.5, 2.0, 3.0. Plot the loss versus SWR for the X870A under test at 10.3 kmc. If desired, it may be repeated at other frequencies. Graphs of tuner loss are useful for correcting power measurements.

SECTION VIII
415B STANDING WAVE INDICATOR

8-1 SPECIFICATIONS

Frequency:	1000 cps ±2%
Sensitivity:	0.1 microvolts at the 200 -ohm level for full scale deflection.
Calibration:	Square law. The meter has both SWR and db scales.
Range:	70 db. Input attenuator provides 60 db in 10-db steps.
Accuracy:	±0.1 db per 10-db step. Cumulative error ±0.2 db maximum.
Input:	"BOLO" 200 ohms. Bias provided for 8.4-ma bolometer or 1/100 amp fuse; or 4.3-ma low-current bolometer.
	"CRYSTAL" 200 ohms for the crystal rectifier, and 200,000 ohms for the crystal rectifier as null indicator.

8-2 POWER SUPPLY CHECK

1) Remove the cabinet from the 415B. Connect the 415B to a 115 volt ac power source. Turn on the instrument and allow it to warm up for 15 minutes.

2) Connect the 410B Voltmeter between the cathode (pin 3) of the series regulator tube V5 and chassis ground.

3) Adjust control R45 for a voltmeter reading of 245 volts dc with the line voltage at 115 volts.

4) Vary the line voltage from 103 to 127 volts with the autotransformer. The voltmeter reading should not vary more than ±1%.

5) Replace the cabinet.

8-3 MECHANICAL ZERO SET

1) Turn on the 415B. When the meter movement reaches the ambient temperature within the cabinet, turn off the 415B.

2) Rotate the mechanical zero-adjusting screw on the meter clockwise until the meter pointer is moving to the left toward 1.3 on the EXPANDED SWR scale. Stop at 1.3. If the pointer passes 1.3, rotate the adjustment screw clockwise and re-approach from the high side of the scale. Do not turn the adjustment screw counterclockwise.

8-4 SENSITIVITY CALIBRATION

1) Connect the equipment as shown in Figure 8-1.

2) 415B Control Settings:
   METER SCALE switch to NORMAL.
   GAIN control to maximum.
   RANGE switch to 0 db.
   INPUT SELECTOR switch to CRYSTAL 200KΩ.

3) 205AG Signal Generator Control Settings:
   FREQ. RANGE switch to X10.
   Frequency dial to 100.
   Attenuators to 0.
   IMPEDANCE control to 600.
   AMP control to 0.

4) Set the 400H Voltmeter range switch to 0.3 volts.

5) Turn on all the equipment and allow it to warm up for 15 minutes.

6) Adjust the 205AG Signal Generator output and the RT-5 Ratio Transformer for a deflection on the 415B meter.

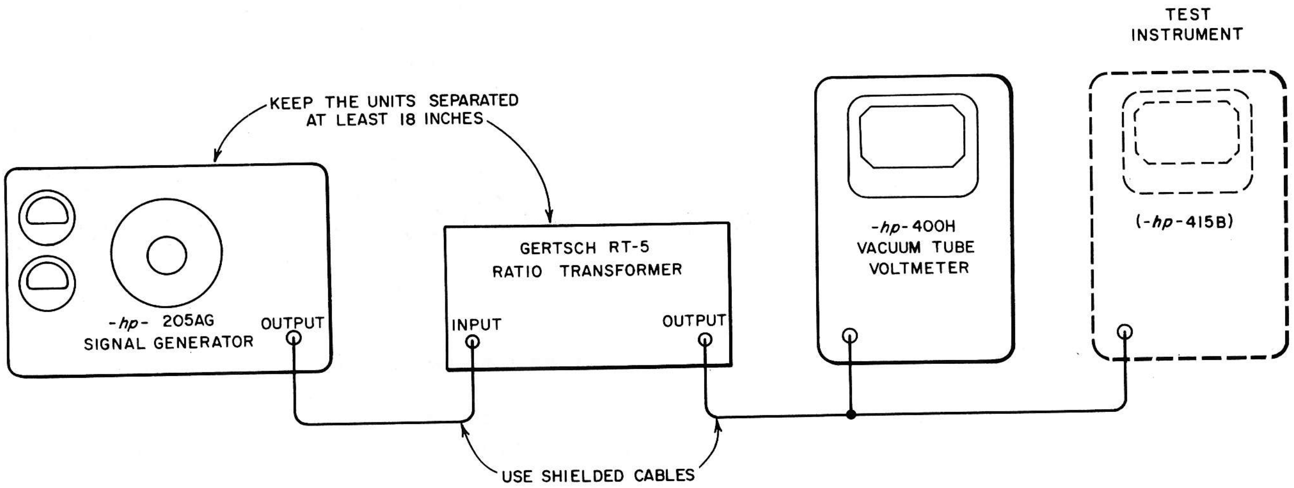

Figure 8-1. 415B Standing Wave Indicator Sensitivity, Ranging, and Tracking Calibration

7) Adjust the 205AG frequency dial for maximum meter deflection. Adjust the 205AG output for full-scale deflection and record the indication on the 400H Voltmeter.

If the input voltage for full-scale deflection is greater than 0.2 volts, the 415B should be submitted to maintenance personnel.

8-5 RANGE SWITCH CALIBRATION

1) Use the equipment setup shown in Figure 8-1, but omit the 400H Voltmeter.

2) 415B Control Settings:
   METER SCALE switch to EXPAND.
   RANGE switch to 30.
   INPUT SELECTOR switch to CRYSTAL 200Ω.
   GAIN control to maximum gain.

3) Set the RT-5 Ratio Transformer to 0.0001.

4) Set the 205AG Signal Generator output for full-scale meter deflection.

5) Adjust the 415B gain for a reading exactly 0.1 db below full scale.

6) Adjust the 415B RANGE switch to 20 and the RT-5 to 0.001. Record the deviation from 0.1 db.

7) Reset the RANGE switch to 30 and the RT-5 to 0.0001. Check the initial meter settings.

8) Repeat the measurements until consistent readings are obtained. Record the error in db.

NOTE

A meter deflection to the left of the nominal reading is recorded as a positive quantity, to the right as a negative quantity. For example, when switching the RANGE switch from 30 to 20 and the RT-5 from 0.0001 to 0.001 the meter deviates 0.1 db to the left of reference. Hence the meter reading is 20.1 db or an error of +0.1 db.

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9) Repeat the measurements for the 415B, switching from the 30 to the 10 and 0 ranges. The 415B and RT-5 Ratio Transformer settings are shown in Table 8-1.

TABLE 8-1. INSTRUMENT SETTINGS FOR 415B RANGE SWITCH CALIBRATION (I)

415B RANGE Setting	RT-5 Ratio Transformer Setting	Error of Reading in db
30	0.0001	0
20	0.0010	
10	0.0100	
0	0.1000	

10) To calibrate the RANGE switch above 30 db, set the 205AG attenuators to 60 db.

11) Determine the errors in the 40- and 50-db steps using the procedure described above and the instrument control settings in Table 8-2.

TABLE 8-2. INSTRUMENT SETTINGS FOR 415B RANGE SWITCH CALIBRATION (II)

415B RANGE Setting	RT-5 Ratio Transformer Setting	Error of Reading in db
30	0.100	0
40	0.010	
50	0.001	

12) To minimize the effects of noise on the 60-db RANGE switch setting, reduce the 415B gain and increase the input signal. Set the 415B RANGE switch to 50 and the RT-5 to 0.01. Adjust the 415B GAIN control to the 0.1-db mark.

13) Adjust the 415B to 60 and the RT-5 to 0.001. Determine the error on the 60-db range relative to that on the 50-db range. Add the error on the 60-db range to that on the 50-db range and record.

8-6 TRACKING CALIBRATION

1) Connect the equipment as shown in Figure 8-1 but omit the 400H Voltmeter.

2) 415B Control Settings:
   METER SCALE switch to EXPAND.
   RANGE switch to 30.
   GAIN control to maximum gain.

3) Set the RT-5 to 0.1.

4) Set the 205AG output for full-scale meter indication.

5) Adjust the RT-5 to the readings in Table 8-3 and record the errors. If the errors exceed 0.02 db, remove the cabinet and adjust R33. Repeat the measurements until the readings are within specifications.

TABLE 8-3. EXPANDED DB SCALE TRACKING CALIBRATION

RT-5 Ratio Transformer Setting	415B Reading in db	Error in db
0.0891	0.5	
0.0794	1.0	
0.0708	1.5	
0.0631	2.0	

6) Set the 415B METER SCALE switch to NORMAL.

7) Set the RT-5 to 0.1.

8) Set the 205AG output for full-scale meter deflection.

9) Adjust the RT-5 to the readings in Table 8-4 and record the errors.

TABLE 8-4. NORMAL DB SCALE TRACKING CALIBRATION

RT-5 Ratio Transformer Setting	415B Reading in db	Error in db
0.0794	1	
0.0631	2	
0.0501	3	
0.0316	5	
0.0100	10	

10) To check the 415B -5db switch, adjust the METER SCALE switch to -5db and the RT-5 to 0.0316. Adjust the 205AG for a full scale deflection. Set the METER SCALE switch to NORMAL and the RT-5 to 0.1. The 415B should again read full scale. Any deviation indicates error.

SECTION IX
430C POWER METER

9-1 SPECIFICATIONS

Power Ranges:	5 ranges. Full scale readings of 0.1, 0.3, 1, 3, and 10 mw. Also calibrated in dbm, -20 to +10 dbm.
External Bolometer:	Resistance level of 100 or 200 ohms available. Positive or negative temperature coefficients. DC bias up to 16 ma.
Accuracy:	±5% of full scale reading.

9-2 RAPID CALIBRATION CHECK

The following test may be performed with the 430C in its cabinet. This test is an indication of accurate power measurements on all ranges of the 430C.

1) Connect the equipment as shown in Figure 9-1. (The VTVM must be newly calibrated using either a 100- or 400-cps source with a 0.25% accuracy. The meter must be checked at voltages of 0.2, 0.5, 1, and 3 volts.)

2) 430C Control Settings:
   COEF switch to NEG.
   RES switch to 200.
   BIAS CURRENT switch to OFF.
   ZERO SET controls fully counterclockwise.
   POWER RANGE switch to 10 mw.

3) Connect the equipment to a source of 115V ac power. Turn on the equipment and set the BIAS CURRENT and ZERO SET controls for an up-scale meter indication. Allow the instrument to warm up for 20 minutes.

4) Zero-set the 430C using the BIAS CURRENT and ZERO SET controls. Record the voltage indicated on the 400H VTVM. This voltage must fall within the range indicated in the ZERO SET column in Table 9-1.

5) Set the meter on the 430C to full scale using the BIAS CURRENT and ZERO SET controls. Record the

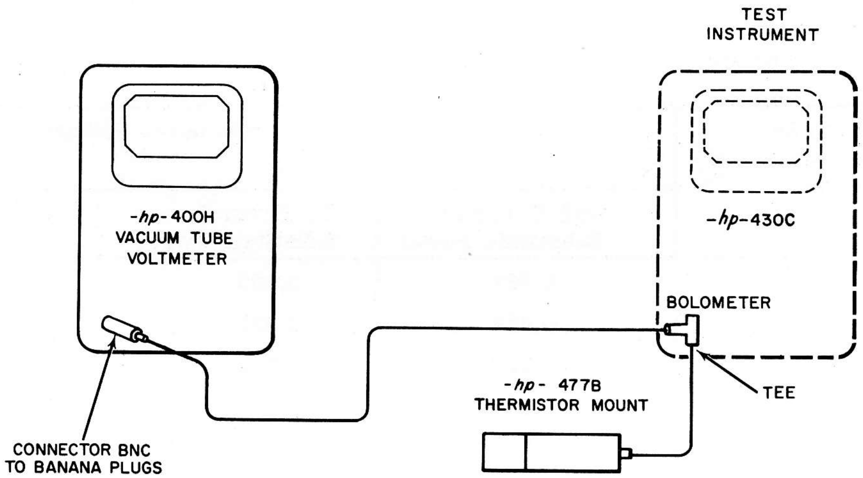

Figure 9-1. Checking Operation of the 430C Power Meter

voltage indicated by the 400H VTVM. This voltage must be within the voltage limits for ±5% error in the measurement of subsitiuted power for the particular zero set voltage condition. The voltages with asterisks indicate the ideal values.

6) If desired, check the other 430C power ranges. Multiply the voltages in Table 9-1 by the following values to obtain the zero-set and full-scale voltages for the remaining ranges.

430C RANGE	Multiplier
3 mv	0.5623
1 mv	0.3162
0.3 mv	0.1778
0.1 mv	0.1000

If the 430C voltages agree with those in the table or the calculated values, the Power Meter is calibrated. If the readings do not check, proceed with the calibration.

7) Turn the BIAS CURRENT switch to OFF and the ZERO SET controls fully counterclockwise before disconnecting the Thermistor Mount.

9-3 POWER SUPPLY CHECK

1) Turn off the 430C.

2) Loosen the two screws at the back of the cabinet and then remove the cabinet. Turn the chassis on its side.

3) 410B Vacuum Tube Voltmeter Control Settings:
SELECTOR switch to +.
RANGE switch to 300V.

4) Turn on the equipment and allow it to warm up.

CAUTION

The 430C contains voltages as high as 250 volts. Use care in handling the chassis.

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5) Set the 430C COEF switch to POS. Do not make any connection to the VOLTMETER jack.

6) Measure the voltage from pin 6 of tube V8 to ground using the 410B Voltmeter DC and COMMON leads. If the voltage is not 250 volts ±3 volts, adjust resistor R75. R75 is found near tubes V9 and V7.

7) Vary the line voltage from 103 to 127 volts. Allow one minute for the voltage to stabilize before measuring the regulated voltage. The voltage should not vary more than ±1%.

9-4 METER MECHANICAL ZERO CALIBRATION

1) Turn the 430C to its proper position.

2) Turn the power on and allow the equipment to warm up to operating temperature. Then turn the power off.

3) Rotate the meter mechanical zero adjusting screw (located below the window on the meter) clockwise until the meter pointer is traveling downscale toward zero and stops at zero. If the pointer goes too far, continue clockwise rotation of the screw until the

TABLE 9-1. POWER METER CALIBRATION VOLTAGES FOR 10 MILLIWATT RANGE

Zero Set Bolometer Voltage	Full Scale Bolometer Voltage		
	-5% Error In Substitute Power	0% Error In Substitute Power	+5% Error In Substitute Power
1.50	0.387	0.500	0.592
1.52	0.459	0.557	0.641
1.54	0.521	0.610	0.687
* 1.55	0.550	* 0.632	0.709
1.56	0.578	0.658	0.730
1.58	0.630	0.705	0.772
1.60	0.678	0.748	0.813

pointer is again traveling downscale and stops exactly on zero.

9-5 VOLTMETER CALIBRATION

1) 430C Control Settings:
   BIAS CURRENT switch to OFF.
   ZERO SET controls fully counterclockwise.
   COEF switch to POS.
   RES switch to 200.
   POWER RANGE switch to 1.0 mw.

2) Connect the equipment as shown in Figure 9-2.

3) Turn on the equipment and allow it to warm up.

4) Adjust the 430C BIAS CURRENT and ZERO SET controls so the 400H VTVM indicates exactly 0.465 volts.

5) The meter on the 430C should now indicate exactly zero. If not, adjust resistor R59.

6) Adjust the BIAS CURRENT and ZERO SET controls for an indication on the 400H VTVM of exactly 0.190 volts.

7) The meter on the 430C should now indicate full scale. If not, adjust resistor R63. Repeat steps 3 through 7 until no further improvement can be made. The 430C is now calibrated. If desired, stability, oscillator frequency, and bolometer bridge resistance checks may be made. The procedure is fully described in the 430C Power Meter Operating Manual. Normally it is not necessary to make these checks unless components have been replaced.

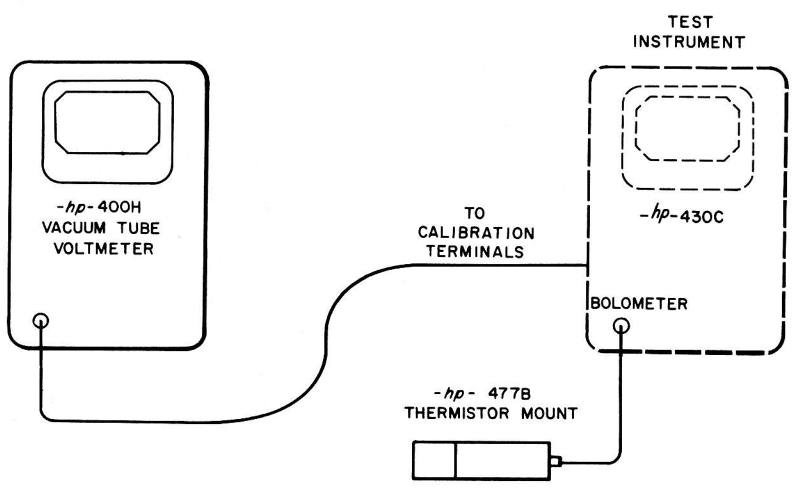

Figure 9-2. 430C Power Meter Calibration.

SECTION X
614A AND 616A SIGNAL GENERATOR

10-1 SPECIFICATIONS

Frequency Range:	614A: 800 to 2100 megacycles. 616A: 1800 to 4000 megacycles.
Frequency Calibration Accuracy:	±1%
Output Range:	1 mw or 0.223 volt to 0.1 μv (0 dbm to -127 dbm) into a 50-ohm load. Directly calibrated in microvolts and decibels; continuously monitored.
Output Accuracy:	614A: within ±1 db from -10 dbm to -127 dbm at the end of a 6-foot output cable terminated in a 50-ohm load. 616A: within ±1.5 db from -7 dbm to -127 dbm at the end of a 6-foot output cable, terminated in a 50-ohm load.
Internal Impedance:	614A: 50 ohms, nominal. SWR less than 1.6. 616A: 50 ohms, nominal. SWR less than 1.8.
Modulation:	Internal or external pulse and internal fm.
Internal Pulse Modulation:	Repetition rate variable from 40 to 4000 pulses per second; pulse length variable from 1 to 10 μsec; delay variable from 3 to 300 μsec (between synchronizing signal and rf pulse).
External Pulse Modulation:	Pulse requirements: Amplitude from 40 to 70 volts positive or negative, width 1.0 μsec (2.0 μsec for 616A) to 2500 μsec. May be square wave modulated.
Trigger Pulses Out:	1. Simultaneous with rf pulse. 2. In advance of rf pulse, variable 3 to 300 μsec. (Both approximately 1.0 μsec rise time, 10 to 50 volts amplitude.)
External Sync Pulse Required For Internal Modulation:	Amplitude from 10 to 50 volts of either positive or negative polarity and 1 to 20 μsec width. May also be synchronized with sine waves.
FM Modulation	Oscillator frequency sweeps at power line frequency. Phasing and sweep range controls provided. Maximum deviation approximately ±5 mc.

10-2 PRELIMINARY NOTES

This procedure describes the calibration of the 614A and 616A Signal Generators. The pulse rate, pulse delay, and pulse width controls very seldom require adjustment and usually only need to be calibrated when tubes are changed.

To remove the signal generator chassis from the case proceed as follows:

1) Place the signal generator on a low surface or the floor with the panel upward.

2) Turn the POWER SET and OUTPUT ATTEN. controls fully counterclockwise. The precaution will prevent damage to the output cable or attenuator.

3) Loosen the eight knurled captive screws around the edge of the front panel and carefully lift the generator out of the case by the guard rail handles.

Replace the case by reversing the above procedure. Be sure that the output cable between the attenuator and the front panel does not catch on the case.

CAUTION

Use care when making tests with the Model 614A or 616A operating with the cover removed. Regulated voltages up to 600 volts are used throughout the circuits of the signal generator.

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10-3 REGULATED POWER SUPPLY CALIBRATION

1) Connect the equipment to a 115V ac power source. Turn on the equipment and allow it to warm up for 10 minutes.

2) Measure the voltage between pin 7 of tube V107 and ground with the 410B Voltmeter. The voltage should be -320 volts.

3) If necessary adjust resistor R152 located on the rear of the instrument chassis for exactly -320 volts.

4) Vary the line voltage from 103 to 127 volts to check the regulation. The power supply voltage should not vary more than ±2 volts.

10-4 KLYSTRON CHECK

1) Connect the 420A Crystal Detector to the Signal Generator RF OUTPUT. Connect the output of the 420A to the oscilloscope vertical input.

2) Signal Generator Control Settings:
ZERO SET control for a zero-set meter reading.
FM-CW-OFF switch to CW.
POWER SET control for a power set reading.
OUTPUT ATTEN. control for 0 dbm.
FM-CW-OFF switch to INT.
PULSE RATE and PULSE WIDTH controls to their maximum positions.

3) Adjust the oscilloscope vertical sensitivity and sweep speed for a good presentation on the screen.

4) Vary the Signal Generator FREQUENCY control over the entire range and observe the pulsed output. The klystron should give pulsed operation over the entire range. If it does not, refer to the manual.

10-5 FREQUENCY DIAL CALIBRATION

1) Connect the equipment as shown in Figure 10-1.

2) Check the 524B or D Electronic Counter thermometer to insure that the output is up to operating temperature. If the 524B power cord has been disconnected for any appreciable amount of time, a three-hour

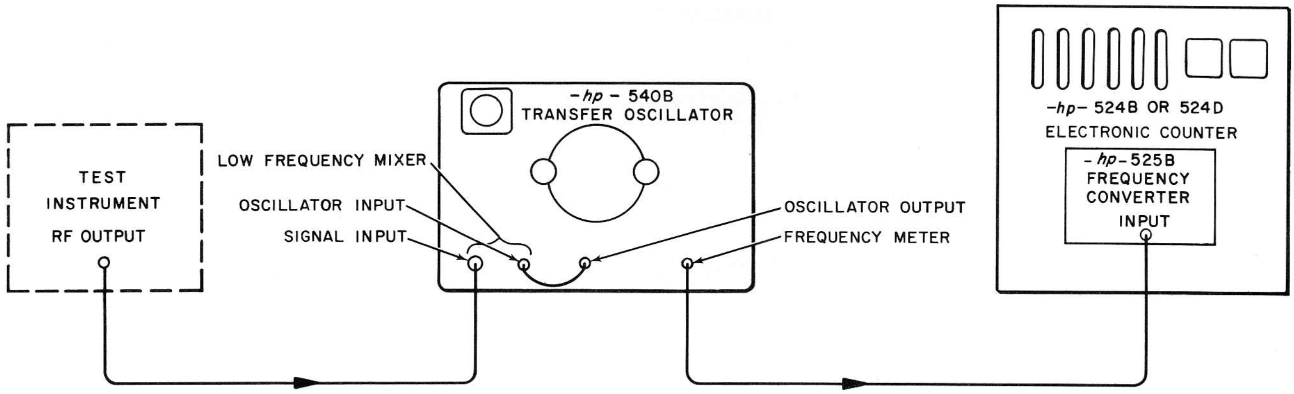

Figure 10-1. Frequency Dial Calibration

warm-up is required with the POWER switch in the STANDBY position.

When the 524B crystal is up to operating temperature, set the Signal Generator, 540B Transfer Oscillator, and the 524B Electronic Counter POWER switches to the ON position and allow the instruments to warm up for at least 15 minutes.

Self-check the 524B Electronic Counter to insure proper operation.

3) Connect the signal from the Signal Generator to the 540B Transfer Oscillator low frequency mixer SIGNAL INPUT jack.

4) Set the 540B VIDEO RESPONSE controls to their maximum clockwise positions.

5) Turn the 540B FINE VERNIER control to the center of its rotation (white dot straight up).

6) Set the 524B Electronic Counter controls as follows:
FUNCTION SELECTOR switch to FREQUENCY.
FREQUENCY UNIT switch to 0.01 seconds.
DISPLAY TIME control fully counterclockwise.

7) Signal Generator Control Settings:
ZERO-SET control for a zero set meter reading with FM-CW-OFF switch set to OFF.
FM-CW-OFF switch to CW.
POWER SET control for a power set reading.
OUTPUT ATTEN. control to -10 dbm.
Frequency control 614A - 2100 mc.
616A - 4000 mc.

8) Tune the 540B Transfer Oscillator COARSE VERNIER tuning control until a response is seen on the oscilloscope screen. Adjust the INTENSITY and FOCUS controls for a clear trace. Tune as close to a zero-beat as is conveniently possible with the COARSE VERNIER control.

NOTE

For more trace resolution, use an external oscilloscope. Connect the vertical input to the 540B Transfer Oscillator VIDEO OUTPUT jack.

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9) With the 540B FINE VERNIER tuning control, reduce the difference-frequency response on the oscilloscope to as close to a zero-beat as the stability of the measured signal will allow. Absolute zero-beat will be obtained when the oscilloscope trace appears as a horizontal line. Various looped-patterns are obtained as the 540B is tuned slightly away from the measured frequency. Any distinct pattern, such as one of those illustrated in the 540B Transfer Oscillator Manual is sufficiently close to zero-beat for most measurements, and is more practical to use than the absolute zero-beat.

10) Measure the fundamental frequency of the mixing signal with the 524B Electronic Counter by first setting the MIXER-DIRECT-WAVEMETER switch to WAVEMETER. Tune the MIXING FREQUENCY SELECTOR control until the tuning eye closes. Set the MIXING FREQUENCY control to the position indicated by the MIXING FREQUENCY SELECTOR dial. Set the MIXER-DIRECT-WAVEMETER switch to MIXER. The fundamental frequency is obtained by adding the reading of the MIXING FREQUENCY control (frequency in mc) to the reading on the display system (frequency in kc). It is also indicated on the 540B Transfer Oscillator tuning dial.

11) Tune the 540B Transfer Oscillator COARSE VERNIER tuning control for an adjacent 540B Transfer Oscillator mixing frequency that produces a zero-beat and measure the fundamental frequency with the 524B Electronic Counter as before. When two adjacent transfer oscillator frequencies produce zero-beats, the harmonic number (N_1) of f_1 can be found by following the formula:

$$N_1 = \frac{f_2}{f_1 - f_2},$$

where N_1 is always a whole number, and f_1 is the larger of the two fundamental frequencies.

The frequency of the Signal Generator is then:

$$f_x = N_1 f_1.$$

12) If it is necessary to adjust the rf output frequency to 2100 (4000 for the 616A) megacycles, loosen one set screw in the frequency drive gear hub behind the front panel. The set screw will be visible when the 614A tuning dial is set to approximately 1800 megacycles or the 616A set to 2700 mc.

13) Set the frequency to exactly 2100 or 4000 mc.

14) Loosen the remaining set screw and while holding the drive shaft stationary in the gear hub with pliers, turn the frequency dial until 2100 or 4000 is under the hairline.

15) Tighten the set screws. Check the frequency dial calibration across the full frequency range and refine the above adjustments as necessary for the desired frequency dial calibration accuracy.

10-6 PULSE RATE CALIBRATION

1) Connect the Signal Generator SYNC OUT connector to the 524B Electronic Counter SIGNAL INPUT jack.

2) Set the 524B Electronic Counter FUNCTION SELECTOR switch to FREQUENCY and the FREQUENCY UNIT control to 10 sec.

3) Signal Generator Control Settings:
FM-CW-OFF switch to INT.
SYNC SELECTOR switch to X10.
PULSE RATE switch to 100.
PULSE DELAY control to its minimum position.

Other controls may be set to any position.

Screwdriver adjustment resistor R107 to its mechanical center of rotation.

Screwdriver adjustment resistor R110 to three-fourths of fully clockwise.

4) Adjust the PULSE RATE control to obtain 1000 pps as read on the counter.

5) Set the SYNC SELECTOR switch to X1. If necessary, adjust resistor R107 to obtain 100 pps on the frequency counter.

6) If necessary, slip the dial on the shaft so that it reads 100.

7) Set the PULSE RATE control to read 400 and the SYNC SELECTOR to X10. Measure the pulse repetition rate. If necessary, adjust resistor R110 to obtain 4000 pps.

8) Recheck the intermediate calibration points and refine the above adjustments for further improvement. The PULSE RATE dial is within calibration if the pulse rate is within ±25% of the indicated pulse rate.

10-7 PULSE DELAY CALIBRATION

1) Connect the Signal Generator SYNC OUT connector to the oscilloscope external sync and the RF OUTPUT to the vertical input through a 420A Crystal Detector.

2) Signal Generator Control Settings:
FM-CW-OFF switch to INT.
SYNC SELECTOR switch to X10.
PULSE RATE switch to 100.
PULSE DELAY control to maximum clockwise position for maximum delay.

Other controls may be set in any position.

3) Oscilloscope Control Settings:
Sync selector to External.
Trigger slope switch to +.

Adjust the vertical sensitivity and sweep speed for a good presentation.

4) Measure the actual pulse delay between the SYNC OUT pulse and the demodulated RF OUTPUT pulse. If necessary, adjust resistor R197 (R188 for 616A) to obtain a maximum pulse delay of between 330 and 350 microseconds.

5) Set the PULSE DELAY control for minimum delay. Measure the actual delay. The minimum delay should be 3 microseconds or less. If it is not, try another tube (6J6) for delay multivibrator tube V104.

6) Set the PULSE DELAY dial to obtain a 50-microsecond delay as read on the calibrated oscilloscope. If necessary, slip the PULSE DELAY dial so that it reads 50.

7) Set the PULSE DELAY dial to 300. Measure the actual pulse delay, and if necessary, adjust resistor R197 (R188 for 616A) to obtain a delay of 300 microseconds. Refine the above adjustments to obtain the best over-all accuracy.

10-8 PULSE WIDTH CALIBRATION

1) Connect the Signal Generator RF OUTPUT to the oscilloscope vertical input through a 420A Crystal Detector.

2) Signal Generator Control Settings:
FM-CW-OFF switch to INT.
SYNC SELECTOR switch to X10.
PULSE RATE switch to 100.
PULSE WIDTH control for maximum pulse width.
SIGNAL FREQUENCY control for a signal frequency which gives an average length output pulse, or where desired.

The remaining controls may be set to any position.

3) Oscilloscope Control Settings:
Sync selector to External.
Trigger slope switch to +.

Adjust the vertical sensitivity and sweep speed for a good presentation.

4) Measure the actual rf pulse width. If necessary, adjust resistor R185 to obtain a maximum pulse width of approximately 14 microseconds.

5) Set the PULSE WIDTH control to obtain a two-microsecond-long rf output pulse as read on oscilloscope. If necessary, slip the PULSE WIDTH dial on its shaft to make it read two microseconds.

6) Set the PULSE WIDTH dial to read 10. If necessary, adjust resistor R185 to obtain a pulse width of 10 microseconds.

7) Check the overall calibration and refine the above adjustments for best overall accuracy or the particular calibration desired.

10-9 POWER MONITOR AND RF OUTPUT ATTENUATOR CALIBRATION

If the power monitor probe or attenuator probe is replaced or repaired, the calibration of the attenuator dial will be affected and it must be recalibrated as instructed below. The main operations are: setting the power monitor probe to the correct depth (not required if power monitor probe is undisturbed); measuring the frequency response of the attenuator and calibrating it.

POWER MONITOR PROBE PENETRATION

1) With the Signal Generator removed from its cabinet and operating on CW, tune across the band and note the frequency which gives the lowest reading on the POWER SET meter. Set the signal generator to this frequency.

2) Set the POWER SET dial for maximum penetration of the power monitor probe. Note the rotational position of the probe so that this position can be maintained while adjusting the depth.

3) Loosen the set screws holding the probe and adjust the depth so that a +2 reading is obtained on the POWER SET meter. Tighten the set screws.

4) Tune the Signal Generator to the rf frequency giving the highest reading on the POWER SET meter. With the POWER SET control turned to minimum, it should now be possible to obtain a reading as low as -2 or -3 db below POWER SET on the meter scale. If it is not possible to obtain such a reading, the power monitor must be carefully withdrawn a very small amount to obtain the best compromise between this reading and the one obtained in step 3. In any compromise of this setting, it must always be possible to obtain a reading at POWER SET on the meter at any rf output frequency.

ATTENUATOR CALIBRATION

1) Connect the equipment as shown in Figure 10-2.

2) Signal Generator Control Settings:
FM-CW-OFF switch to OFF.
FREQUENCY control to 800 mc for 614A and 1800 mc for 616A.

3) 430C Power Meter Control Settings:
BIAS CURRENT control to OFF.
COARSE and FINE controls fully counterclockwise.
RES switch to 200.
COEF switch to NEG.
POWER RANGE switch to 0.1 mw for 614A, 0.3 mw for 616A.

4) Connect the 430C Power Meter to a 115V ac, 50/1000-cps power source. Turn on the Power Meter and allow it to warm up for 15 minutes.

5) Set the BIAS CURRENT switch to the first step of the 10-16 MA position.

6) Rotate the ZERO SET controls clockwise. If the pointer goes off-scale at the high end or moves to a position on-scale, zero-set the meter with the ZERO SET control.

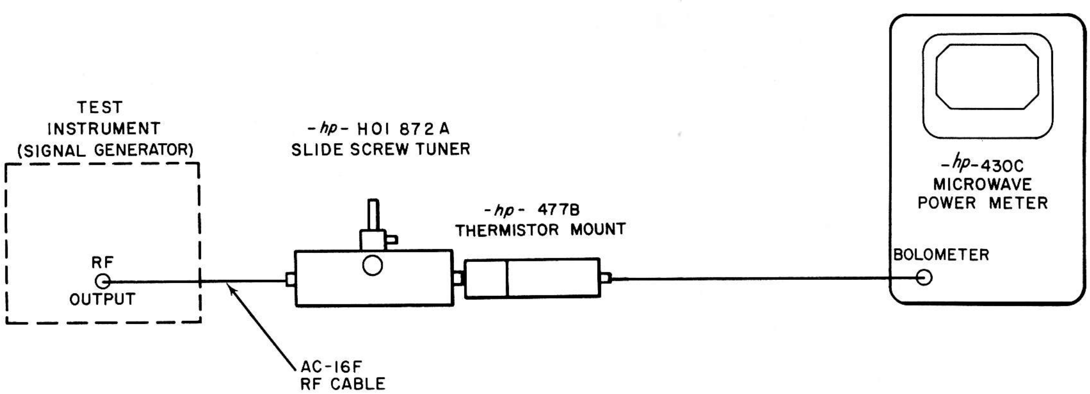

Figure 10-2. Signal Generator Attenuator Calibration

If the pointer rests off-scale at the low end, return the ZERO SET controls to the fully counterclockwise position. Increase the BIAS CURRENT switch setting one step at a time and attempt to zero the meter. Always return the ZERO SET controls to the fully counterclockwise position (minimum bias) before advancing the BIAS CURRENT switch to the next higher position. Do not go beyond the setting which corresponds to the maximum current for the bolometer in use.

7) Adjust the ZERO SET control for a zero-set on the POWER SET meter. Then set the CW-FM-OFF switch to CW and adjust the POWER SET control to obtain a reading at SET LEVEL on the POWER SET meter.

Tune the H01 872A Slide Screw Tuner for maximum power and set the output attenuator to obtain a reading of -11 dbm for the 614A and -7 dbm for the 616A on the external power meter. Note the attenuator dial indication. This attenuator reading must be used for all the power measurements made at the remaining frequencies.

8) Repeat the above power measurement at each 200-megacycle interval over the full frequency range of the generator. Record the power reading made at each frequency on a graph, so that a frequency response curve of the Signal Generator is obtained.

9) Determine the power level and the rf output frequency at the mid-power point in the frequency response curve thus obtained. Tune the Signal Generator to this frequency.

10) At this frequency adjust the attenuator probe penetration to make the actual power reading on the external power meter and the attenuator dial calibration agree. To adjust the probe penetration, loosen the set screws in the collar and move the probe for the proper attenuation. If the attenuator dial is not more than 1 db out of calibration, the dial may be shifted on the shaft. To calibrate the dial by shifting it, remove the center cover on the attenuator dial. Loosen the two set screws in the collar holding the attenuator dial and slip the dial until the -11 dbm or -7 dbm mark on the dial is under the index line. This adjustment must be made without moving the attenuator plunger. Tighten both set screws. Replace the dial cover and check that the power meter indicates -11 dbm or -7 dbm when the attenuator dial is set to -11 dbm or -7 dbm.

CAUTION

The power set and output attenuator drive systems are spring-loaded and work on a common fixed shaft that protrudes through the attenuator dial. The center cover on the attenuator dial is held by a single screw into the end of the fixed shaft. The spring loading might be accidentally lost if the attenuator dial or ring around the dial is pulled away from the panel while the screw for the dial cover is removed.

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10-10 EXTERNAL MODULATION CHECK

1) Connect the Signal Generator RF output to the oscilloscope vertical input through a 420 Crystal Detector. Connect the Signal Generator EXT. MOD. connector to the 211A Square Wave Generator output.

2) Signal Generator Control Settings:
FM-CW-OFF switch to EXT. POS.
OUTPUT ATTEN. switch to -10 dbm.
FREQUENCY control to any setting.

3) 211A Square Wave Generator Control Settings:
AMPLITUDE control to maximum.
Frequency control to any setting above 200 cps.

4) Oscilloscope Control Settings:
Sync selector to internal.
Trigger slope to +.

Adjust the vertical sensitivity and a sweep speed for a good presentation.

5) Observe the output waveform on the oscilloscope. Switch to FM-CW-OFF switch to EXT. NEG. and check the output waveform.

SECTION XI
715A KLYSTRON POWER SUPPLY

11-1 SPECIFICATIONS

Supply No. 1 (Beam Supply):	Voltage range, -250 to -400 volts; maximum current, 30 ma at 250 volts, and 50 ma at 400 volts; regulation, less than 1% change from no load to full load or for line voltage variations of 115 volts ±10%; ripple, less than 7 mv; calibrated voltage controls provided.
Supply No. 2 (Reflector Supply):	Voltage range, 0 to -900 volts with respect to supply No. 1; maximum current, 10 μa; regulation, within 1% for line voltages of 115 volts ±10% for fixed currents; ripple, less than 10 mv; calibrated voltage controls provided.
Filament Supply:	1.5 amperes at 6.3V ac.
Modulation (Supply No. 2):	Square-wave modulation: amplitude, 0 to 120 volts peak-to-peak; rise and decay time, less than 10 microseconds; frequency, 900 to 1100 cps. Sinusoidal modulation: frequency, 60 cps; amplitude, 350 volts peak-to-peak. External modulation: input impedance, 100,000 ohms.

CAUTION

Because of the high voltage on the output terminals, make all connections before turning on the 715A Klystron Power Supply.

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11-2 BEAM VOLTAGE SUPPLY CALIBRATION

1) Connect the 410B Voltmeter common lead to the 715A ground and the DC probe to the C terminal.

2) Set the 410B Voltmeter SELECTOR switch to "-" and the RANGE switch to 1000V.

3) Set the MOD. SELECTOR and REFLECTOR RANGE switches to OFF.

4) Connect the instruments to a 115V ac power source. Turn on the equipment and allow it to warm up for five minutes.

5) Switch the MOD. SELECTOR switch to CW and the REFLECTOR RANGE switch to 0-300. Turn the BEAM VOLTS dial from one stop to the other. The voltage range should be at least from -250 to -400 volts. Compare the dial reading with the 410B Voltmeter reading and loosen the screws and slip the dial, if necessary, until they coincide.

6) Vary the line voltage with the autotransformer from 103 to 127 volts to check regulation. The maximum beam voltage variation should be less than 1% for ±10% changes in line voltage (115 volts nominal).

11-3 REFLECTOR VOLTAGE SUPPLY CALIBRATION

1) Connect the 410B Voltmeter common lead to the 715A C terminal and the DC probe to the R terminal.

2) Set the 410B Voltmeter SELECTOR switch to "-" and the RANGE switch to 1000V.

3) Turn the MOD. SELECTOR switch to CW and the REFLECTOR RANGE to 0-300. Turn the REFLECTOR VOLTS dial from one stop to the other and note the readings. Repeat for the 300-600 and 600-900 ranges. If consistent errors exist, loosen the dial screws and slip the dial to complete the calibration.

4) Set the MOD. SELECTOR and REFLECTOR RANGE switches to OFF.

5) Vary the line voltage with the autotransformer from 103 to 127 volts to check regulation. The maximum reflector voltage variation should be less than 1% for ±10% changes in line voltage (115 volts nominal).

11-4 MODULATION CHECK

1) Connect the 524B Electronic Counter SIGNAL INPUT jack to the 715A ground and R terminal.

2) 715A Control Settings:
   REFLECTOR VOLTS control to minimum.
   BEAM VOLTS control to minimum.
   MOD. SELECTOR switch to 1000∿ .
   REFLECTOR RANGE switch to 0-300.

3) 524B Electronic Counter Control Settings:
   FUNCTION SELECTOR switch to FREQUENCY.
   FREQUENCY UNIT control to 1 sec.
   DISPLAY TIME control fully counterclockwise.
   MIXER-DIRECT-WAVEMETER switch to DIRECT.

4) Adjust the MOD. FREQ. control to measure minimum and maximum frequencies. The frequency should be variable from 900 to 1100 cps.

5) Connect an oscilloscope to the same terminals and adjust the oscilloscope controls for a presentation on the screen. The AMPLITUDE control should provide a 110-volt peak-to-peak wave. Measure the rise and decay times. They should be no greater than 10 microseconds.

6) Switch the 715A MOD. SELECTOR control to 60∿ modulation. The AMPLITUDE control should provide at least 350 volts peak-to-peak.

7) With the MOD. SELECTOR in the 60∿ position, adjust the oscilloscope sweep speed so that one cycle completely fills 10 centimeters of the screen. Varying the PHASE control should move the trace about 1.5 centimeters.

SECTION XII
540B TRANSFER OSCILLATOR

12-1 SPECIFICATIONS

GENERAL:

Frequency Range:	10 mc to at least 12.4 kmc.
Type of Input Signal:	CW, AM, FM, or pulse.
Input Signal Level:	Maximum, +20 dbm. Mimimum, depends on the mixer and frequency.
Accuracy:	CW, approximately one in 10^7 or better for stable signal. Depends on the character of the unknown signal, the accuracy of comparison, and the accuracy with which the fundamental is measured. See the discussion in the Microwave Standards Techniques Application Note.

OSCILLATOR:

Fundamental Frequency Range:	100 mc to 220 mc.
Harmonic Frequency Range:	Above 12.4 kmc.
Stability:	Less than 0.002% change per minute after a thirty-minute warm-up period.
Dial Accuracy:	±0.5%.
Output:	Approximately 2 volts into 50 ohms. Adjusted for optimum crystal harmonic generation.

AMPLIFIER:

Gain:	Adjustable to 40 db maximum.
Bandwidth:	100 cycles to 2 megacycles.
High Frequency Control:	3-db point adjustable from below 1 kc to above 2 mc.
Low Frequency Control:	3-db point switched from 100 cycles to below 10 kc, then continuously adjustable to above 400 kc.
Maximum Undistorted Output:	1 volt rms usable signal across 1000 ohm load.

OSCILLOSCOPE:

Frequency Range:	100 cps to 200 kc.
Vertical Deflection Sensitivity:	5 mv rms per inch.
Horizontal Sweep:	External, 1 volt per inch, 20 cps to 5 kc. Internal, power supply frequency with phase control.

12-2 PRELIMINARY NOTES

To remove the 540B from the cabinet, place the instrument on its back to gain access to the bottom. Loosen the two large slotted set screws, one on each side of the bottom, toward the front of the panel. Withdraw these screws about one-quarter inch. The front panel and chassis are now free and the cabinet can be lifted off.

The High Frequency Mixer contains a high-pass filter. The shunt inductor of this filter is made of a piece of copper wire 0.001 inch in diameter. DO NOT CHECK THIS CIRCUIT WITH AN OHMMETER as excessive current flow will cause the wire to burn out. The inductor is not field-replaceable.

Check the tubes before changing the setting of any internal control. Adjustments made in an attempt to compensate for defective tubes or circuit components will often complicate a calibration problem.

MAKE ADJUSTMENTS ONLY IF THE RESULTS OF THE TEST ARE NOT WITHIN THE LIMITS GIVEN.

12-3 POWER SUPPLY CHECK

Check the setting of the power supply voltages. DO NOT ADJUST THESE IN ORDER TO REFINE THE SETTINGS UNLESS THE VOLTAGE IS COMPLETLY OUTSIDE THE RANGE OF SPECIFICATIONS.

1) To check the regulated +225-volt supply, connect the reference DC voltmeter to the small red lead on the left-hand resistor board at the rear of the instrument.

2) This voltage should read +225 (±9) volts with a 115V ac power input. Adjust resistor R73 if the voltage exceeds these specifications. If the voltage cannot be adjusted, consult the manual.

NOTE

Re-set the filament oscillator voltage whenever the +225-volt supply is adjusted.

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3) Check the operation of the regulated +225 volt supply by varying the line voltage from 103 to 127 volts with an autotransformer. If the voltage varies appreciably, check the regulator tubes.

4) To check the oscillator voltage, connect a Model 400H Voltmeter to the pink lead on the top of the oscillator housing.

5) The oscillator voltage should be between 5.4 and 6.0 volts. If this voltage is not within these limits, set variable resistor R55 to obtain a reading of 5.8 volts. If the voltage cannot be adjusted within limits, consult the manual.

6) Check the unregulated +330-volt supply with a dc voltmeter. The +330-volt output is found on the violet wire on the right-hand terminal board at the rear of the instrument. It should be checked whenever both the output of the regulated +225-volt supply and the plate voltage on V6 and V8 are low. The +330-volt output varies with the line voltage and is nominally 330 volts when the line voltage is 115 volts.

7) The unregulated -730-volt supply funrishes high voltage for the oscilloscope. Check this voltage whenever difficulty is encountered with the intensity of the trace on the screen. It may be measured on the large red wire on the left-hand terminal board at the rear of the instrument. The output of this supply varies with the line voltage and is nominally -730 volts with a line voltage of 115 volts. If the output is too low, consult the manual.

12-4 TUNING DIAL CALIBRATION

1) Measure the terminated output of the oscillator. To perform this measurement, plug one end of the 455A Coaxial "T" Connector (equipped with Type-N-to-BNC adapters) into the OSCILLATOR OUTPUT jack and terminate the other end with an AC-67A 50-ohm termination. Unscrew the cap on the end of 410B Voltmeter AC Probe and plug it into the 455A Coaxial "T" Connector. Measure the voltage over the band. This voltage should range from approximately 1.75V at 100 mc, to 2.2V at 200 mc. If the voltage is less than 2.0 volts at its highest point, adjust trimmer capacitors C3 and C28, on the top of the rf housing, for maximum

2) To measure the frequency of the 540B Oscillator, connect the front panel FREQUENCY METER jack to the 525B Frequency Converter input. Check the overall frequency range of the oscillator. It should be 100 to 220 megacycles. Check the frequency at 100 mc. If the dial is out of specifications, loosen the dial screws and slip the dial to the correct position.

3) Set the main tuning dial to 200 megacycles and note the frequency indication on the 524D Electronic Counter. If the frequency is not 200 megacycles, readjust capacitors C3 and C28 to bring the frequency to 200 megacycles. Check the voltage output to make sure that it is maximum. Remove the rubber caps from the capacitors to make the adjustment.

In addition to tuning the total capacitance value, the proportion of capacitance between the two capacitors must be balanced for maximum output. After tuning the capacitors, de-tune one capacitor and retune with the other while noting the output. Continue this procedure until maximum output is obtained. When this point is reached, de-tuning either capacitor and retuning with the other will cause the output to go down. The capacitance balancing is very broad. If the condenser studs are preset to protrude 11/16 inch from the casting they will probably be close enough. Be sure to retune as the final step.

4) Check the dial position at 100 mc. Repeat steps 2 and 3 for further refinement.

12-5 OSCILLOSCOPE CALIBRATION

1) Adjust the horizontal position of the trace on the front panel oscilloscope to center with the Horizontal Position control (R32).

2) Adjust the vertical position of the trace to center with the Vertical Position control (R34).

12-6 SENSITIVITY CALIBRATION

The sensitivity of the instrument is the minimum input signal level which will give a mixer output equal to twice the output obtained with no input signal (noise), i.e., the signal that will give an output 6 db above noise level.

1) To measure the sensitivity, set all VIDEO RESPONSE controls fully clockwise.

2) Connect the OSCILLATOR OUTPUT to the OSCILLATOR INPUT of the mixer covering the frequency being measured.

3) Connect the 400H Voltmeter to the VIDEO OUTPUT jack and measure the noise. It should be less than 0.1 volt. If the noise level is greater than 0.1 volt, change crystals.

4) Connect a signal generator to the SIGNAL INPUT jack of the mixer being used. Adjust the output of the signal generator until the reading on the 400H Voltmeter is twice that noted in step 3. This is the sensitivity of the mixer at that frequency. Typical sensitivities of the mixers are shown in the manual. Actual sensitivity at a particular frequency may be better or worse than the average value shown. Variations of ±10 db from the curves may occur at particular frequencies. If greater sensitivity is needed, replace the crystals in the mixers as instructed in the drawings in the 540B manual.

SECTION XIII
202A LOW FREQUENCY FUNCTION GENERATOR

13-1 SPECIFICATIONS

Frequency Range:	0.008 to 1200 cps in five decade ranges.
Dial Accuracy:	Within ±2% at a dial setting between "1.2" and "12", and ±3% at a dial setting between "0.8" and "1.2".
Frequency Stability:	Within ±1%.
Output Waveforms:	Sinusoidal, square, or triangular.
Maximum Output Voltage:	At least 30 volts peak-to-peak across a rated load (4000 ohms) for all three waveforms. 10.6 volts rms for sine wave.
Frequency Response:	Constant within ±0.2 db over the entire frequency range at a rated output and load.
Internal Impedance:	Approximately 40 ohms over the entire range.
Sine Wave Distortion:	Less than 1% on all ranges except X100. Less than 2% rms on X100.
Output System:	Balanced or single-ended.
Sync Pulse:	10 volts peak, negative, less than 5 microseconds duration. The sync pulse occurs at the crest of the sine wave, with corresponding positions on the other waveforms.

13-2 PRELIMINARY CALIBRATION

1) Use the 410B Voltmeter to measure the resistance between the inner and outer chassis of the 202A with the OUTPUT terminals disconnected from panel ground or a load. The resistance should be at least two megohms.

2) Connect the shorting strap between the lower output terminal and chassis ground. Connect the 410B Voltmeter between the negative side of the power supply (hereafter called B-) and the inner chassis. The voltmeter must not be grounded, so isolate the chassis from the power line ground with a power plug adapter. The common terminal should be connected to B-.

3) Connect the 202A to a 115V ac power source and turn it on. The 410B Voltmeter should indicate between +190 and +230 volts with the line voltage at 115 volts.

4) Measure the regulated output voltage between B- and pin 2 of tube V5. Adjust resistor R11 to give a voltage of +225 volts.

5) Measure the voltage between pin 5 of tube V5 and B-. This voltage should be about +375 volts. Variations of type 0A3 tubes can cause this voltage to vary from 365 to 393 volts.

6) Measure the voltage between pin 5 of tube V6 and B-. This voltage should be about +75 volts. Variations in 0A3 tubes can cause this voltage to vary from 68 to 85 volts.

7) Repeat step 4 if either tube V5 or V6 is replaced. Cold-cathode regulator tubes drift during the first 72 hours or so of operation. This drift can affect the 202A Function Generator output. A 72-hour aging period is recommended when either V5 or V6 is replaced with a new tube.

8) Test the regulated output voltage at pin 5 of tube V5 while varying line voltage between 103 and 127 volts with an autotransformer. The regulated voltage

will normally not change by more than ±1%. Check power supply tubes if the change is excessive.

13-3 DC BALANCE AND DISTORTION CALIBRATION

The Model 410B Voltmeter used in this procedure must not be grounded, since the common side of the meter is connected to voltages within the 202A that are not at ground potential. A warm up period of at least 30 minutes (preferably one hour) is recommeded before starting this procedure. Do not turn the instrument off during the procedure; otherwise, an additional warmup period is required. Since many of these controls are interacting, rapid adjustment of the controls is necessary.

1) Connect the 410B Voltmeter between B- and the center arm of R118. Adjust R118 for a reading of 170 volts.

2) Connect the equipment as shown in Figure 13-1.

3) Set the FREQUENCY dial to 10, the RANGE switch to X10 (100 cps), the FUNCTION selector switch to SINE, and the AMPLITUDE control for an output of approximately 10 volts rms.

4) Adjust resistors R49 and R51 to eliminate the points or spikes at the ends of the oscilloscope pattern. Adjustment of these controls will vary the output frequency. Follow the frequency variation with the 330B Distortion Analyzer. Adjust the 330B Distortion Analyzer sensitivity as necessary to obtain a useful pattern on the oscilloscope.

5) Adjust resistor R60 for minimum distortion as indicated on the 330B Distortion Analyzer.

6) Set the FREQUENCY dial to 1 and the RANGE switch to X100 (100 cps). Adjust R119 for minimum distortion. Repeat the procedure in steps 4, 5, and 6 until the distortion measured is at least 40 db below the output voltage (1%).

7) Adjust the insulated 410B Voltmeter to indicate 0.5 on the 1-volt scale with the dc voltmeter leads shorted. Use either the "+" or the "-" position of the SELECTOR switch, whichever permits the 0.5 setting with the ZERO ADJ. control. This meter indication will be called "0 volt" in the remaining portion of the DC balance adjustment.

8) Connect the COMMON lead from the voltmeter to the common junction of AMPLITUDE control resistors R93A and R93B (violet wire).

9) Connect the DC volts probe to the opposite end of resistor R93A or R93B. This is the outside slate wire connected to the AMPLITUDE control.

10) Set the FUNCTION switch to TRIANGULAR and adjust resistor R54 for a voltmeter indication of "0 volt". Adjust as closely as possible.

11) Connect the DC volts probe to the opposite end of resistor R93B or R93A. This is a green wire connected to the AMPLITUDE control.

12) Adjust the FUNCTION selector switch to TRIANGULAR and note the voltmeter indication (0.5 on the 0-1 scale is "0 volt"). Adjust resistor R49 to reduce the dc voltage to one-half of its initial value. Adjust resistor R51 to remove the remaining dc voltage. The voltmeter should now indicate "0 volt".

13) Connect the 410B Voltmeter to the output terminals. With the AMPLITUDE control in the minimum position, adjust resistor R65, located behind a hole in the panel near the OUTPUT terminals, for an indication of "0 volt". Adjust as closely as possible.

14) Set the AMPLITUDE control to the maximum position and note any dc output voltage.

15) Set the FUNCTION selector to SINE and adjust R118 for the same dc output voltage as in step 14.

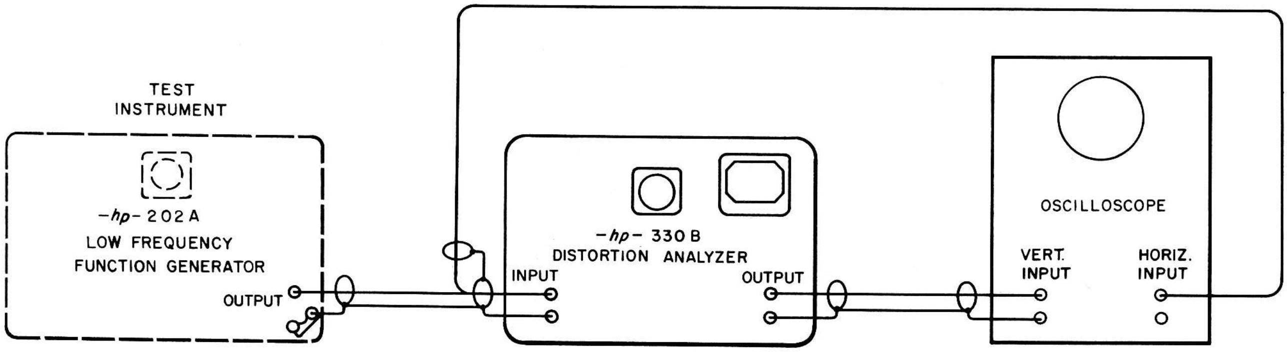

Figure 13-1. Mimimum Distortion and Frequency Adjustment Instrumentation

16) Set the FUNCTION selector to SQUARE and adjust R22 for the same dc output voltage as in step 14.

17) Connect a 4000-ohm load across the output. Vary the AMPLITUDE control from minimum to maximum and note the output dc voltage. If it deviates more than ±0.05 volts from 0 volts, repeat the procedure.

13-4 SQUAREWAVE AMPLITUDE CALIBRATION

1) Connect the 202A output to the oscilloscope vertical amplifier input.

2) Set the 202A to a convenient frequency and adjust the oscilloscope for a good presentation.

3) Adjust resistor R63 to produce an output square wave with the same peak-to-peak amplitude as the sine and triangular output waveforms.

13-5 FREQUENCY CALIBRATION

1) Check to see that the 202A upper and lower dial stops fall about an equal distance outside the upper and lower dial calibration marks. Correct the dial setting, if necessary, by rotating the dial on the dial mounting hub. The dial stops, and not the potentiometer mechanical stops, should be limiting dial travel.

2) Connect the 202A output to the 524D Electronic Counter SIGNAL INPUT terminal.

3) 524D Electronic Counter Control Settings:
FUNCTION SELECTOR switch to PERIOD.
DISPLAY TIME control for the desired display time (usually fully counterclockwise).
MIXER-DIRECT-WAVEMETER switch to DIRECT.

4) 202A Control Settings:
FUNCTION switch to SQUARE.
RANGE switch to X1.
Frequency dial to 0.8.
AMPLITUDE control to fully clockwise.

5) Turn on the equipment. Allow the test equipment to warm up for one hour.

6) Measure the period of the 202A frequency with the 524D Electronic Counter. It should be 1250 milliseconds.

7) Set the 202A frequency dial to 12 and measure the period. It should be 83.3 milliseconds.

8) If the period, at a dial indication of 12, is not 83.3 milliseconds, loosen the coupler between the dial and the potentiometer (R58) shafts. Refer to the instruction manual for coupler access hole location. Rotate one shaft with respect to the other to obtain a period of 83.3 milliseconds with a dial reading of 12. Tighten both set screws in the coupler.

9) Set the frequency dial to 0.8 and adjust resistor R109 to obtain a period of 1250 milliseconds. Check the setting made in paragraph 8 and repeat if necessary.

If resistor R109 has an insufficient range, center the control mechanically and repeat steps 8 and 9. This will electrically center the adjustment range of resistor R109, which can then be used to make any final adjustments.

10) Check the calibration at other points on the X1 range and on the other ranges. If the output frequency is not within 2% of the dial reading, refer the 202A to servicing personnel. The procedure for calibrating the 202A is described in the 202A Low Frequency Function Generator Manual.

NOTE

Removing the cabinet from the instrument will lower the frequency by approximately 1/2% because of the reduction of temperature.

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SECTION XIV
205AG AUDIO SIGNAL GENERATOR

14-1 SPECIFICATIONS

Frequency Range: 20 cps to 20 kc in three decade bands.

Frequency Stability: In excess of ±2% over extended periods.

Output: 5 watts maximum into resistive loads of 50, 200, 600, and 5000 ohms. Output circuit is balanced and center tapped - any terminal may be grounded.

Frequency Response: ±1 db from 20 cps to 20 kc at output levels up to +30 dbm with the output meter reading held constant at +37 db; ±1.5 db from 20 cps to 20 kc at output levels above +30 dbm with the output meter reading held constant at +37 db (reference 1000 cps).

Distortion: Less than 1% at frequencies above 30 cps.

Internal Impedance: Approximately one-sixth of the load impedance with zero attenuator setting. Approaches load impedance with attenuator settings of 20 db or more.

Output Meter: Calibrated in volts and dbm (0 dbm = 1 mw, 600 ohms). Full scale values, 65 volts, +37 dbm. Reads on 600 ohm basis regardless of output impedance selected.

Output Attenuator: Provides 110 db in 1-db steps.

Input Meter: Calibrated in dbm (0 db = 1 mw, 600 ohms) from -5 to -8 dbm and in volts from 0 to 2 volts rms. Voltage accuracy is ±5% of full scale.

Input Attenuator: Extends the meter range to +48 dbm and to 200V rms in 5-db steps. Accuracy ±0.1 db.

14-2 PRELIMINARY NOTES

Remove the four screws from the rear of the cabinet and remove the rear cover of the cabinet. Place the instrument on its back, and loosen the two Allen-head screws, located on the underside of the front panel bezel. Work the cabinet free and lift it from the instrument.

Inspect and clean the instrument. Using a low-pressure air hose, blow out any dust that may be on the tuning capacitor.

The capacitor drive should be lubricated once a year. Remove the cover plate from the top of the capacitor shield. Put one drop of light oil on each of the bearings on the small gear shaft at the top of the drive. The capacitor ball bearings do not need lubrication.

14-3 FREQUENCY AND OUTPUT CALIBRATION

1) Connect the output of the 205AG to the SIGNAL INPUT jack of the 524D Electronic Counter. Connect the 400H Voltmeter across the 205AG output terminals.

2) 524D Electronic Counter Control Settings:
FUNCTION SELECTOR switch to FREQUENCY.
FREQUENCY UNIT control to 1 SEC.
DISPLAY TIME control to desired display time (usually fully counterclockwise).

3) Set the 205AG IMPEDANCE switch to 600 and the LOAD switch to ON. Set the attenuators to 0.

4) Set the 400H Voltmeter to the 100-volt range.

5) Connect the equipment to a 115V ac power source. Turn on the equipment and allow it to warm up for 30 minutes.

6) Check the frequency calibration and output on all ranges. If the output frequency is not within 2% of that indicated by the dial, or if the output voltage (as measured with the 400H Voltmeter) varies more than ±1 db from 200 to 2000 cps (with the output voltage set at +37 db on the OUTPUT METER), proceed with the calibration.

NOTE

The frequency calibration will be correct only when the shields around and above the main tuning capacitor are firmly in place.

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7) Check the 205AG for the proper seating of the dial on the shaft. At one end of the frequency dial there will be either a small dot or an extra line. This should be under the indicator hairline when the tuning capacitor is at that end of its travel. This may be adjusted by loosening the set screws on the dial and rotating the dial until it is lined up correctly.

Check and tighten all set screws in the dial drive mechanism.

8) 205AG Control Settings:
RANGE switch to X10.
Dial to 20.
AMPLITUDE control for a 400H Voltmeter reading of 50 volts.

9) Check the frequency with the 524D Electronic Counter. If necessary, slip the dial for a correct frequency indication.

10) Change the 205AG dial setting to 200 and adjust capacitor C22 for the correct frequency (2000 cps). Observe the 400H Voltmeter deviation from 50 volts. Adjust capacitor C22 for a reading of one-half the deviation, disregarding any changes in frequency.

11) Adjust capacitor C1 for the correct frequency of 2000 cps.

12) Set the dial to 20 and read the frequency on the counter. If the frequency is not 200 cps, slip the dial in relationship to the shaft for the correct reading.

13) Repeat the procedure until no further improvement can be obtained.

NOTE

Add a 5-$\mu\mu$f capacitor across capacitor C22 if more capacitance is needed.

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14) Check the tracking of the dial at other frequencies. If the dial is out of calibration by more than 2%, return the instrument to an authorized repair station or to the factory.

15) Check the other frequency ranges. If the instrument is out of calibration at the other ranges, return the instrument to an authorized repair station or to the factory since the procedure involves padding resistors and requires considerable experience. If it is not practical to return the instrument, proceed as follows.

X100 RANGE

Change the padding resistor in series with the precision resistor (R3 or R4). A change of 1000 ohms will change the frequency approximately 1% on this range. Then 20,000 cycles on the dial is corrected by varying capacitor C7. A change of 50 to 200 $\mu\mu$f is usually adequate. Check the frequency response. The response can be corrected by changing the ratio of resistance in one leg to that in the other, keeping the total resistance constant.

X1 RANGE

An increase of 100,000 ohms in the padding resistor (precision resistor R1 or R6) will decrease the frequency approximately 1% on this range. There may be a small tracking error (less than 2%) at the top or the bottom of the X1 range. This is normal for the instrument and connot be eliminated. The frequency response may be corrected, if necessary, by changing the ratio of resistance in one leg to that in the other, keeping the total resistance constant.

14-4 OUTPUT LEVEL METER CALIBRATION

1) Turn on the instrument and allow it to reach operating temperature. Turn the AMPLITUDE control to zero and adjust the meter pointer to zero with the zero adjustment screw on the meter front. Always approach zero with the pointer moving down-scale.

2) Connect the 400H Voltmeter to the OUTPUT terminals.

3) Turn on the 205AG and allow it to warm up.

4) 205AG Control Settings:
IMPEDANCE switch to 600 ohms.
LOAD switch to ON.

Attenuators to zero.
FREQ. RANGE switch to X10.
Dial to 40.
AMPLITUDE control for 50 volts on the 400H Voltmeter.

5) Adjust the variable resistor R29 until the OUTPUT LEVEL meter indicates exactly 50 volts. The resistor R29, which is reached through a hole on the left side of the chassis when facing the instrument from the back, can be turned with a screwdriver.

14-5 INPUT LEVEL METER CALIBRATION

1) With the instrument operating and the AMPLITUDE control to minimum, adjust the meter pointer to zero with the zero adjustment screw on the meter. Always approach zero from the up-scale side.

2) Connect the 205AG INPUT DB terminals to the OUTPUT terminals. Connect the 400H Voltmeter to the OUTPUT terminals.

3) 205AG Control Settings.
INPUT DB switch to 0.
FREQ. RANGE switch to X10.
Dial to 400.
LOAD switch to ON.
IMPEDANCE switch to 600.
Attenuators to 28 db.
AMPLITUDE control for a 2-volt indication on the 400H Voltmeter.

4) The INPUT LEVEL meter should indicate 2 volts with the controls set as above. If the meter indication is incorrect, adjust variable resistor R47 to correct the meter indication. The variable resistor R47 is reached through a hole on the right side of the chassis when facing the instrument from the back. For the best calibration, set the resistor for a reading 2% less than 2 volts.