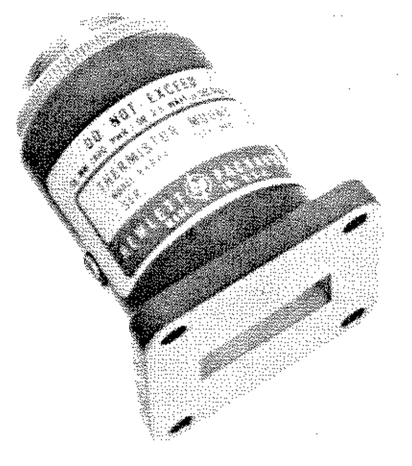
HP 486A

OPERATING NOT

THERMISTOR MOUNT
486A



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GENERAL INFORMATION

Introduction

The Hewlett-Packard Model 486A Thermistor Mounts are designed for use with the Hewlett-Packard Model 431 and 432 Power Meters in the measurement of microwave power from 1 μW to 10 mW in the range from 2.6 to 40.0 GHz. Design of power meter and thermistor mount is such that the measurement system is temperature-compensated. This feature permits microwave power measurements that are relatively free of the drift in meter indication that otherwise occurs with changes in ambient temperature.

For improved accuracy of measurement results, Calibration Factor and Efficiency are measured at selected frequencies across the operating range of each mount, and the results recorded on the label of the mount. In addition, each mount is tested on a swept-frequency basis to assure that interpolation between measured points is valid.

NOTE

Do not remove polyfoam insert — damage to the thermistor element may occur.

Each Model 486A Mount is designed to provide a good impedance match (low SWR) over the full frequency range of its waveguide size without external tuning.

Incoming Inspection

Unpack and inspect the Model 486A as soon as it is received. Inspect for mechanical damage such as dents, scratches, etc. Also check it electrically; if the mount was subjected to severe mechanical shock during shipment, the match between the thermistors will be affected. To check thermistor match, proceed as described under MAINTENANCE.

If any damage is found, notify the carrier and your Hewlett-Packard Sales and Service office immediately.

OPERATION

Precautions

Mechanical Shock. DO NOT DROP OR SUBJECT TO SEVERE MECHANICAL SHOCK. SHOCK MAY DESTROY THE MATCH BETWEEN THERMISTORS AND INCREASE SUSCEPTIBILITY TO DRIFT.

CAUTION

Before connecting a 200-ohm thermistor mount (K or R486A) to a power meter, set MOUNT RES switch to 200 ohm position. CONNECTING A 200-OHM MOUNT TO A POWER METER SET FOR A 100—OHM MOUNT CAN RESULT IN THERMISTOR DAMAGE.

Table 1. Specifications

Model	Freq Range (GHz)	Max SWR	Operating Resistance (ohms)	Fits Waveguide Size Nominal OD (inches)	Fits Waveguide Size EIA	Equiv Flange JAN Type	Approx Length (inches)	Approx Length (mm)	Net Weight (oz)	Net Weight (g)
S486A	2.6 - 3.95	1.35	100	3 x 1-1/2	WR284	UG-53/U	2-7/8	74	24	670
G486A	3.95 - 5.85	1.5	100	2 x 1	WR187	UG-149A/U	3-9/32	83	11	310
J486A	5.3 - 8.2	1.5	100	1-1/2 x 3/4	WR137	UG-344/U	3-5/32	80	8-1/2	240
H486A	7.05 - 10.0	1.5	100	1-1/4 x 5/8	WR112	UG-51/U	2-3/4	70	5-1/4	150
X486A	8.2 - 12.4	1.5	100	1 x 1/2	WR90	UG-39/U	2-1/8	54	3	80
M486A	10.0 - 15.0	1.5	100	0.850 x 0.475	WR75	--	2-1/8	54	3-1/4	90
P486A	12.4 - 18.0	1.5	100	0.702 x 0.391	WR51	UG-419/U	2-3/8	60	3-1/4	90
K486A[1]	18.0 - 26.5	2.0	200	1/2 x 1/4	WR42	UG-595/U	3	76	4-1/2	126
R486A[1]	26.5 - 40.0	2.0	200	0.360 x 0.220	WR28	UG-599/U	3	76	4-1/2	126

Mount Calibration: Calibration Factor and Effective Efficiency furnished at selected frequencies. Maximum uncertainty of data available upon request; contact local Hewlett-Packard Sales and Service office.

Power Range: 1 μW to 10 mW.

Power Sensing Element: Permanently installed thermistor.

Output Connector: 6-pin connector mates with cable furnished with Power Meter.

[1]Circular contact flange adapter available: K-band (UG-425/U) order HP 11515A; R-band (UG-381/U) order HP 11516A.

Maximum Input. The Model 486A / power meter combination responds to the average RF power applied. The maximum signal applied to the thermistor mount should not exceed the limitations for 1) average power, 2) pulse energy, and 3) peak pulse power. Excessive input can permanently damage the Model 486A by altering the match between the RF and compensation thermistors (resulting in excessive drift or zero shift) or cause error in indicated power.

Average Power. The 486A/power meter combination can measure average power up to 10 mW. To measure power in excess of 10 mW, a directional coupler (such as one of the Hewlett-Packard Model 752 series) can be inserted between the mount and the source. UNDER NO CIRCUMSTANCES APPLY MORE THAN 15 mW AVERAGE TO THE MOUNT.

Pulse Energy and Peak Power. In measuring pulse power, there is a limit on the energy per pulse which may be applied to the mount. For a pulse repetition frequency (PRF) less than 1 kHz, energy per pulse can be up to 2.5 Watt-μsec; for a PRF 1 kHz and above, up to 4 Watt-μsec (for lack of space, only the lower limit is shown on the mount name plate). However, this energy limit applies only to pulses shorter than 250 μsec. In Figure 1, the pulse energy limit is translated into a maximum power-meter reading for any PRF. For pulses in this category, allowable peak power is inversely proportional to pulse width but should never exceed 100 Watts.

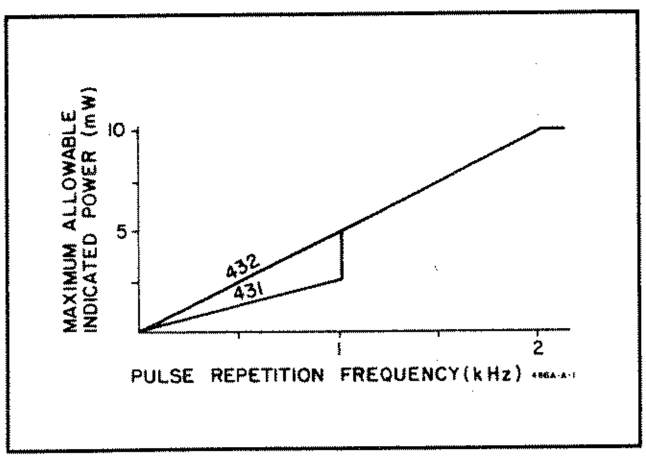

Figure 1. Maximum Power Meter Reading versus PRF for Pulses Shorter than 250 μsec.

For pulses longer than 250 μsec, the peak power limitation can be expressed in terms of PRF: 10 mW for a PRF below 1 kHz, 20 mW for a PRF 1 kHz or above provided 15 mW average is not exceeded. In Figure 2, the peak power limit is translated into power-meter reading versus duty cycle.

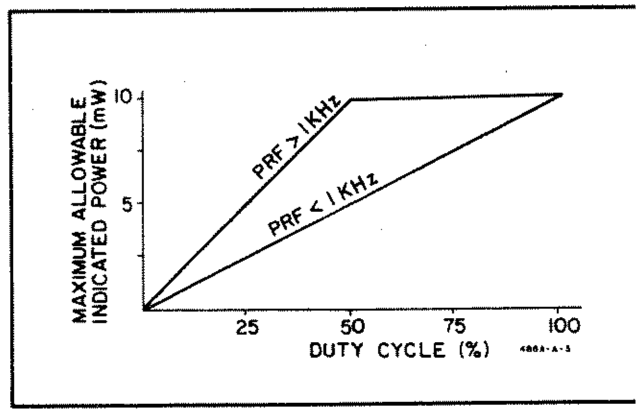

Figure 2. Maximum Power Meter Reading versus Duty Cycle for Pulses Longer than 250 μsec.

Square-wave modulation is a special case of pulse modulation, and maximum power-meter reading versus square-wave frequency is illustrated in Figure 3. This figure also holds for sine-wave modulation.

In the discussions above, the primary consideration is maximum power or energy. However, for modulation frequencies less than 100 Hz, the low repetition frequency itself causes errors in indicated power. These errors may be as large as 2% regardless of range or reading.

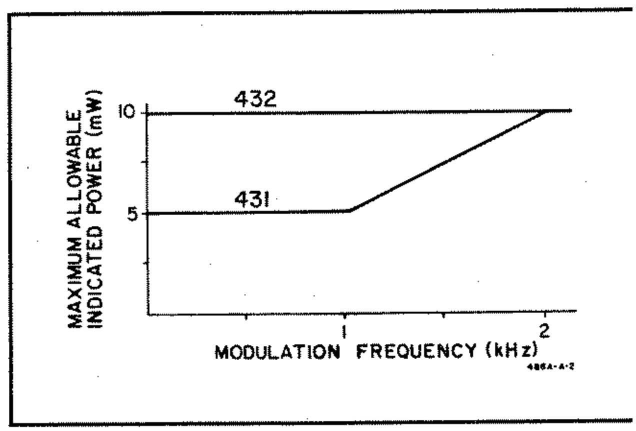

Figure 3. Maximum Power Meter Reading vs. Square and Sine-Wave Modulation Frequency

Drift

Thermistors are inherently temperature sensitive devices. A cold thermistor mount connected to a warm piece of equipment or vice versa, produces rapid drift. FOR MINIMUM DRIFT ON SENSITIVE RANGES MAKE SURE THAT THE MOUNT AND THE EQUIPMENT CONNECTED TO IT ARE AT NEARLY THE SAME TEMPERATURE BEFORE MAKING A MEASUREMENT.

Zero-Set

It is necessary to electrically zero-set the power meter before making a power measurement. To preserve the same zero reference throughout the measurement, especially when operating on the more sensitive ranges, maintain the same thermal environment when RF power is applied. Three recommended setups for zero-set are presented below:

RF Power Turned Off. There is minimum zero drift when zero is set with the RF system connected to the thermistor mount and RF power turned off at the generator or shorted out by a shorting switch. After allowing time for the mount to stabilize thermally, follow the steps for zero-set described in the power meter manual, and then turn on the RF power for measurement.

Use of High Attenuation with RF Source On. When it is inconvenient to turn off the RF source for zero-set, connect a waveguide variable attenuator, such as the HP Model 382A, between the RF system and the thermistor mount. Attenuate the RF power at least 30 dB for zero-set, and reduce attenuation to zero during the measurement.

Disconnecting the Mount. When it is inconvenient to turn off or attenuate RF power, simply remove the mount from the source and, using COARSE and FINE ZERO, zero the power meter.

Power Measurement

The thermistor has a long thermal time constant, which causes it to respond to average microwave power whether CW or modulated (pulse, sine wave, or square wave).

In pulse modulation, response is proportional to the amplitude and the duty cycle of the pulse. The power level of an individual pulse can be determined by dividing the average power reading by the duty cycle of the pulse. Accurate measurements can be made with pulse repetition rates as low as 50 Hz.

To measure microwave power in excess of 10 mW insert a calibrated attenuator, such as one of the HP 382A, or 375A series, or a directional coupler, such as one of the HP 752 series, between the mount and the RF source to be measured.

CAUTION

Do not exceed maximum power rating of attenuator or directional coupler.

Mount Calibration Data

The calibration points imprinted on the label of each 486A allow power measurements to be made with increased accuracy. Values of Calibration Factor and Effective Efficiency are given at specific frequencies and the mounts are tested on a swept-frequency basis to assure accurate interpolation between calibration points. Calibration Factor and Effective Efficiency values are traceable to the National Bureau of Standards to the extent allowed by the Bureau's calibration facilities.

Calibration Factor. Calibration Factor is the ratio of substituted audio or dc power in a thermistor mount to the microwave RF power incident upon the mount.

$$\text{Calibration Factor} = \frac{P_{dc}\ \text{Substituted}}{P_{\mu\text{wave}}\ \text{Incident}}$$

Calibration Factor is a figure of merit assigned to a thermistor mount to correct for the following sources of error: 1) RF reflected by the mount due to mismatch, 2) RF loss caused by absorption within the mount but not in the detection thermistor elements, and 3) dc-to-microwave power substitution error. Calibration Factor is applied as a correction factor to all measurements made without a tuner. When these factors and thermoelectric effect are taken into consideration, the power indicated is the power that would be delivered by the RF source to the characteristic impedance of the transmission line. The total SWR in the transmission line determines a region of uncertainty about the measured power. This subject is discussed in Application Note 64, available from any Hewlett-Packard Sales and Service office.

Effective Efficiency. Effective Efficiency is the ratio of substituted audio or dc power in a thermistor mount to the microwave RF power dissipated within the mount.

$$\text{Effective Efficiency} = \frac{P_{dc}\ \text{Substituted}}{P_{\mu\text{wave}}\ \text{Dissipated}}$$

Effective Efficiency corrects for power absorbed in parts of the mount other than the detection thermistor elements and dc-to-microwave power substitution error in the thermistor mount. Effective Efficiency is applied as a correction factor when a tuner is used to match the thermistor mount to the transmission line or RF source. In this case, all of the RF power incident upon the mount is absorbed in the mount, measurement uncertainty due to mount SWR is eliminated; however, losses in the tuner must be considered.

Calibration Data Application

When the 486A is used with Model 431 or 432 Power Meters, Calibration Factor or Effective Efficiency corrections can be made by setting a front panel switch. With the proper setting, the 431 or 432 compensates for the Calibration Factor or Effective Efficiency in the 486A. If the 486A is used with a power meter other than the 431 or 432, Calibration Factor or Effective Efficiency corrections can be made by dividing the measured power by the Calibration Factor or Effective Efficiency value respectively.

Thermoelectric Effect Error

The 432 Power Meter is not affected by thermoelectric effect error. However, the 431 Power Meter, which applies ac bias to the thermistors, is significantly affected: the magnitude of this error can be as high as 0.3 μW (0.1 μW typical). Thermoelectric effect error is important on the most sensitive ranges (.01, .03 and 0.1 mW) and when making dc substitution measurements. Refer to the 431 Power Meter manual for a procedure to measure the error and correct for it.

OPERATING PRINCIPLES

The Thermistors

Thermistors have a negative temperature coefficient; that is, when a thermistor's temperature increases, its resistance decreases. The 486A uses two thermistors: a detection thermistor that samples RF power and a compensation thermistor that compensates for ambient temperature changes. When the 486A is attached to a 432 Power Meter the detection thermistor (labeled D in Figure 4) is part of the RF bridge in the power meter; the compensation thermistor (labeled C in Figure 4) is part of the compensation bridge, and the bridges supply sufficient dc bias to drive the thermistors to their operating resistances (100 or 200 ohms).

Detection Thermistor

The detection thermistor is mounted within the mount's shorted waveguide section and is located so that it samples the E field and provides an optimum match across the band. As it absorbs RF power, its temperature (and therefore its resistance) attempts to change. However, the RF bridge circuit is self-balancing and reduces thermistor bias current to maintain the thermistor's proper operating resistance. Since the amount of bias change is proportional to incoming RF power, it is measured and used to indicate the RF power absorbed by the mount.

Compensation Thermistor

To prevent ambient temperature changes fron affecting power readings, a compensation thermis tor is mounted so that it shares the detectioı thermistor's thermal environment. Any change ii ambient temperature causes a bias change in botl thermistor bridges. This means that the total bia change in the detection thermistor is caused by incoming RF power plus ambient temperature. Bu the bias change in the compensation thermistor i caused only by ambient temperature. The powe meter subtracts compensation bias from detectioı bias to get stable, error-free power readings.

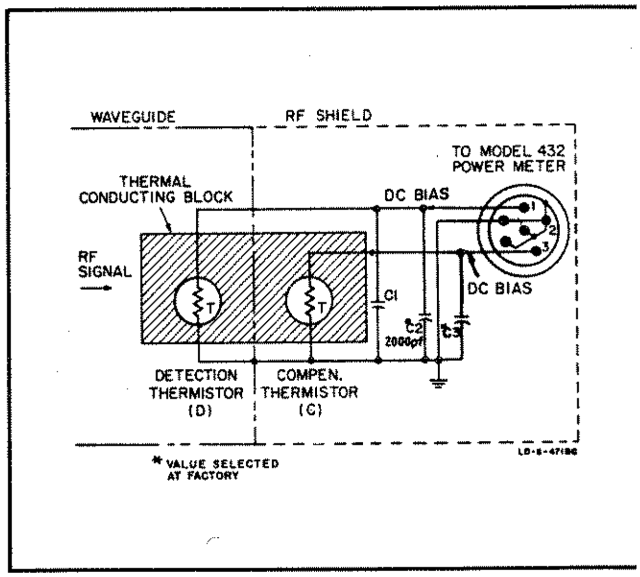

Figure 4. Thermistor Mount Schematic Diagram

MAINTENANCE

Cleanliness

Except for the K and R Models, thermistor I (mounted inside the waveguide) is protecte against air currents, dirt, and mechanical damag by two layers of polyfoam plastic. Polyfoam i soluble in most volatile solvents, such as gasoline alcohol, benzene, carbon tetrachloride, acetone etc., so great care should be used if one of these i used to clean the flange or inner surfaces of th waveguide. Use the plastic flange cover to protec the mount from dirt and mechanical damage wher ever it is not in use. Any burn, dents or dirt on th flange or waveguide surfaces will increase the SWR This is particularly important in the case of th K486A and R486A, which do not have the poly foam plastic protection.

Check on Thermistor Match

Damage to the match between the thermistors may be checked at room temperature by comparing the thermistor resistances under simulated operating conditions. Connect the equipment to the pins of the connector at the rear of the thermistor mount as shown in Figure 5. Take readings with switches connected to pin 1 and then to pin 3. Thermistor match is satisfactory if the two readings do not differ by more than 0.015 volt.

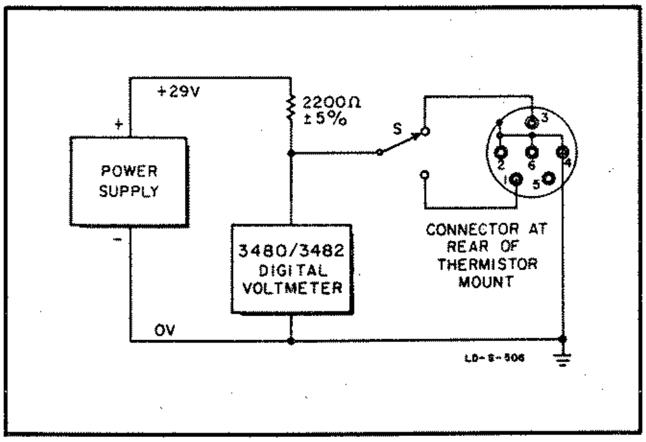

Figure 5. Check on Model 486A Thermistor Resistance Match

Repair

Exceeding the CW or pulse power limits of the Model 486A Thermistor Mount may result in damage such that the mount will no longer zero on the power meter.

Before adjusting the mount in any way, make sure that the mount is the cause of the problem. If the power meter will not zero, measure the resistance between pins 1 and 2, and between pins 2 and 3 of the mount's 6-pin connector. This resistance should be between 500 and 5000 ohms. If the resistance in both cases is within this range, the mount may be repairable. An open or short indication calls for factory repair.

If possible, test the mount by connecting it to a power meter and cable which are known to be good. A faulty cable will not have continuity through the respective connector pins, or may have poor contact at the mount connector. Poor contact will show up as intermittence or a great deal of noise (visible on the meter) when the cable is gently flexed near the connector end.

If the meter remains pegged upscale (or overrange), factory repair of the mount is indicated.

CAUTION

Under no conditions should the mount be required to carry current higher than 10 mA.

Mount Compensation

If the resistance reading of the mount is satisfactory, it may be possible to recompensate the mount, and return it to service. The drift with temperature changes will be higher because of damage to the thermistors, but it will be possible to zero the meter and to make measurements.

NOTE

After recompensation, the Calibration Factor and Effective Efficiency recorded on the label of the mount will no longer be valid. If desired, the instrument may be sent to the factory for repair and recalibration. Any Hewlett-Packard Sales and Service office will arrange for such repair.

There is an adjusting screw inside the instrument which permits recompensation within limits. Instruments which were manufactured without the adjusting screw are modified when they are sent in for repair.

To recompensate the mount with a 432 Power Meter, refer to Figure 6 and proceed as follows:

a. Remove cover screws (A).

b. Slide instrument out of cover.

c. Set power meter MOUNT RES to proper value.

d. Plug cover into mount cable.

e. Set RANGE to COARSE ZERO and center COARSE ZERO pot.

f. Set RANGE to 10 mW.

g. If meter is pegged upscale, turn compensating screw (B) counterclockwise to zero meter.

h. If meter is pegged downscale, turn screw clockwise to zero meter.

WARNING

If there is a sudden jump in meter indication when turning compensating screw clockwise, back off 1/8 turn. If screw bottoms, do not apply force. Factory repair is indicated.

i. Replace cover and cover screws (A).

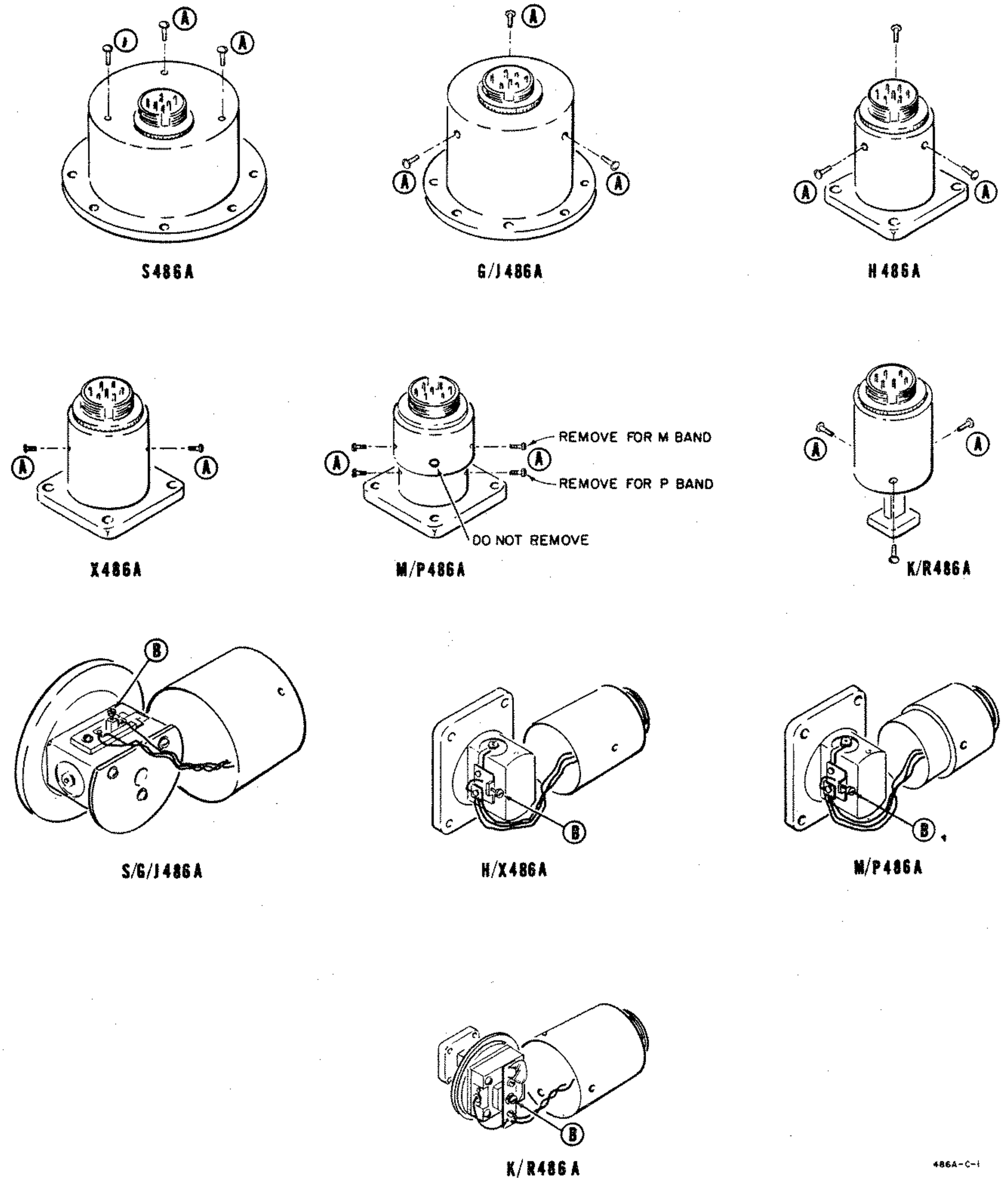

Figure 6. Cover Screws (A) and Compensating Screws (B) in Model 486A Thermistor Mounts

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

Service contracts or customer assistance agreements are available for Hewlett-Packard products that require maintenance and repair on-site.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

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To obtain servicing information and order replacement parts, contact the nearest Hewlett-Packard Sales and Service Office in HP Catalog, or contact the nearest regional office.

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