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The -*hp*- Program for Waveguide Type Measuring Equipment

FOR some time the Hewlett-Packard Company has been working on a program to provide measuring equipment for waveguide systems in the range from 2600 to 18,000 megacycles. To make this program of real value to users of -*hp*- equipment, the new designs have been pointed toward three special objectives. First, each instrument has been designed to be of a broad band type that covers a complete waveguide range of frequencies wherever possible. Thus, the number of instruments necessary for general work is minimized. Second, a complete, integrated set of measuring equipment is provided for each waveguide size. Third, an attempt has been made to achieve novel designs that will permit a moderate selling price without sacrifice of quality or accuracy. A good example of this feature is shown in the set of slotted lines described later.

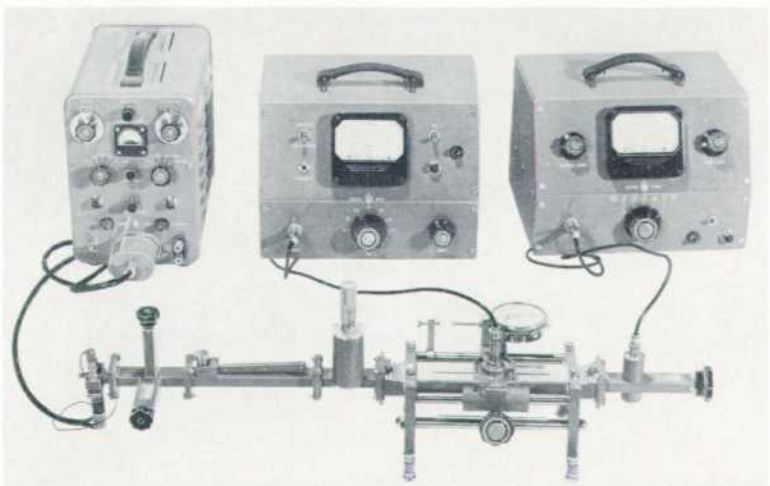


Figure 1. *Set-up for waveguide measurements using new -hp- waveguide measuring instruments.*

The instruments to be made available include:

- Slotted line sections
- Slotted line probes
- Adjustable shorts
- E-H and slide-screw transformers
- Crystal and bolometer type detecting mounts
- Frequency meters
- Series, shunt, and hybrid tees
- Fixed and variable attenuators
- Low and high power terminations

In general, the instruments developed under the program will be provided in models for each of six commonly-used waveguide sizes. Each of these sizes is designated by a letter that is also used as a prefix to the instrument model number. Thus, the model number with its prefix both identifies the instrument and specifies its waveguide size. The various waveguide sizes and identifying letters are shown below:

S: 3″ x 1½″ H: 1¼″ x ⅝″
G: 2″ x 1″ X: 1″ x ½″
J: 1½″ x ¾″ P: .391″ x .702″

The -*hp*- waveguide equipment program has been expedited by an arrangement with Varian Associates whereby -*hp*- has taken over some Varian designs. Thus, in many cases final designs are a combination of the efforts of the Varian and -*hp*- engineering departments.

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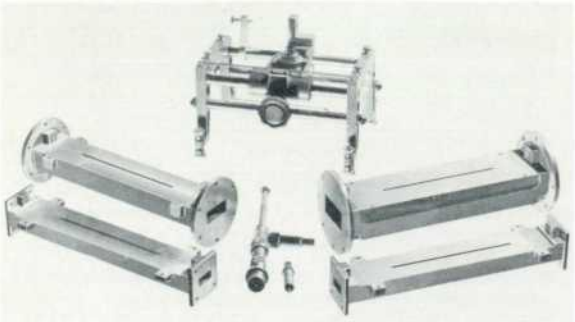


Figure 2. *New set of waveguide slotted line equipment including 809B carriage assembly with four 810B slotted sections, and two broadband probes.*

The new slotted sections and probes that have been developed will be described in the following. Remaining instruments will be described in future issues.

SLOTTED SECTIONS

The focal point of the whole program is the set of slotted line sections shown in Figure 2. The set consists of four slotted waveguide sections, a carriage assembly, and two types of broad band probes. Each component of the set is available separately so that only those components necessary for a given measurements project need be used. The complete set of slotted sections with either probe covers a range of 3950 to 12,400 mc.

To achieve a moderate selling price, the set is designed so that all four slotted sections are usable with one carriage assembly and one probe. In effect, this arrangement eliminates three carriage assemblies, thereby saving much costly machining from the set as a whole. To put into use a slotted line for any of the four waveguide sizes from 3950 to 12,400 mc, it is only necessary to set in place the desired slotted section and tighten four thumbscrews.

The carriage assembly has been carefully designed to obtain mechanical accuracy and freedom from wear. The probe carriage rides on two solid one-half inch diameter stainless steel bars that are precision ground and honed to within 0.0002". The necessary longitudinal bearing is obtained on the front supporting bar through use of two linear ball bushings, special bearings that provide the advantages of ball bearings in linear motion applications. Such an arrangement allows the front bearings to be dust sealed and gives a positive support to the carriage without need for spring-loading. The rear support for the carriage consists of two opposed ball bearings that ride linearly on the rear support bar.

The linear type bearings and freedom from sliding parts make the probe carriage adaptable to an unusual technique in standing-wave measurements. In Figure 3 the probe carriage is shown coupled to a slow-speed motor in such a way as to give a reciprocating motion to the carriage. By coupling the output of the probe to a low-frequency or dc oscilloscope through a suitable amplifier, a visual indication of the standing wave pattern is obtained. The obvious feature of this technique is that adjustments in loading or tuning can be made much quicker than with the conventional point-by-point technique. Sweep voltage for the oscilloscope can be obtained from a contact sliding on a resistor as shown in the illustration. The motor drive arrangement is not provided but can easily be made up in breadboard form in the laboratory.

The travel of the probe carriage is 10 cm, or more than three-quarters of a guide wavelength at the lowest operating frequency of 3950 mc. The probe position relative to the right-hand or output face of the slotted section is indicated on a metric scale with a vernier reading to one-tenth of a millimeter. In addition, the probe carriage is equipped to mount a dial indicator (Figure 4) so that null patterns can be measured with very high mechanical accuracy. The dial indicator is not provided with the carriage, although any standard dial indicator can be used. The dial indicator shown in Figure 4 reads up to 2.5 cm in divisions of 0.01 millimeter.

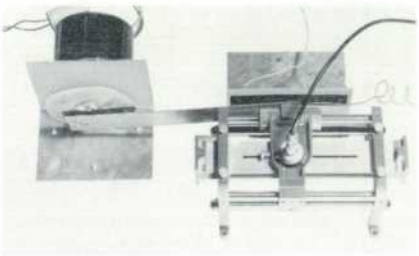


Figure 3. *Breadboard set-up for motor drive for use with Model 809B carriage assembly.*

The Model 810B slotted sections and the Model 809B carriage assembly are machined to very close mechanical tolerances. With reasonable care in interchanging sections and aligning joints, VSWR measurements of 1.02 or better can be made.

PROBES

Two probes are available for use with the slotted sections. Both cover the complete 3950 to 12,400 mc range. The Model 444A probe is unconventional in that it provides rectified output but is an untuned device. Being untuned, this probe is unusually convenient to operate and allows a series of measurements to be



Figure 4. *-hp- Model 809B carriage assembly with dial indicator.*

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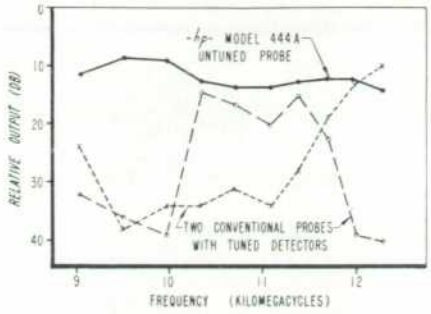


Figure 5. *Typical response and efficiency characteristics of Model 444A untuned probe compared with conventional probes having tuned detectors.*

made rapidly. In addition, the probe design is such that good efficiency and response characteristics are provided. The efficiency and response of the Model 444A are compared in Figure 5 with those of two conventional tuned type probes.

The high efficiency and flat response of the 444A probe have been achieved by locating the detector element quite close to the r-f pick-up antenna, thereby minimizing residual reactances. The detector element itself is a modified 1N26 silicon crystal, and the probe is thus suitable for general - purpose applications where a crystal type detector can be used.

The second probe, Model 442A, is basically an r-f pick-up antenna connected to a type N connector to allow the field in the waveguide to be sampled. Thus, the probe can be used in applications where it is desired to use an h-f receiver as a standing-wave indicator. However, a companion detector mount, Model 440A, is available so that the probe can be used with bolometer elements, crystals, or suitable fuses as detector elements. The tunable detector mount is shown with the Model 442A probe in Figure 6.

I.R.E. EXHIBIT

The new *-hp-* waveguide measuring equipment described in this issue will be exhibited at I.R.E. Radio Engineering Show, which will be held from March 19 to 22 at the Grand Central Palace, New York City. The *-hp-* Model 524A high-speed Frequency Meter described in last month's issue also will be exhibited along with other *-hp-* instruments.

You are cordially invited to visit the *-hp-* booths, numbers 40 and 41. Representatives both from the factory and field will be on hand.

WIDE BAND COAXIAL SECTION

Besides the set of slotted sections described above, two other slotted sections have been designed—the Models 806B and S810A. The 806B is a coaxial section for use over the range from 3,000 to 12,000 megacycles. The design of this section is similar to that of the widely-used *-hp-* Model 805 slotted line where the outer conductor consists of two parallel semi-planes. Such a design modifies the field configuration so that errors arising from normal variations in probe penetration are significantly reduced.

The section is constructed from solid blocks of aluminum. The position of the center conductor with respect to the parallel semi-planes is fixed and no adjustments in the line itself are necessary. The center conductor is supported by a teflon bead that is compensated to give low reflection. For example, the residual VSWR of the 806B is less than 1.04 below 8 kilo-megacycles, approximately 1.06 at 10 kmc, and approximately 1.1 at 12 kmc.

The 806B consists only of the coaxial section itself. The unit is arranged to be used with the carriage assembly and either of the probes described above.

S-BAND WAVEGUIDE SECTION

The remaining section is the Model S810A. As indicated by its prefix letter, the S810A is a slotted section of 3″ x 1½″ waveguide for use over the range from 2600 to 3950 mc. This instrument differs from all of the above sections in that it is provided with its own carriage assembly and can not be used with the Model 809B carriage assembly described above. However, the S810A does use either of the two probes described before.

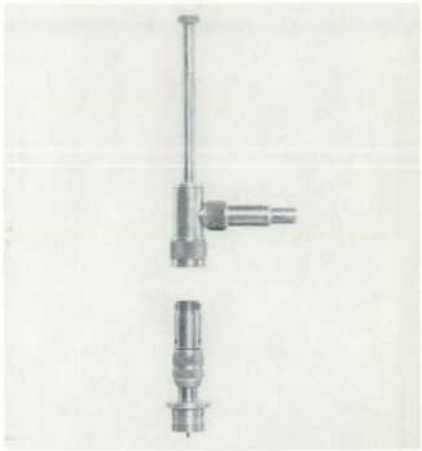


Figure 6. *Model 440A detector mount (above) and 442A probe combine to make tuned slotted line probe. 440A will accommodate crystals, bolometers, or suitable fuses.*

FLANGES

All *-hp-* waveguide equipment is provided with plain cover flanges. For applications requiring choke flanges, the Model 280A cover-to-choke flange adapters are available in each size of waveguide.

EQUIPMENT RÉSUMÉ

A tabulation of the complete line of waveguide equipment is given on the back page of this issue.

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Acknowledgment is due Mr. R. M. Kingman of the *-hp-* Mechanical Design Department for his valuable contributions toward the development of the instruments designed under the program and particularly toward the development of the slotted line equipment. Acknowledgment is also due Mr. Arthur Fong for the development of the 806B coaxial section.

—N. B. Schrock

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