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A New Standing Wave Indicator With an Expanded VSWR Scale

THE widely-used -*hp*- Model 415A Standing Wave Indicator is an instrument which measures standing-wave ratios directly when used in slotted line set-ups in combination with detector elements such as crystals or barretters. This instrument has now been redesigned to be even more convenient to use through addition of an expanded VSWR scale, a half-step attenuator which always permits readings to be made in the upper half of the scale, and a new bolometer bias arrangement which permits use of both 8.5 ma and 4.5 ma bolometer elements as detectors. An output jack for operating a recorder has also been included. The new instrument retains such former features as an alternate high-impedance input channel for use in bridge measurements and a high sensitivity of 0.1 microvolt full scale.

SEE ALSO:
"New Microwave Power Meter", p. 3

Fig. 1. *New -hp- Model 415B Standing Wave Indicator has expanded VSWR and DB scales for easy reading of low VSWR values.*

Basically, a standing-wave indicator is a tuned audio amplifier of unusually high sensitivity which is provided with an output meter and an accurate step attenuator. Since the instrument is an audio device which measures the relative outputs of an r-f detector, it must be used with an r-f detector and an amplitude-modulated signal (see accompanying set-up diagrams). Commonly, 1,000-cps square-wave modulation is used. The Model 415B as supplied is normally tuned to this frequency. The tuning circuits in the instrument are constructed in the form of an internal plug-in unit, however, and on special order the instrument can be supplied with plug-in units for any desired frequency from 315 to 3,000 cps. Additional plug-in units can be supplied to enable one instrument to be used with different frequencies by changing plug-in units.

When measuring low VSWR's, it is often desirable to be able to make the reading with higher definition than otherwise. For such purposes the meter face on the new Model 415B is arranged with an extra VSWR scale which reads from 1 to 1.3 and which is expanded so that it occupies the whole meter swing. This scale is shown accented in Fig. 2. A lever switch on the front panel brings the scale into use. The expanded VSWR scale is accompanied by an expanded db scale for

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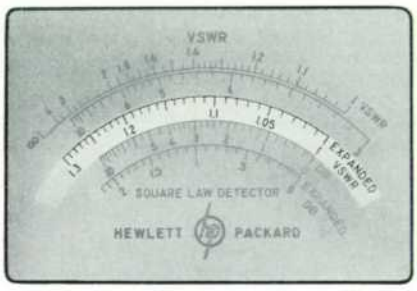


Fig. 2. *Meter face used on new 415B SWI. 1 - 1.3 expanded VSWR scale shown accented. Expanded db scale is at bottom of meter face.*

applications where it is desired to make readings in db.

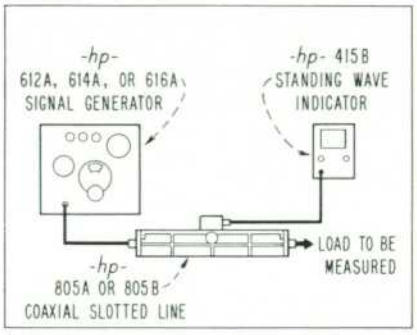
The same lever switch can be used to maintain any VSWR reading in the upper half of the meter. This feature is useful when measuring higher VSWR's where the readings may occur in the more compressed lower half of the meter face. The switch introduces a half-step attenuation of 5 db. A reading that occurs in the lower half of the 10 db range of the meter scale can thus be brought into the upper half by setting the lever switch and dropping back one position on the main range switch.

BIAS CURRENT

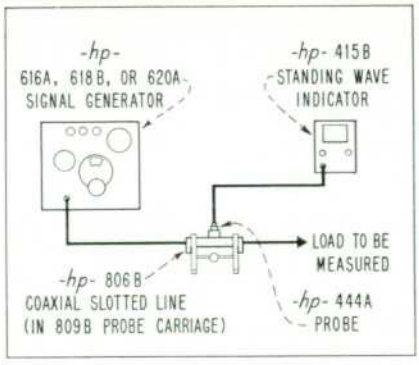
When standing-wave indicators are used with bolometer elements such as barretters, it is customary to operate the bolometer with a d-c bias current such as to bias the bolometer resistance to 200 ohms. The new 415B is arranged to supply a constant current of either 8.5 or 4.5 milliamperes, the two bias currents commonly required. The desired current is selected with a panel switch. A panel jack is also provided so that the bias current can be monitored by an external milliammeter, should this be desired. The bias current can be varied by adding external resistance in series with the meter.

HIGH IMPEDANCE INPUT

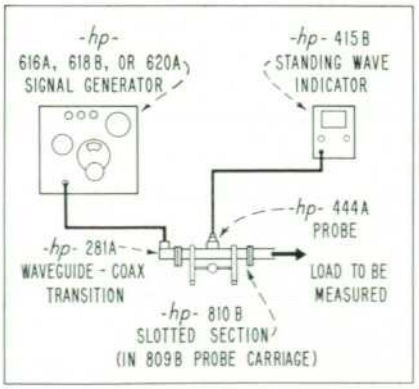
A high-gain 1,000-cps audio amplifier such as the 415B is an excellent detector for use with impedance bridges. In order that the instrument can be used for such purposes, it is provided with an alternate high-impedance 200,000-ohm channel which can be selected by the input switch. This order of impedance combined with the 3 microvolt full-scale sensitivity of the high-impedance channel permits very sensitive detection of nulls. If the bridge application will permit a 200-ohm detector, of course, up to 0.1 microvolt sensitivity can be obtained in the "Crystal" position of the input switch. For detector use, head phones can be plugged into the "Recorder" jack.



Set-up for measuring VSWR in coaxial systems over 500 - 4,000 megacycle range.



Set-up for measuring VSWR in coaxial systems over 3 - 11 kilomegacycle range.



Set-up for measuring VSWR in wave guide systems over 2.6 - 11 kilomegacycle range.

RECORDER OUTPUT

A recorder output jack is provided on the instrument for operating 1 ma d-c recorders of approximately 1500 ohms resistance. This arrangement will permit plots to be made of VSWR where this is desired for record purposes. It will also permit the instrument to be used where it is desired to monitor a low level signal in the 315-3,000 cps range with a 1 ma d-c recorder. —*Brunton Bauer*

SPECIFICATIONS
-hp-
MODEL 415B STANDING WAVE INDICATOR

FREQUENCY: Normally 1,000 cps ±2%. Available on special order for other frequencies: 315 to 3,000 cps.

SENSITIVITY: 0.1 μv or less provides full scale deflection on "Crystal" and "Bolo" inputs.

NOISE LEVEL: Equivalent noise referred to input less than 0.03 μv.

AMPLIFIER Q: 25 - 35.

CALIBRATION: For use with square law detectors. Meter indicates SWR and db.

RANGE: 70 db. Input attenuator provides 60 db in 10 db steps. Accuracy ±0.1 db per 10 db step.

SCALE SELECTOR SWITCH: Normal, Expand, and —5 db.

METER SCALES: "Normal", SWR 1 to 4, 3.0 to 10.0 and 0 to 10 db. "Expand", SWR 1 to 1.3. "—5db", 0 to 10 db (accuracy of attenuator .05 db).

GAIN CONTROL: Adjusts meter to convenient reference level. Range approximately 12 db.

INPUT: (a) "Bolo" (200 ohms): bias provided for 8.5 ma bolometer or 1/100 ampere instrument fuse; or 4.5 ma low current bolometer. (b) "Crystal": 200 ohms for crystal rectifier. (c) "200,000": high impedance for crystal rectifier or null detector.

OUTPUT: For recording milliammeter having a 1 ma full scale deflection and internal resistance of approximately 1,500 ohms.

INPUT CONNECTOR: Type BNC.

POWER: 115/230 volts ±10%; 50/60 cps; 60 watts.

SIZE: Cabinet Mount: 7¼" wide, 11¼" high, 14" deep. Rack Mount: 19" wide, 7" high, 11" deep.

WEIGHT: Cabinet Mount: 18 lbs., shipping weight 30 lbs. Rack Mount: 20 lbs., shipping weight 35 lbs.

ACCESSORIES PROVIDED: -hp- AC-16D Cable Assembly, BNC connector one end. -hp- 41A-16E Meter Cable.

ACCESSORIES AVAILABLE: -hp- 415B-42B Plug-in Filter for special operating frequency, 315 to 3,000 cps. $12.00.

PRICE: -hp- 415B Standing Wave Indicator, Cabinet Mount, $200.00 f.o.b. Palo Alto, California. -hp- 415BR Standing Wave Indicator, Rack Mount, $205.00 f.o.b. Palo Alto, California.

Data subject to change without notice.

More Conveniences in the -*hp*- Microwave Power Meter

LAST summer -*hp*- introduced a series of new broadband thermistor mounts† for use in making power measurements in both wave guide and coaxial systems. These mounts have proved very popular. In particular, the mount for coaxial systems has been widely used because this one mount, when combined with the -*hp*- Model 430B Microwave Power Meter, could be used to measure power over the entire frequency range from 10 megacycles to 10 kilomegacycles.

To use the coaxial mount with the -*hp*- 430B Power Meter has required a modification in the meter's bias circuit, since the mount required considerably more bias power than conventional mounts. In the past this modification was made by means of a kit which could be installed either in the field or at the factory.

The 430B Power Meter has now been redesigned so that it will directly accommodate the coaxial mount as well as all other -*hp*- mounts. Further, a number of new refinements have been incorporated to make the instrument even more convenient to use.

The new instrument, known as the Model 430C, will accommodate bolometer elements of either positive or negative temperature coefficient and of either 100- or 200-ohms operating resistance. A list of such elements in general use is shown in the accompanying table.

The panel of the Model 430C is shown in Fig. 1. At the upper left is a switch that adjusts the instrument for either positive or negative temperature coefficient elements. At the upper right is a switch that adjusts the instrument for use with either 100-ohm or 200-ohm elements. The range switch at the lower left provides five measurement ranges from 0.1 milliwatt full scale to 10 milliwatts full scale.

Bias current in the new instrument has been made independent of the power range switch. A separate bias current-selecting switch is located at the lower right of the front panel. This switch is marked with three main current ranges which provide for bias currents from 0 to 16 ma. The upper two ranges are divided into a number of current steps which simplify selection of a required current. A dual "Coarse - Fine" control in the lower center of the panel acts as a vernier for the switch steps.

Fig. 1. *New -hp- Model 430C Microwave Power Meter will operate with bolometer elements of either positive or negative t-c, 100- or 200-ohm value. Very high d-c regulation is used to minimize drift on low ranges.*

†Wm. Gallagher and B. P. Hand, "New Conveniences for Microwave Power Measurements," Hewlett-Packard Journal, Vol. 5, No. 11, July, 1954.

COAXIAL MOUNTS

-*hp*- MODEL	FREQ. RANGE	MAX. POWER	MAX. VSWR	TYPE OF ELEMENT USED	NOTES
475B	1-4 kmc	10 mw	....	Pos*	Tuned
476A	10 mc - 1 kmc	10 mw	1.25	Pos	Untuned
477A	10 mc - 10 kmc	10 mw	1.5	Neg	Untuned

WAVE GUIDE MOUNTS

-*hp*- MODEL	FREQ. RANGE	MAX. POWER	MAX. VSWR	TYPE OF ELEMENT USED	NOTES
S485A	2.6 - 3.95 kmc	10 mw	1.35	Pos*	Untuned
G485B	3.95 - 5.85 kmc	10 mw	1.25	Pos*	Tuned
J485B	5.85 - 8.20 kmc	10 mw	1.25	Pos*	Tuned
H485B	7.05 - 10.0 kmc	10 mw	1.25	Pos*	Tuned
X485B	8.2 - 12.4 kmc	10 mw	1.25	Pos*	Tuned
G487A	3.95 - 5.85 kmc	10 mw	1.5	Neg	Untuned
J487A	5.85 - 8.20 kmc	10 mw	1.5	Neg	Untuned
H487A	7.05 - 10.0 kmc	10 mw	1.5	Neg	Untuned
X487A	8.2 - 12.4 kmc	10 mw	1.5	Neg	Untuned

**Negative temperature coefficient elements can also be used in these mounts. See Hewlett-Packard Journal, Vol. 3, No. 3, Nov., 1951.*

0.05% REGULATOR

Besides increasing the amount of bias power that the instrument will supply, the new 430C has been designed to have an unusually high order of regulation in its d-c circuits. This feature offers important benefits when measuring small powers where most of the bias power that the instrument applies to the bolometer element is d-c power. If line voltage fluctuations change the d-c power into the bolometer element by more than a few microwatts on the 0.1 milliwatt range of the instrument, the result will appear as a drift or fluctuations in the

meter pointer. For this reason the regulation of the d-c circuits in the 430C for ±10% line voltage changes is maintained within at least 0.05%. In practice this means that meter pointer drifts resulting from line current effects in the power meter amount to only two or so of the 2 microwatt divisions on the meter face and this occurs only on the lowest range of the instrument.

BOLOMETER MOUNTS

A wide range of *-hp-* bolometer mounts is available for making power measurements in both coaxial and wave guide systems. Characteristics of these mounts are summarized in the accompanying table. Included are both tuned and untuned mounts, i.e., mounts which must be manually tuned for the r-f frequency used and mounts which do not require tuning. A number of typical set-ups using these mounts are diagrammed in Vol. 5, No. 11 (July, 1954) of the *Hewlett-Packard Journal*.

—Don Carmean

SPECIFICATIONS
-hp-
MODEL 430C MICROWAVE POWER METER

POWER RANGE: 5 ranges, front panel selector. Full scale readings of 0.1, 0.3, 1, 3, and 10 milliwatts. Also calibrated in db to give continuous reading from −20 dbm to +10 dbm (0 dbm = 1 mw). Power range can be extended with attenuators or directional couplers.

EXTERNAL BOLOMETER: Frequency range depends on bolometer mount. Bolometers can operate at resistance levels of 100 or 200 ohms and can have positive or negative temperature coefficients. Any DC bias current up to 16 ma is available for biasing positive or negative temperature coefficient bolometers. DC bias current is continuously adjustable and independent of bolometer resistance and power level range. Sufficient latitude is provided to insure operation over usual room-temperature range.

ACCURACY: Within 5% of full scale value.

POWER SUPPLY: 115/230 volts ±10%, 50/1000 cycles approximately 75 watts.

SIZE: Cabinet: 7⅜" wide, 11½" high, 12¼" deep. Rack Mount: 19" wide, 7" high, 12½" deep.

WEIGHT: Cabinet: Net 20 lbs.; shipping 32 lbs. Rack Mount: Net 23 lbs.; shipping 35 lbs.

ACCESSORIES FURNISHED: 1—AC-16D cable assembly, consisting of 44" RG-58/U 50-ohm coaxial cable terminated on one end with UG-88/U BNC connector.

ACCESSORIES AVAILABLE: -hp- Stock No. G-28A selected instrument fuses (200-ohms at 8.75 ma at 25°C) for use with *-hp-* 475B or as a single element, 10 for $10.00. Usable up to 4,000 mc.

PRICE: Cabinet: $250.00 f.o.b. Palo Alto, California. Rack Mount: $255.00 f.o.b. Palo Alto, California.

Data subject to change without notice.

NOTES ON BOLOMETER ELEMENTS

The *-hp-* Model 430C Microwave Power Meter will operate with either positive temperature coefficient bolometer elements (usually called "barretters") or negative coefficient elements (called "thermistors"). These elements are available in a variety of shapes and types of construction, but *-hp-* mounts generally use a cartridge style barretter or a capsuled or uncapsuled thermistor.

Pertinent electrical characteristics of a number of 100- and 200-ohm bolometer elements which can be used with the *-hp-* 430B and 430C power meters are shown in the table.

Certain instrument fuses may also be used as barretters as is done in the *-hp-* Model 475B and the 476A. For this use, however, the fuses must be selected and subjected to a special but simple treatment.

Barretters are sometimes used in standing-wave measurements as detector elements. This use should be carefully distinguished from their use as bolometer elements in power measurements. In detector use the barretter is used in the same manner as a silicon crystal. Detection occurs because the resistance of the barretter changes with the modulation cycle. A constant current through the barretter will thus result in an audio voltage across the barretter. The response of barretters used as detectors is closer to a true square-law response than is the response of crystals.

The sensitivity of barretters when used as detectors is about 20 db below that of silicon crystals at a frequency of 1,000 cps. Instrument fuses may also be used as detectors, but their sensitivity is about 3 db below that of conventional barretters.

Thermistors are generally preferred for measuring the average value of pulsed power because they generally have longer time constants.

BOLOMETERS

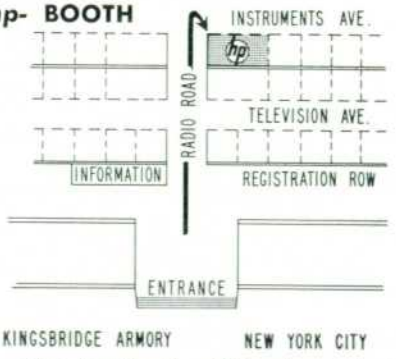
Make - Model	Sign of Temp. Coef.	Current Reqd. MA	Oper. Res. Ω	Max. Safe Pwr. MW	Max. Safe Current MA	Power Sens. Ω/MW
Sperry 821	Pos	8.75	200	32	10.5	4.5
Narda N821B	Pos	8.75	200	32	10.5	4.5
Narda N610B	Pos	8.75	200	32	10.5	4.5
PRD 610A	Pos	4.5	200	7.5	6	8.4
PRD 614	Pos	4.5	200	7.5	6	8.4
PRD 617	Pos	4.5	200	7.5	6	8.4
PRD 631C	Pos	4.5	200			
Buss MJB 1/100 Amp. Fuse	Pos	8.75	200	60	14	3
W.E. Co. D166382	Neg	11.8	100	>25	>25	13
D170575	Neg	6.7	200			36
Victory 32A3, 32A5	Neg	11.8	100	>25	>25	13
	Neg	6.7	200			36
Narda 333, 334	Neg	11.8	100	>25	>25	13
	Neg	6.7	200			36

All values of current and power are approximate.

VISIT THE -hp- BOOTH

At the March 21-24 IRE Radio Engineering Show in New York *-hp-* will have on exhibit a number of unusually interesting instruments. Included among these will be a pre-showing of a system for measuring the r-f frequency of r-f pulses—a system with a high definition such that r-f frequency shifts during an r-f pulse can be measured.

Additional instruments to be shown include *-hp-'s* new 15 - 21 kilomegacycle signal generator, a simple industrial counter which will speed many production measurements, a coaxial directional coupler, a new 415B and 430C described in this issue, and others.



The *-hp-* booth will be located at the corner of Radio Road and Instruments Avenue. *-hp-* engineers from both factory and field will be on hand. You are most cordially invited to stop by.