

MSGT. W.F. POOLIN

PHILCO

TECHREP DIVISION BULLETIN



NOVEMBER

1951

BULLETIN BINDERS

Last month, a letter was sent to all BULLETIN readers in the field, announcing that we intended to procure binders for this magazine and make them available at cost, provided that a sufficient number of readers indicated a desire for such binders.

At the bottom of that letter was a reservation blank to be filled in and returned to the BULLETIN office, if one or more of these binders were desired. Many readers have already sent us their reservation requests, but we have not yet received a sufficient number to justify placement of an order. Therefore, those readers who desire a binder but have not yet returned their reservation slip are requested to do so promptly.

(BULLETIN readers on the local Headquarters mailing lists have not yet been sent reservation slips, but will be contacted as soon as we receive enough field requests to make it definite that an order will be placed.)

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PHILCO TECHREP DIVISION BULLETIN

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If any information contained herein conflicts with a technical order, manual, or other official publication of the U.S. Armed Forces, the information in the official publication should be used.

Letters To The Editor

In looking over our mail this past month, we came up with the pleasing discovery that this column is read as avidly as any other part of the magazine. Not only do BULLETIN readers read this column, but some readers are acting on suggestions made here by others. This is very heartening; the more cooperation we get from the field, the more valuable we can make this magazine to you. Here is a sample of what we received:

"One thing the BULLETIN has accomplished is the stimulation of interest in the problems facing Field Engineers in other jobs. Several of the men have told me they never realized how complicated were the jobs other Field Engineers are engaged in until they read of some of their solutions in the TechRep BULLETIN. If there were only some way you could interest, attract, or persuade the men to write in more often with their solutions, then I feel your 'practical' reading audience would multiply by leaps and bounds. As it is, though, everyone borrows my copy often enough now! Keep your emphasis on the practical discussions, and illustrate each article as profusely as possible."

Daniel B. Campbell
Supervisor, Ground Forces
Tokyo Office

(For those who need moral support before sending in their article(s), this should do it. Even though your solution to a problem doesn't seem very important to you, others are interested in it, so let's have it.)

"While making the rounds with the military, and asking them if they would like to be included on the BULLETIN mailing list, we found that it was one of the most eagerly sought-after technical publications in the Far East. In our opinion this is one of the many things you people at Headquarters are doing that really gives our field operations a boost."

L. A. Andrews
Supervisor, Air Forces
Tokyo Office

(Thanks for the kind words.)

"One thing in particular that I like about the BULLETIN is the way the enlisted men study each new issue. It opens the way to

discuss related electronic subjects in which it would otherwise be difficult to raise interest.

"My recommendations are to continue the sound policy already adopted, under which as much practical information as possible is given, while enough varied subjects are included to add zest for the casual reader."

Bud M. Compton
Philco Team Leader
APO 731

"Am enclosing the reservation slip for binders for the BULLETIN. The BULLETIN is doing a wonderful job, and I hope you keep up the good work. Other field engineers here to whom I've loaned copies have been very favorably impressed by it. If it's possible, I'd like to see some articles dealing with ECM, since that is now my primary concern."

Chet Riker
Philco Field Engineer
El Paso, Texas

(How about it, ECM men?)

"Congratulations on the wonderful job you are doing on the BULLETIN. I find the contents interesting, stimulating, and of considerable practical value. I look forward to receiving my copy every month, and when I do, I read it from cover to cover.

"The BULLETIN has stirred considerable interest in the squadron. The 'What's Your Answer?' page is very popular with the Airmen and Officers of the Radar Section. Many of them would like very much to have a copy for themselves."

Gerald S. Cohen
Philco Field Engineer
Fort Meade, Maryland

(Fine—send us their names.)

"Regarding the 'What's Your Answer?' department, the problem in the October issue created quite a stir around the offices of Communications and Electronics. Work was neglected by many who were trying to solve it. I and several others came up with answers of $\frac{5}{8}$ ohm by the use of logic and a little Ohm's Law. One Major arrived at the same answer by going into a long series of simultaneous linear equations several pages long. All agree that the Major's method is the only one that will work if the resistors are of different values."

Frank H. Jeys
Philco Field Engineer
Hq. ADC

(Continued on page 26)

Editorial

THERE IS A FUTURE IN FIELD ENGINEERING

By John E. Remich, Manager, Technical Department

The field-engineering profession has come of age. This is evidenced by the fact that the scope of field-engineering has expanded steadily, not only during World War II, but throughout the period of "peace" between the end of the War and the current national emergency.

Almost daily, new electronic equipment is being devised, manufactured in ever-increasing quantity, with each succeeding device seemingly more complex than the last, and requiring more and better-trained personnel to install, maintain, and operate it. The Armed Forces share with industry a growing dependence upon electronic devices to increase the efficiency of their operations, whether they be firing a gun, or getting more production per man hour. The demand for more and more field engineers to service and maintain these devices, and to train other personnel in their operation and maintenance continues to grow.

With this expansion of field-engineering activities, there is, of course, a corresponding increase in the number of supervisory and management positions available to qualified men who are able and willing to assume greater responsibility. Indeed, the problem facing the entire electronics industry is one of finding a sufficient number of trained and experienced men to fill the positions already available. Unquestionably, few professions offer the opportunities now available to the field engineer who knows his job, and does it well.

Dummy Antenna for T-14/TRC

By Harold Newman
Philco Field Engineer

Construction data for a dummy antenna to be used in testing the power-output capabilities of the T-14/TRC transmitter.

(Editor's Note: This article describes a practical measurement device which closely parallels one of the methods described in the article, "High-Frequency Power Measurement," in this same issue. Here is a striking example of how an ingenious field engineer has made use of his knowledge of fundamentals, to facilitate field testing.)

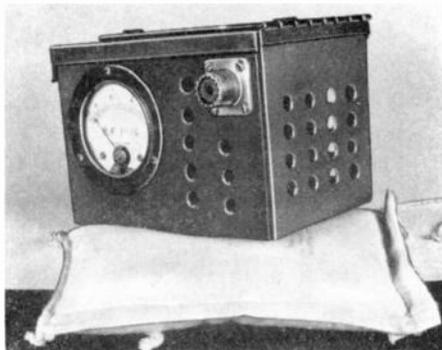


Figure 1. External View of Dummy Antenna

THIS DUMMY antenna was one of the results of a project to standardize test equipment and the layout of base shops and communications centers in the Pacific area.

The unit is housed in a 4" x 4" x 5" metal box with a hinged top, as shown in figure 1. Numerous holes have been drilled into the box to facilitate heat dissipation, since the T-14/TRC has a rated output of about 50 watts.

Figure 2 shows a schematic diagram of the unit, which consists of a non-inductive resistor (R_1) capable of dissipating 60 watts, and a voltmeter circuit for monitoring power. Basically, the

meter responds to the peak voltage applied to the crystal rectifier, but R_2 , R_3 , and R_4 are chosen so that 1 ampere of r-m-s current in the load (R_1) produce a full-scale meter indication. This is also equivalent to 50 volts, r.m.s., across the load, or 50 watts of r-f power; thus, the meter scale could be calibrated in volts, amperes, or watts, as desired. The unit shown in figure 1 is calibrated in amperes.

Figure 3 shows the construction of R_1 , which consists of thirty 1500-ohm.

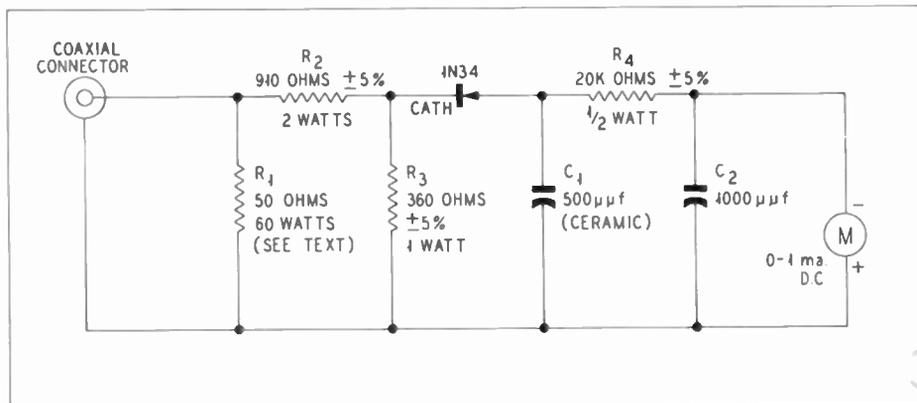


Figure 2. Schematic Diagram of Dummy Antenna

2-watt metallized resistors, thus providing a 50-ohm, 60-watt load. This method of construction was used for several reasons: (1) the load can readily be made from available parts; (2) the parallel connection reduces inductive-lead effects to a minimum; and (3) the tolerance is improved because a random selection of resistors results in values both above and below the desired value, so that the extremes tend to cancel each other.

In figure 4, which shows an internal view of the completed unit, the location of components can be clearly seen. The use of short leads is apparent; the importance of this design feature cannot be overemphasized.

Calibration of the meter scale can best be done with the aid of a standard instrument designed for the 100-mc. region; however, the unit can be calibrated at 60 c.p.s. if the effect of the meter circuit is taken into account. Because of circuit values, the meter reads peak voltage in the 100-mc. region, and 1 ampere of r-m-s load current at these frequencies will deflect it to full scale; however, at 60 c.p.s. the meter will read about 32% of full scale ($\frac{1}{2}$ average value) for 1 r-m-s ampere. To compensate for this, the value of C_1 can be

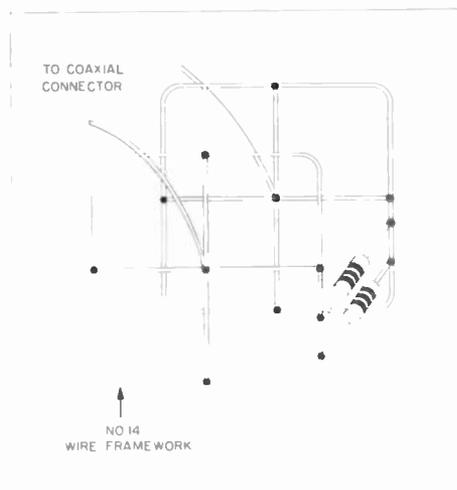


Figure 3. Construction Details of Framework for Resistor Load R_1

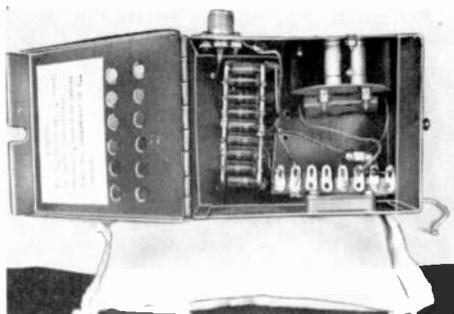


Figure 4. Internal View of Dummy Antenna, Showing Placement of Components

increased to 5 μ f. or larger, so that the effect at 60 c.p.s. will be equivalent to the action of C_1 at frequencies above 600 kc.

Calibration at 60 c.p.s. should be performed as follows:

1. Connect load to variable 60-c.p.s. source.
2. Connect reliable 0—1-ampere, a-c ammeter in series with load.
3. Connect a 10- μ f. capacitor across C_1 (negative end to crystal).
4. Adjust source for current flow of 1 ampere.
5. Mark meter scale for 1 ampere.
6. Adjust source voltage for current of .9 ampere.
7. Mark meter scale for .9 ampere.
8. Adjust source for current of .8 ampere.
9. Mark meter scale for .8 ampere.
10. Continue calibration, as above, to lowest desired value.
11. Remove the 10- μ f. capacitor.

This dummy antenna has been used quite successfully at several locations, and found to be far superior to the light-bulb load formerly used. In addition, it can be adapted with little difficulty to other equipments whose ratings do not exceed those of the T-14/TRC. Readings should be accurate down to frequencies as low as 600 kc. If operation at still lower frequencies is desired, the value of C_1 can be increased accordingly.

High-Frequency Power Measurement

By Gail W. Woodward
Headquarters Technical Staff

A discussion of some of the more common methods of h-f power measurement in modern use.

THE NEED for accurate r-f power measurement was recognized in the early days of electronics, and several methods of power determination were developed. These methods, which were based upon established methods used in the measurement of commercial power, worked out very nicely, *at first*. As the field of electronics advanced, however, the trend was toward increasingly higher frequencies, and the maximum frequency at which the older types of power-measuring equipment could be used was limited by the effects of distributed inductance and capacitance. By a process known as scaling, the physical size of the r-f components of the measuring equipment was reduced, thereby effecting a reduction in distributed inductance and capacitance; but since a linear, two-to-one reduction will only double the maximum frequency, this process has been abandoned in favor of newer techniques.

At the present time, there are a great many different types of power-measuring equipments in field service, but for some of these equipments, the principles of operation are not always readily available. It is the purpose of this article to discuss the principles involved in the more common types of high-frequency power-measuring equipment.

NEED FOR R-F POWER MEASUREMENT

The question often arises as to why it is necessary to accurately measure r-f power, since it is well known that a considerable loss of power does not materially reduce operating range. Accurate means of power measurement are desirable so that the service technician can tell when small *changes* in power

have occurred. A change in power level is always accompanied by altered operating conditions which, if continued, may lead to equipment failure. If an initial small change in operation is detected and corrected, an impending major failure may be avoided.

Accurate power-measuring equipment is desirable so that performance can be evaluated readily by comparison of measured power output with the manufacturer's specifications. Where several instruments are used interchangeably, all of them should have an equal degree of accuracy, so that they will give identical readings on the same measurement. Suppose that a technician has two voltmeters which give different readings for a certain voltage. As long as only one meter is used, a change in reading from one day to the next indicates trouble; but if the two meters are used indiscriminately, a change in reading on successive days does not necessarily indicate trouble.

DIRECT POWER MEASUREMENT

For low-frequency or d-c measurements, direct power measurement has proved to be very reliable. Where d.c. is involved, power can be measured simply by placing a current meter in series with the circuit, and a voltmeter across the load to be measured; the power is equal to the product of the voltage and the current. This method can be employed in lower frequency a-c circuits (if a-c meters are used); however, the voltage-current product produces what is called "apparent" power, which must be multiplied by the circuit power factor to give true power. The use of the moving-coil wattmeter simplifies this procedure by automatically including

the power-factor term, thus giving a true wattage indication.

Direct measurement of r-f current has been accomplished up to about 60 mc. by the use of the thermocouple meter. However, it is more difficult to measure r-f voltage, and still more difficult to establish power factor at high frequencies. Fortunately, most high-frequency power measurements are made at unity power factor, which allows the use of a simplified method. Figure 1 shows the circuit used to measure antenna input

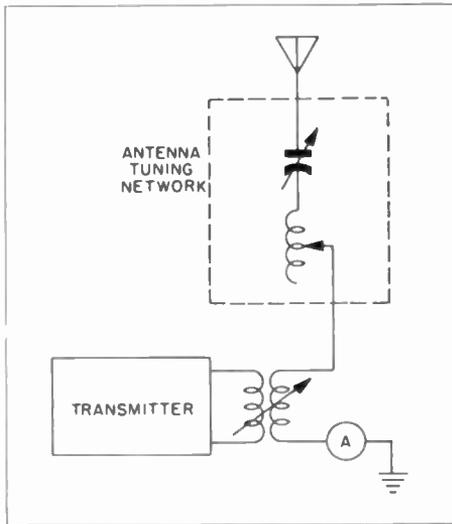


Figure 1. Circuit for Measurement of Antenna Input Power

power by means of a thermocouple ammeter. The power into the antenna (which must be tuned to resonance) is the product of the antenna resistance and the square of the current value. The reading is simplified by the use of a meter whose scale reads the square of the actual current value. This method is accepted by the FCC for use at broadcast stations; however, it is imperative that the antenna resistance be accurately known. Before the FCC will accept measurements on the above basis, some reliable measurement agency must accurately determine the antenna resistance.

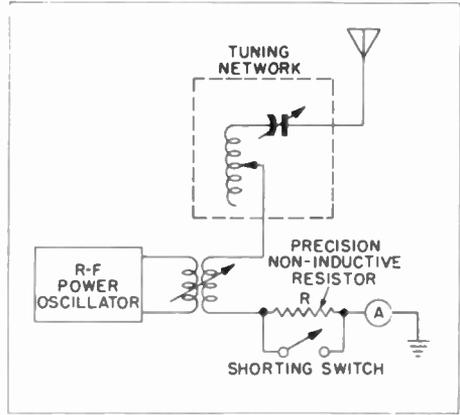


Figure 2. Circuit for Measurement of Antenna Resistance

This can be done with the aid of the circuit shown in figure 2. The method involves the use of a precision noninductive resistor, whose value is small compared to the antenna resistance, and a power oscillator.

The power oscillator is tuned to the frequency of the normal power source, and is loosely coupled to the antenna circuit, with sufficient coupling maintained to give a readable meter indication. The antenna is carefully tuned to resonance, with R shorted, by tuning the series network for maximum current. A reading of current is taken, which we will denote as I. R is inserted into the circuit and a second reading obtained, which we will denote as I_1 . The value of antenna resistance is calculated from the formula:

$$R_{\text{antenna}} = \frac{I_1 R}{I - I_1}$$

(This formula assumes that the induced voltage is constant for both current values.)

INDIRECT POWER MEASUREMENT

Direct, meter-type power measurement cannot be applied to frequencies in the UHF range or above; therefore, some indirect method must be used. A surprising number of indirect high-frequency power measurement methods

have been developed, but in general the basic method consists of causing the r-f power to heat an object, and then measuring the heat value by some standard method.

Lamp Load

A conventional electric lamp can be readily used as a power indicator, provided that it is matched to the power-source impedance. For example, a 28-volt, 4-watt lamp has a hot resistance of 196 ohms; therefore, three lamps in parallel will provide a 65-ohm load, and will produce a 12-watt dissipation at 65 ohms (if the lamps are not at full brilliance, the resistance will fall off). This combination is typified in the TS-78/U, which terminates a 50-ohm coaxial line (the mismatch is not sufficient to cause trouble). The brightness of the lamps provides an indication of power output. However, the power indication is very inaccurate, because the eye cannot accurately determine the intensity of light output. Figure 3 shows how the light output of a lamp varies with power,

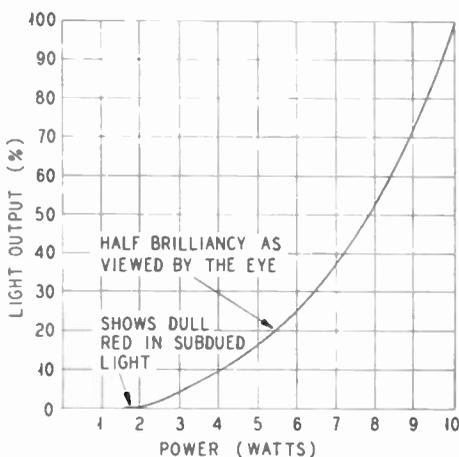


Figure 3. Graph of Light Output Versus Power, for a Typical Incandescent Lamp

and indicates the effect of nonlinear visual response to changes in brightness. The problem of accuracy can be resolved to a large degree by using the setup shown in figure 4. The important factor

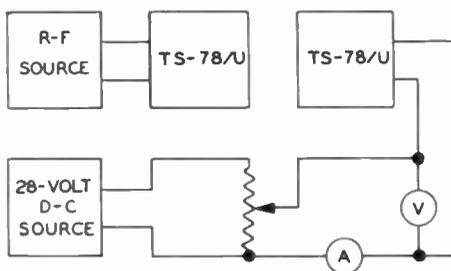


Figure 4. Lamp-Load Calibration Setup

is the use of identical lamp combinations (figure 4 shows two TS-78/U combinations). The two lamp loads are placed side by side, and the potentiometer is adjusted until all the lamps appear equally brilliant. Then the two meters are read, and the d-c power which is equal to the r-f power is calculated. This method is feasible because the eye can judge the relative brilliance of two light sources much more accurately than it can estimate absolute brilliance.

Different power levels require different lamp combinations. Two things must be considered: first, the total wattage rating should be greater than the power level to be measured; and second, the resistance of the combination should approximately match the impedance of the power source. For example, a No. 47 dial lamp has a hot resistance of 42 ohms, whereas a 40-watt, 115-volt lamp has a hot resistance of 330 ohms.

To eliminate the inaccuracies introduced by nonlinear visual response, several test sets using the setup shown in figure 5 have been developed. A lamp load is matched to the r-f input line by merely tuning the network for maximum light output. The light intensity is read by means of a photoelectric cell and a meter which is calibrated in watts, either directly or by means of a chart. To obtain multiple ranges, lamp banks of various ratings can be used with corresponding meter charts. One example

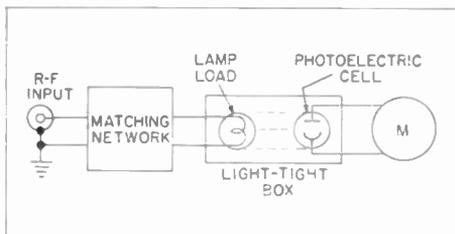


Figure 5. Photoelectric-Type Lamp-Load Power Meter

of this type of instrument is the TS-70/AP, which is accurate to within 10 per cent in the frequency range of 200 mc. to 750 mc. (when connected to a 50-ohm line).

Resistor Load

Power level can be determined by measuring the temperature rise in a resistor which is acting as a load for an r-f source. Resistors such as bifilar wire-wound or carbon types can be used, without tuning, to match an r-f line, or, as in the case of the lamp load, a matching network can be used to obtain the proper impedance. One common method of measuring the temperature rise in a resistor is to force a stream of air past the resistor, and, by the use of thermocouples, to measure the rise of air temperature (see figure 6). If the rate of air flow and the temperature rise are known, the power value can easily be obtained by chart or calculation. If the load resistor is contained within an airtight box and surrounded by an inert gas, it can be operated at high temperatures over long periods of time without changes in its characteristics. An example of this type of power meter is the TS-206/AR, which matches a 50-ohm line, and gives an accuracy within 10 per cent up to one kw. in the 60-mc. range.

Power level can also be determined with a resistor load by connecting a diode rectifier and a vacuum tube voltmeter across the resistor, and calculating the peak power value. Once the peak value is known, the average power can

be calculated, if desired, by multiplying the peak power by the duty cycle. This method is used in the TS-226A/AP, which operates in the 400-mc. to 500-mc. band; this instrument reads the power out of a 50-ohm line, and provides an accuracy within 15 per cent.

Bolometer

In the previously mentioned power-measurement methods, the highest useful frequency does not exceed the UHF range. Lamp loads have been applied to SHF measurements, but the loads are very delicate and are therefore difficult to produce in large quantities with any degree of uniformity. In the SHF range, the bolometer has become the standard of measurement. The bolometer works at any frequency below its maximum range; however, since it is relatively complicated to use, simpler methods are preferable at lower frequencies.

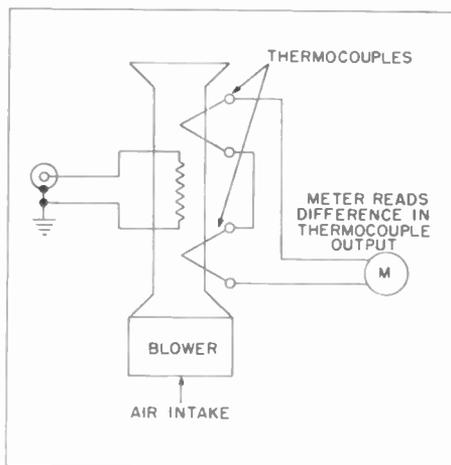


Figure 6. Resistor-Load-Type Air-Flow Power Meter

Two major types of bolometers have been extensively used: the barretter and the thermistor. The barretter consists of a very fine wire (usually tungsten) supported in an insulating capsule between two metallic ends. Its appearance is quite similar to a cartridge fuse; in fact, the earliest barretter was a meter-

type cartridge fuse. However, the cartridge-fuse version is crude, and its precision is low.

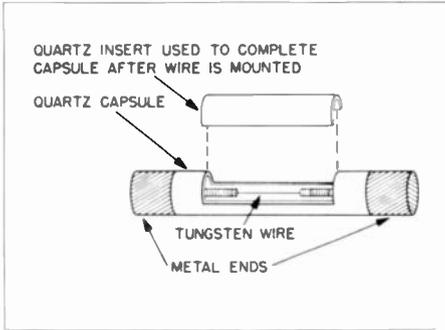


Figure 7. Typical Barretter

Figure 7 shows the structure of a typical barretter. The fine tungsten wire is supported between the two metal ends, which also serve as connectors. The quartz capsule, which protects the fine wire, is made in two parts, with the insert cemented into position after the tungsten wire is mounted between the end supports. For the barretter to react equally to r-f and d-c, the wire must be sufficiently fine to enable the r-f current to penetrate to the center of the conductor (in the SHF range, skin effect is very pronounced). In operation, the barretter is matched to an r-f line; the resistance of the wire is then measured in the presence of the r-f signal, and again without the r-f signal. The resistance change can be correlated directly with the amount of r-f heating present. The absolute power value is found by producing the same resistance change with a monitored d-c source; the r-f power then is equal to the d-c power. Normally, the barretter is made part of a bridge circuit containing a meter whose scale is calibrated directly in power. It is interesting to note that the barretter is very nearly a square-law detector (in terms of power versus resistance).

The thermistor has been developed to a high degree of precision, as is evidenced by its wide use. Figure 8 shows

a typical power-measuring thermistor of the bead type, which uses a semiconductor as the active material. The bead of active material is small enough to allow r-f penetration to its core, and is supported by fine conducting wires inside a glass capsule. Heavy pigtail leads are imbedded in each end of the glass capsule, to serve as terminals and also to support the entire assembly. Thermistor action differs from barretter action in that thermistor resistance decreases with the application of r-f power, whereas barretter resistance increases (positive temperature coefficient is characteristic of metals).

The negative temperature coefficient of resistance of the thermistor is highly desirable, since this property reduces the possibility of power burnout. If excessive power is applied to a thermistor, the resultant drop in resistance will cause an r-f mismatch, thus reducing the efficiency of power transfer to the point where burnout is less likely to occur.

The thermistor element is normally included as a part of a bridge circuit as is the barretter. The thermistor bridge may also contain other thermistor elements, called compensating thermistors, which react to ambient temperature changes to maintain bridge balance over a wide temperature range. Compensating thermistors are usually made in the form of a disk which can be mounted upon a flat metal surface such as a chassis or wave guide. Since the theory

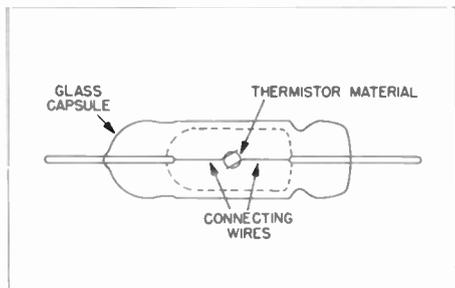


Figure 8. Bead-Type Thermistor

of the compensated thermistor bridge is developed in detail in currently available manuals, a discussion of bridge circuitry is omitted here.

Attenuation

The thermistor and barretter are essentially low-power devices because of their small physical size. It is standard practice to operate a thermistor at a power level of about one milliwatt; therefore, additional equipment is required for high-level power measurement. The use of calibrated attenuators has greatly extended the range of the thermistor bridge. The most common attenuator consists of a section of wave guide operating at a frequency well below cutoff. The length is made adjustable, and the wave-guide section is excited and terminated by coaxial feed lines. The attenuation of a length of wave guide operated at a frequency below cutoff is roughly 30 db per unit width, and is linear in terms of db versus length, except for very low values of loss.

When a calibrated attenuator is used with a thermistor bridge, it is standard practice to attenuate the input signal to some known reference level, such as 1 milliwatt or 6 milliwatts. If the attenuation level is known for a standard output, the input power level is easily calculated. When using the 1-milliwatt reference level, the power can be expressed in terms of dbm (decibels relative to 1 milliwatt).

The resistive-type wave-guide attenuator has achieved a high degree of precision in the last few years, and is now being widely used. This type usually consists of a glass strip coated with a thin film of platinum (or some other stable metal), located within a section of wave guide. The strip extends along the wave guide, and is moved laterally by means of a spring-loaded cam or lead-screw drive mechanism. The control shaft which moves the strip also drives a dial which is calibrated in

units of attenuation. Currently available models have a maximum range of 40 db (with an accuracy of .5 db) as compared with cutoff wave-guide attenuators, which do not have comparable stability or accuracy, but can easily achieve a range of 100 db.

HIGH-POWER MEASUREMENT

The development of modern radars, with their high-level power output, imposed a need for new microwave measurement devices capable of handling the high power. (If the output of even a small airborne radar is fed directly into a thermistor, the thermistor element will promptly burn out; if it is fed into an attenuator, the attenuator element will overheat, resulting in either complete disability or serious changes in performance.)

One technique used in high-power measurement makes use of a sampling device which removes a small, known percentage of the total power for monitoring purposes, so that the power meter operates at a low level. Some of the more commonly known sampling devices are the pickup antenna, r-f probe, power divider, and directional coupler. When a sampling device is used, it is imperative that the coupling loss be accurately known, and, if possible, that the loss be of a constant, stable value (these characteristics are readily achieved in the directional coupler).

Direct measurement of high-level microwave power has been most effectively

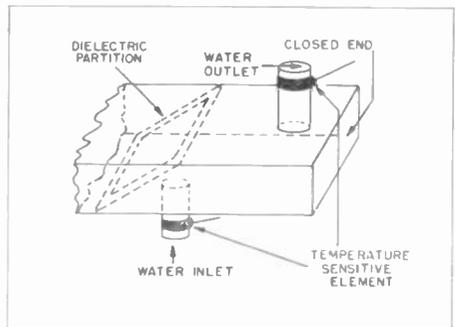


Figure 9. Water-Load Power Meter

accomplished by means of the water load, which is shown in figure 9. A section of wave guide is made watertight by means of a dielectric partition which is usually slanted across the wave guide so as to present a tapered surface to power flow, and thus minimize reflections. Water is circulated through the load at a carefully measured rate, and is heated by power absorption. To insure complete power absorption, a matching network is usually included in the wave-guide system; the matching network is adjusted for minimum reflected power, with the aid of standing-wave measuring equipment. The temperature of the water is monitored at the entry and exit points of the load, and the difference is carefully noted. By knowing the volume of water and the temperature rise over a given period of time, the power can be calculated with the aid of formulas found in any basic physics book. The above method is quite accurate, but, because of its complexity, is used only for calibration purposes.

Figure 10 shows a somewhat cruder method used to measure high-power microwave energy. This device, called a gas load, consists of a section of wave guide filled with ammonia gas which is enclosed by means of a dielectric window similar to that employed in the water load. A manometer tube, filled with colored kerosene, is attached to the wave guide for the purpose of measuring the gas pressure. Again, as in the case of the water load, a matching device insures complete power absorption. The temperature rise in the gas results in an increase in pressure, which pushes the manometer fluid higher on the pressure scale. The rise in pressure can be calibrated directly in terms of power.

Another method of measuring high power involves the use of a sand load which contains a temperature-sensitive element. The sand load is a section of wave guide (or coaxial line) filled with a mixture of sand and aquadag. When

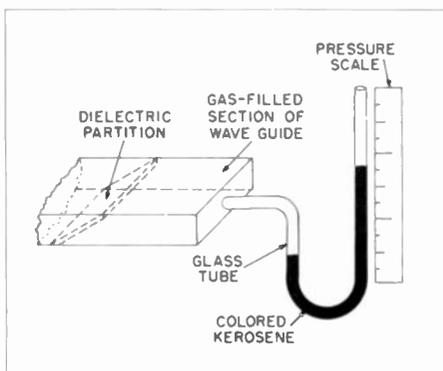


Figure 10. Gas-Load Power Meter

the correct percentage of aquadag is used, and the surface of the sand is tapered, this type of load will operate quite effectively without matching. A temperature-sensitive element, placed in thermal contact with the sand, is used to indicate the temperature rise of the mixture; this temperature change can then be converted to the power value. Notice that this method is quite similar to the resistor-load and air-flow method used at lower frequencies.

NEON-LAMP POWER METER

A neon lamp can be used to indicate the voltage across a matched load, and thus give an indication of power. However, this method is not widely used, since its accuracy is poor, and since there is considerable variation in the characteristics of neon lamps. It is relatively easy to construct a neon-lamp power meter that can give relative power indications that are fairly reliable. If calibrated, this type of meter can furnish power-output indications with sufficient accuracy for maintenance testing.

Figure 11 shows an easily built neon-lamp power meter which uses conventional parts. If the wave-guide sections are not available, they can be constructed from sheet copper or brass. The wave-guide horn pickup is not critical; an opening of about three inches square will give good results in the X-band. The neon lamp can be any standard type, such as the NE-2 or the NE-51

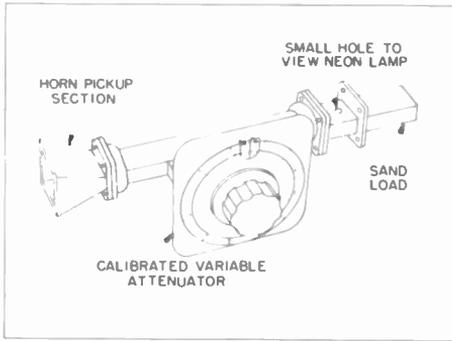


Figure 11. Neon-Lamp Power Meter

with its base removed. Cement the neon lamp in the center of the wave guide, directly under the viewing hole, with polystyrene cement. The size of the wave guide will be determined by the frequency in use ($\frac{1}{2}$ " x 1" O.D. for X-Band).

To operate, proceed as follows: (1) locate the assembly about one radar-ish

diameter directly in front of the radar antenna. (2) orient the horn so that its polarization agrees with that of the radar. (3) reduce the attenuation until the neon lamp lights. (4) increase the attenuation until the lamp just goes out, and (5) read the attenuator dial. The dial indicates relative power unless calibrated with a reliable test set. If daily readings are taken under similar conditions, any loss of r-f output will be indicated by a reduced final attenuator reading.

For use with low-powered c-w transmitters, the power meter can be made much more sensitive by removing the neon lamp and replacing the sand load with a matched crystal detector. A meter or scope can be used to adjust the attenuator to obtain some standard indication (the meter can be used for c-w signals, and the scope for AM signals).

IN COMING ISSUES

Readers who have been looking forward to the two articles mentioned in this column last month have no doubt noticed that those articles are not contained in this issue. They were "Slide-rule Techniques for the Engineer," by Lt. Col. William B. Wrigley, and "Cable Practices for the Radio Station," by Murray M. Elson.

A number of unexpected last-minute production problems were encountered in the preparation of these articles, so we decided to hold them for the December issue in order to give them proper treatment. We trust that the authors and our readers will forgive us.

Next month's issue will also contain a fascinating article by Mr. Spencer Ross, Ass't Engineer, Systems Engineering Group. The article describes the Platte Pipe Line Company's new ultra-modern microwave communications system, which was designed, engineered, and installed by Philco. The system incorporates 41 microwave stations spaced over a distance of nearly a thousand miles, between Casper, Wyoming and Wood River, Illinois, and is functionally the most complex system yet devised by the industry.

An Air-Transportable AN/MPN-1

By George Bluhm
Philco Team Leader, FEAMCOM

A description of modifications made on an AN/MPN-1 unit, and the special loading and unloading procedures necessary to transport the unit by air.

Editor's Note: Photos in this article are included through the courtesy of the United States Air Force (FEAMCOM).

THE PROJECT of making an AN/MPN-1 radar set air-transportable was assigned to the GCA Overhaul Shop at FEAMCOM. It was necessary, in this case, that every effort be made to reduce the weight of the equipment, and to provide for rapid disassembly and reassembly of component parts. The largest available planes which could be handled by the airfields in the theatre were C-119 Flying Boxcars, the payload of which varies with the distance and the altitude at which the plane must fly. By actual measurement, it was found that the cargo compartment of a C-119 has a side-to-side clearance of 110 inches, and a bottom-to-top clearance of 96 inches when the heater ducts were removed. Since the plane was more than long enough, no measurements of length were made.

The standard prime mover used with the AN/MPN-1 is 97 inches wide and 122 inches high, and weighs 24,125 lb. The trailer, or van, is 96 inches wide and 130 inches high, and weighs 22,500 lb. with the equipment installed. Thus, the 110 inches of width in the C-119 cargo compartment was sufficient, which simplified the problem to one of reducing the heights of the prime mover and trailer to less than 110 inches, and of reducing the weight of each unit to the limit which the plane could carry.

The standard 6x6 4-ton prime mover was replaced with a 6x6 2½-ton prime mover, and two PE-95 power units

were mounted on it to replace the PE-185B power unit originally used with the equipment. (The smaller prime mover was considered adequate, since the unit was to be flown to the base at which it was to be used, and no long or difficult hauls were expected.) The results of these changes were a reduction in height to 92 inches (with top and bows removed), and a reduction in total weight to 14,000 lb. A further reduction in weight is possible, when necessary, by transporting the two PE-95's and the air conditioner separately.

Examination of the van revealed that if the body were removed from the chassis, the height of the body would be approximately 96 inches. This allowed no clearance, and made it almost impossible to load the body into the aircraft, since perfect alignment of the plane and body could not be maintained, and since there would be no room for rollers. The solution to this problem was found after disassembly of the body was started.

The interior of the body was completely dismantled; all components, racks, and wiring were removed, and

Figure 1. Close-Up View of Trailer Chassis with Body Raised





Figure 2. Body Being Lifted by Crane

the trailer was then taken to the body shop. There, all siding and roofing were removed, leaving only the chassis and the body framework intact. At this point, it was found that an additional 5 inches of height could be eliminated from the van body by removing its bottom-outside frame, and leaving it fastened to the chassis, as shown in figure 1. A new frame was built into the bottom of the body, and the framework of the sides and top were reinforced so that the unit could withstand the necessary lifting. Four lifting hooks were built into the top of the body at this time, as shown in figure 2. The body was fastened to the chassis by six bolts, two on each side and two at the rear. Figure 1 shows the small doors which give access to the bolts. One of the doors can be seen at the lower-left corner, and another can be seen at the center-bottom of the body. The two rear bolts are reached from underneath, through the doors in the chassis frame.

The only wiring changes necessary were the rerouting of the commercial-power input cable to the power-distribution panel, and the changes in wiring to the hydraulic motor. This wiring was changed from fixed-conduit wiring to a standard outlet box with flexible wire and a plug. (This was necessary because the motor and hydraulic system are mounted on the chassis.) The ar-

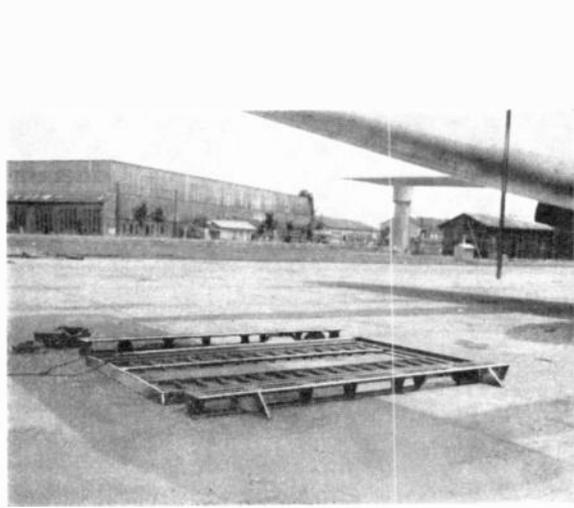


Figure 3. Girders and Roller Frame

rangement works very nicely, because it permits the use of the trailer jacks to level the body with the plane, simply by running an extension cord from one of the prime-mover power units to the hydraulic motor.

An iron framework with built-in rollers was constructed, as well as two girders to act as tracks for the rollers. Portions of the girder body were cut out to reduce the weight. Figure 3 shows the construction of the girders and the roller frame. The combined weight of the roller frame and the body, with all radar and communications components removed, is 11,300 lb. The height of the body, with the elevation-compartment cover removed and resting in the roller frame, was reduced to 94 inches by these modifications.

To load the body into the plane, the trailer is backed to within 10 feet of the plane's tail, as shown in figure 4. Then the rear jack chains, the hy-

Figure 4. Unit Being Backed-Up to Tail of Plane



draulic-motor cover on the chassis, and the chair wells at bays 3, 4, and 6 in the plane are removed. Two braces are installed from the floor to the ceiling of the body, the elevation-compartment cover is removed, and the covers to the lifting hooks are opened. The six bolts holding the body to the chassis are removed, as well as the two channel plates to the rear of the front wheels, and the body is raised by a crane or large wrecker, as shown in figures 1 and 2. Then the girders are slid onto the chassis and bolted down, as in figure 5.

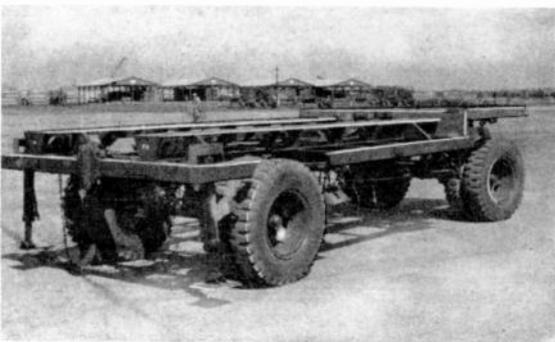


Figure 5. Trailer Chassis with Girders and Rear Pulley in Place

At this time, the front and rear cable pulleys are attached to the chassis, and the winch cable is threaded around the rear pulley and carried to the front. The roller frame is then placed on the girders, the body is lowered onto the frame (figure 6), the lifting cables are removed, and the lifting-hook covers are closed. Note that the roller frame is constructed with T-shaped angle iron in such a manner that the body rests on the frame, and not the rollers. The outside edge of the frame comes up around the body, so that the frame and body are centered with each other at all times. The winch cable is then fastened to the eye bolt at the front-center of the roller frame. Two small U-clamps are dropped over the front edge of the frame and the chassis, to keep the body from moving while the chassis



Figure 6. Unit Ready to Be Pushed into Plane

is being backed up to the rear of the plane. This backing of the chassis into the plane is best accomplished by manpower, because the alignment is very critical. The body must be perfectly aligned with the plane before beginning the backing operation, because once the process starts, there is no means or room to change the direction in which the body moves (see figures 7 and 9).

The rear hydraulic jacks of the chassis are used to level the roller bed with the plane bed. The height of the girders was designed to be 2 inches below the plane bed, under average conditions, because it is easier to jack up the chassis than the plane. The U-clamps are then removed, and the body is winched onto the plane, as shown in figure 8. The winch is a small hand winch permanently mounted to the chassis, behind the right-front wheel. Figure 9 shows the small amount of

Figure 7. Aligning Unit with Plane



clearance between the body and the plane.

After the winch cable has completed its travel, there are approximately 6 feet of the body extending out of the plane. The chassis is then pulled out of the way, and the prime mover is used to push the body into the plane by means of a 4" x 4" block of wood, 5' to 8' long (figure 10). A block and tackle can also be used to pull the body into the plane. In unloading, the reverse procedure is used, except that the winch cable does all of the removing, regardless of how far into the plane the body is placed.



Figure 8. Winching Body into Plane

A second C-119 is used to carry the chassis and the girders (combined weight 7,715 lb.), and the radar components. The radar components are packed separately, in boxes designed to hold them securely yet allow their rapid removal. No special account of the loading of the prime mover or chassis is given, since standard ramp loading can be utilized.

It is estimated that this unit can be flown to an air base and readied for operation within three days after landing. The actual time required to load or unload the entire equipment is approximately 3 hours. The time required to unpack or box the components is about 5 hours. The normal crew required for the entire loading, unloading, and cer-

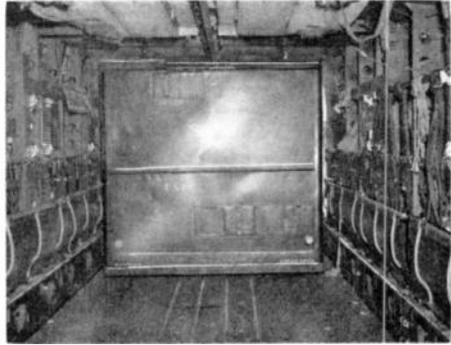


Figure 9. Interior View of C-119 with Body in Place

tain procedures (with the exception of placing the roller frame in position) is 5 men. Because of the weight of the roller frame, it is more easily managed by 10 or 12 men, although the job can be done by a smaller number.

After this method of making an MPN-1 air-transportable proved practical, thought was given to the possibility of improving the project. At present, the main drawback is the difficulty of obtaining a large wrecker or crane for raising the body at the proper moment. It is believed that time will be saved and the operation will be more independent if another method of raising the body is provided. Plans are being made to use jacks or a lever arrangement at the four corners of the body and chassis on future projects.

(Continued on page 24)

Figure 10. Prime Mover Pushes Unit Fully into Plane



A New High-Gain U-H-F TV ANTENNA

By Lloyd O. Krause,
Development Engineer
Electronics Department, General Electric Company

A discussion of the theory and design characteristics of a practical helical antenna system for use in the u-h-f region.

(Editor's note: This article was originally published by the General Electric Company, as an Engineering Brochure (#X54-126) and appears in the BULLETIN through the courtesy of that company.)

We feel that the information in this article is of wide interest to field engineers, since the concept of helical antennas is a relatively recent development. A great deal of research has been and is being done on the action of the helix, and the future holds great promise of interesting developments, as is evidenced by this unique antenna.)

A CONSIDERED PRIME requirement for any u-h-f television antenna is that of providing high gain. Such gain may be achieved in the u-h-f range of frequencies without undue physical size, because of the short wavelengths. A further requirement is that of fairly uniform azimuth pattern. The high gain desired, coupled with a uniform azimuth pattern, requires a beam of narrow angle in the vertical plane. The main problem becomes one of providing a properly excited aperture of many wavelengths, with a minimum of feed complexities. The narrow beam also requires a physical antenna support, including tower and mast, of sufficient rigidity to prevent excessive swaying of the antenna in high winds.

APERTURE EXCITATION

Normal antenna bays, as used up to this time, provide a power gain on the order of unity per bay. Since power gains on the order of 20 are of interest, about that number of bays are required to provide aperture excitation. The large number of feed points needed becomes a mechanical and electrical problem. Stray terminal effects assume increas-

ing importance at higher frequencies, and increase the difficulty of impedance-matching and obtaining uniform power distribution.

To reduce the number of bays, and feed points, it is necessary that each feed provide illumination of an appreciable portion of the total aperture required. A group of resonant antenna currents may be induced from a single feed point. However, a long resonant structure has a very steep reactance slope, with severe limitations in impedance bandwidth. Then, too, there is the added complication of phase-inverting stubs.

Alternatively, a large portion of the aperture may be illuminated by means of a traveling wave. The limiting factor in bandwidth here will be the "beaming-bandwidth," because of the relative phase shift occurring along the wire's length as the frequency is changed. This bandwidth determines the amount of aperture that may be excited from a single feed.

THE TRAVELING-WAVE, HIGH-MODE HELICAL RADIATOR

The antenna described in this article uses the traveling-wave principle to excite a large aperture from a single feed. Further, this traveling wave is made to suffer rather high attenuation, because of radiation loss. The far end of the conductor may be left open or shorted, rather than terminated, with negligible effects from the reflections occurring at the unterminated ends, because of the small amount of energy remaining in the wave at this point. Thus, each por-

tion of the wire serves simultaneously as a radiator and as a feed for successive portions.

Since horizontal polarization is desired, it is necessary for the traveling wave of current to have its greater component in the horizontal plane; yet some vertical travel must be achieved in order to secure the required vertical aperture. A helix can meet these requirements if its pitch and diameter are properly controlled.

The helix must meet certain dimensional requirements as necessitated by the frequency. The currents at like points in each turn of the helix must be in phase. This means that the current, in progressing from turn to turn, must be delayed for each turn a time equal to that consumed by an integral number of cycles. In other words, each turn must be an integral number of wavelengths in helical circumference, as measured at the velocity of propagation along the helix.

It is necessary, of course, to support this helical radiator, preferably with a strong metal mast. The spacing of the helix from the mast must be such that an appreciable amount of radiation loss will occur along each turn of the helix. The total length of the helix must be adjusted, commensurate with the loss per turn, so that the order of resonance due to end reflections is low enough to avoid the partial clover-leafing of the horizontal pattern which results from the resonant-current component. The active length of the helix must not be so great that the beaming bandwidth is too narrow, because of progressive phase shift, yet long enough that a fair portion of the total aperture is illuminated by one feed.

The operation of the helix can be analyzed by studying the radiation from one turn, and then applying well-known array factors to sum up the effect of all the turns. Therefore, preliminary studies were made of the radiation occurring

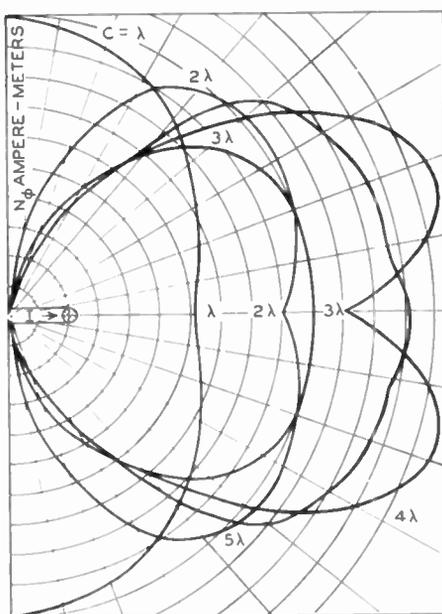


Figure 1. Calculated Vertical Patterns from One Turn of Integral-Mode Helix. Pitch and Attenuation Equal to Zero, Patterns Shown Up to Fifth Mode (Only Half of Patterns Shown)

from one turn, in perfectly general terms; the integral mode case was then studied further for the simplified case where the helix pitch angle and attenuation are zero. For the integral mode case, the helix turn is an integral number of wavelengths, the mode number corresponding to the number of wavelengths. Figure 1 shows the calculated results for the vertical pattern up to modes including the fifth. Note that the one-wavelength mode radiates quite uniformly in most directions, but better along the axis than in its plane. This is the mode commonly used in the presently well-known end-fire helices of circular polarization.

The one-wavelength mode does not lend itself to practical mast support. The strong loop field passes directly through the center of the loop, and a large metallic member causes serious disruption of normal operation. By using a higher-order mode, where the field at the center

is zero, and where the diameter per turn is large enough to permit a sufficiently strong support without seriously disturbing the operation, the desired radiation characteristics can be obtained.

turn for the unattenuated case shows that the azimuth pattern is independent of azimuth angle or helix pitch in the plane at right angle to the helix axis, or the horizon. However, the pattern

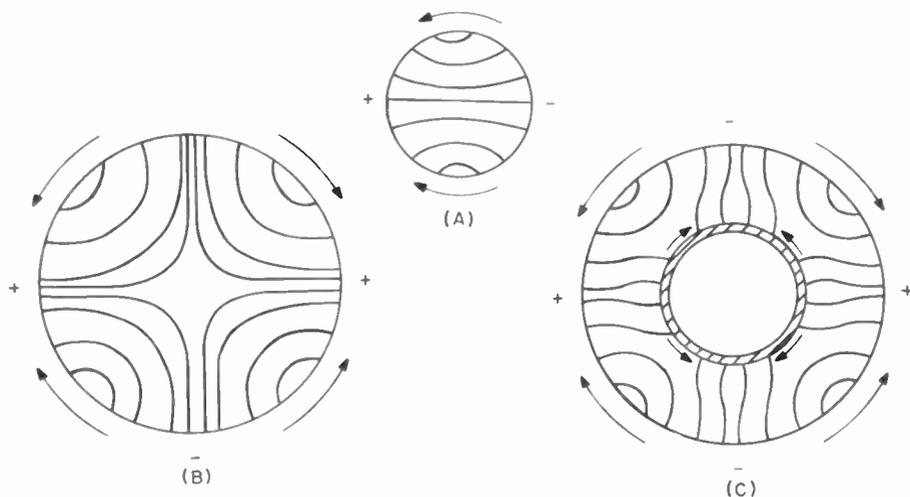


Figure 2. Instantaneous Fields in One Turn of a Helix

- a. First Mode Without Mast
- b. Second Mode Without Mast
- c. Second Mode With Mast

Figures 2a and 2b show sketches of the instantaneous fields existing in one turn of a first-mode and a second-mode helix; figure 2c shows the second-mode helix field after a mast of the required supporting size (for a power gain of 20) has been inserted, for strength reasons, along the axis. The fields of the one-turn helix would induce large counter currents in a mast the size of that shown in figure 2c. Also, the net radiation loss per turn, because of the close spacing, would be too small to permit the construction of a practical attenuated-traveling-wave antenna. The fields in the second-mode helix are not seriously disturbed, and the mast counter currents are proportionately reduced. The radiation loss per turn is now large enough to result in a useful attenuated traveling wave. The mast size may now be adjusted to provide the desired loss per turn.

The mathematical analysis of one

gradually becomes scalloped as the vertical (parallelism with the helix axis) is approached. The depth of scalloping is a function of the helix pitch angle (no scalloping occurs with zero pitch angle). The scalloping is insignificant in the region of the horizontal beam produced by a practical helix.

Naturally, there is some component of vertically polarized radiation from the helix because of the helix pitch, and when based on the analysis of a single turn, the percentage of this component is appreciable. However, by making use of a right- and a left-hand helix, placed end to end, and fed in the center, the vertical components can largely be made to cancel, while the horizontal components are reinforced. By use of this system, it was found by actual measurement that the power going into the vertical component reduces the horizontally polarized power gain on the order of 7 to 10 per cent. This means, for ex-

A 4-BAY HELICAL ANTENNA WITH A POWER GAIN OF 20

The high-gain antenna is made of four vertically stacked bays, each having a power gain of 5. Most of the initial development work was done on models in the 1000- to 2000-mc. region, to facilitate construction and handling. A close-up of one bay of the 4-bay antenna designed for operation at 500 mc. is shown in the photograph of figure 3. Since all four bays of the high-gain antenna are electrically identical, only one bay will be described in detail. Operation in the second mode was found to satisfy all electrical and mechanical requirements; that is, each turn of the helix is 2 wavelengths in circumference at the velocity of propagation along the helix. The antenna has thus come to be called a second-mode side-fire helical antenna.

The length of one bay is 5 wavelengths. This length also corresponds to the distance between feed points of the four bays. A series feed is used, and the distance between feeds is an integral number of wavelengths to yield inphase feeding of the four bays. The 5-wavelength bay spacing results in a near-optimum array factor for the particular pattern produced by one bay.

Figure 4a shows the vertical pattern produced by one bay. Note that sidelobes are lacking, in spite of the fact



Figure 3. One Bay of a 500-Mc. Antenna ample, that a helical antenna with a power gain of 20 would have an equivalent power gain of about 22 if the vertical component were not present.

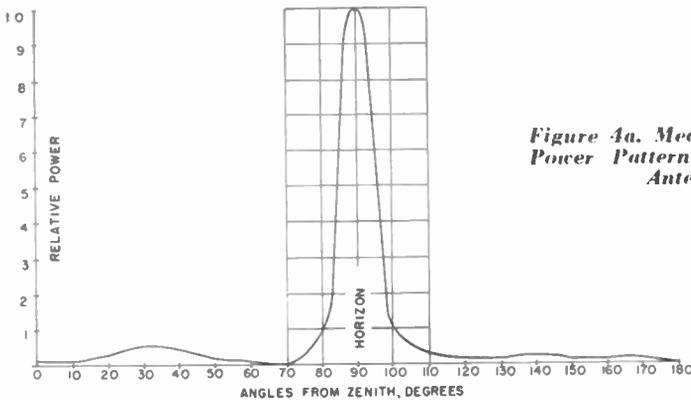


Figure 4a. Measured Vertical Power Patterns of One-Bay Antenna

that each bay in itself is in reality a multibay array. This results from the exponential energy distribution over the aperture of one bay. Figure 4b shows the measured horizontal pattern of one bay.

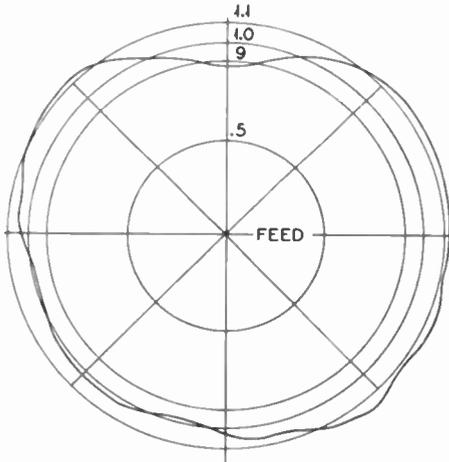


Figure 4b. Measured Horizontal Power Pattern of One-Bay Antenna

A right-hand and a left-hand helix are used in each bay. Each helix has five turns. The two helices are placed end-to-end, and are fed at their junction, which is in the center of the bay. The use of center feed for each bay prevents beam tilt from occurring in the beam of the basic bays as the frequency is changed. The upper and lower portions advance and retard in phase together, keeping the maximum field on the horizon. However, the beam width will increase, resulting in a net reduction of gain. The beaming bandwidth is defined as the total separation between the two frequencies where the power level, measured at the half-power point at the design frequency, has increased 1 db. For television purposes, it was decided to make this bandwidth on the order of 20 megacycles, to insure that over the channel the gain variation would be negligible. The beaming curve has a rather flat bottom; the channel under consideration may be placed on this flat portion. Once the beaming

bandwidth is specified, the maximum gain per bay is fairly well established.

The use of the right-hand and left-hand helices reduces the vertical polarization to a tolerable amount. Feeding the two helices in parallel also has the advantage of reducing the feed resistance per bay to a more convenient value.

By estimating the attenuation, and calculating the surge impedance, it was found that the net distributed radiation resistance per turn is on the order of 100 ohms. In the u-h-f range, even such a high value of distributed resistance results in an insignificant phase angle in the surge impedance of the helix.

The helices are supported by "Kel-F" insulators. This material has excellent mechanical and weathering properties, combined with a very low dielectric constant. A low dielectric constant is desirable to prevent reflections at the support points. The loss factor is high compared to polystyrene or Teflon, but not high enough to cause sufficient loss to damage the insulators, even with 10 kilowatts fed into one bay. There are, of course, no resonant high-voltage points to cause trouble. The ends of the helix may be grounded to the mast to provide lightning protection.

The 500-mc. unit with a power gain of 20 has an over-all height of 41 feet above the tower top.

The vertical pattern of a typical 1000-mc. model is shown in figure 5. Note that three upper and three lower side-lobes now exist in the vertical pattern. They are, however, theoretically and measurably small, as shown.

The intrabay feed system is coaxial, with the mast itself serving as the outer conductor. The inner conductor is shorted to the mast a quarter-wave above the top-bay feed, for mechanical support and r-f isolation of the remaining part of the mast. The main-line input at the bottom of the antenna is designed for 3 1/8-inch line. This input enters the mast from the side through a

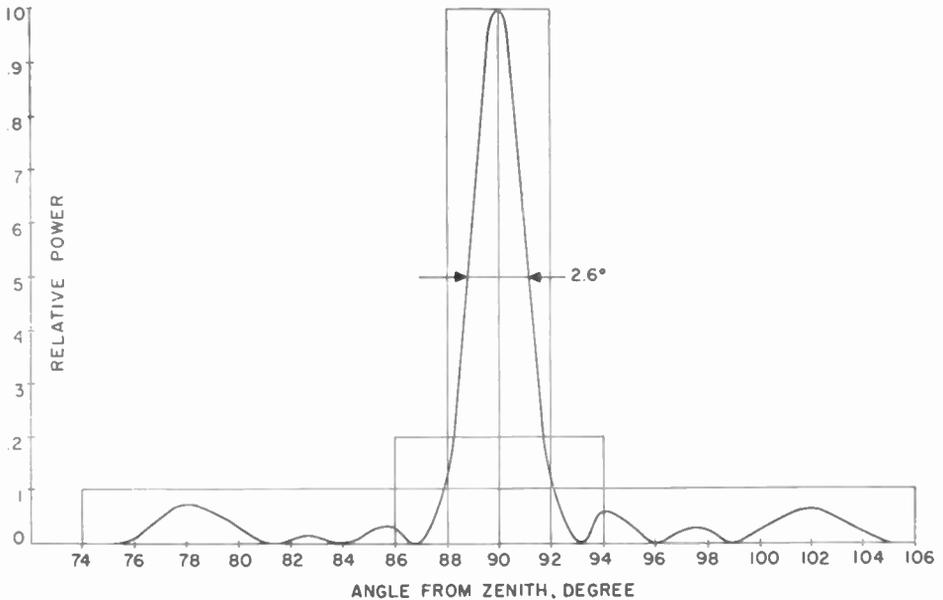


Figure 5. Measured Vertical Power Pattern of Four-Bay, 1000-Mc. Antenna

special compensated "T". The inner conductor is again shorted to the mast a quarter-wave below this input.

The individual bays are probe-coupled to the inner conductor, without making direct connection. The individual probes are adjusted so that each bay receives one-quarter of the input power. Impedance-matching is maintained throughout the mast coax to insure maximum impedance bandwidth.

The hollow inner conductor is of adequate size to permit the beacon lighting cable to pass directly up through it. Thus a means is provided for running this cable without danger of disturbing antenna operation, which might occur if the cable had to be run outside the mast.

The series type of feed system used results in over-all beam tilt when the frequency is shifted far enough from center. However, over one television channel the amount of tilt is inconsequential.

For very high installations it may be desirable to tilt the beam downward so as to graze the horizon, because of the narrow beam. With this antenna, beam tilt to the small amounts desired can be

simply accomplished without disturbing the impedance and power distribution. Since the currents on the antenna are of the traveling-wave type, the instantaneous phase is a function of azimuth; therefore, by mechanically rotating one portion of the antenna relative to the other portion, beam tilt can be produced, because the relative phase between the bays is thereby effectively changed.

Sleet-melting is accomplished by running sufficient 60-cycle current through the helix copperweld conductors. The sleet-melting current is run through all the bays in series. The antenna is grounded only at the upper end of the top helix; therefore, the a-c voltage is applied directly to the lower end of the bottom helix.

CONCLUSION

The sidefire helical antenna offers simplicity of construction for the high gain achieved. This results from excitation of an appreciable aperture by a single feed. A radiation-attenuated, traveling-wave helical current produces the excitation. The rate of attenuation is controlled by helix-to-mast spacing.

The Power of Sound

The lungs and the muscles used in breathing provide the source of power for speech sounds, and thereby control, to a considerable extent, the loudness of the emitted sound. The amount of power used in speech is surprisingly small, however. The vowels, which are the most powerful speech sounds, average about 100 microwatts, with peak values of about 2000 microwatts. The voices of persons capable of very loud speech may reach peak-power values of 5000 microwatts. On the other hand, the minimum instantaneous speech power is probably about 0.01 microwatt, and occurs when the sound "th" is pronounced. Therefore, a telephone system must be capable of handling a range of speech intensity of 500,000 to 1 (57 db). For ordinary conversation, the range is considerably less, being approximately 10,000 to 1 (40 db).

The power used in the production of music is much greater than that used for speech, varying from about 4 microwatts for a softly played violin to nearly 70 watts for a full symphony orchestra. Thus, the intensity range for music is about 20,000,000 to 1 (73 db).

Based on studies of a number of individuals, the average power used in American speech is 10 microwatts; therefore, if a million people were engaged in conversation simultaneously, their combined average speech power would be approximately equivalent to that consumed by a 10-watt electric light bulb. It has been humorously stated that the minimum energy required to produce an audible sound is equivalent to that exerted by a small flea walking a horizontal distance of one centimeter.

Eugene J. Nathan
Tech. Publ. Dept.

ERRATA—October issue, page 31, first column: The word "transistor" is misspelled four times in the book review of "Electrons and Holes in Semiconductors." (At least we were consistent.)

Same issue, page 33, figure 1: The battery is 22.5 volts, not 225 volts. The note on the right side should read "2 120-volt, 100-watt lamps (series)".

Same issue, page 34, bottom of page: "Stewart" Air Force Base should read "Sewart." (Our apologies to Lt. Col. Wrigley, and to Sewart AFB.)

Transportable AN/APN—1

(Continued from page 17)

Changing the method of raising the body would also eliminate the necessity for part of the side bracing and all of the top bracing.

Complete blueprints of the changes necessary are kept on file at the GCA Overhaul Shop, Communications & Electronics Section, Building 340, Hq.

FEAMCOM, APO 323, c/o Postmaster, San Francisco, California, and are available through the proper military channels. Credit for the completion of this project is due Phileo Field Engineer Leo Razaitis, who was in charge from start to finish. M/Sgt. Cranford, of the Showa Body Shop, draws honorable mention for his excellent suggestions and his spirit of cooperation.

SCR-527

Receiving Antenna Modification

By Robert S. Brown
Philco Field Engineer

Modification of the receiving antenna to improve operation on a frequency other than the design frequency.

THE SCR-527, produced late in 1943, was patterned after the SCR-588, but was mounted on trucks to give the set greater mobility. Designed to operate between 206 and 212 mc., it had a detection range of approximately 80 miles in GCI operation, and approximately 100 miles in search operation. The chief distinction of this set was its two antennas: one used for transmitting, and the other for receiving. Each antenna consisted of 32 dipoles connected in such a manner that the upper and lower halves were either in phase or out of phase with each other, for purposes of gap-filling or height-finding.

Recently a number of SCR-527's were turned over to the Air National Guard, for Aircraft Control and Warning Squadrons, and a modified training frequency between the top TV channel and

the 220-mc. ham band was assigned. This higher frequency, outside the design band of frequencies, caused considerable mismatch in the antenna system. Eight matching stubs were provided on the old receiving antenna, for tuning purposes, and each stub had three possible adjustments. Lacking proper test equipment to tune the antenna, it was found simpler to construct a new antenna designed for the new frequency.

After considerable experimentation, four corner-reflector arrays were rigged up on top of the existing antenna in such a manner that either the old or the new antenna could be connected to the set very quickly, for comparison purposes. The dimensions for the corner reflectors were obtained from the ARRL Antenna Book, 1949 edition, page 212.

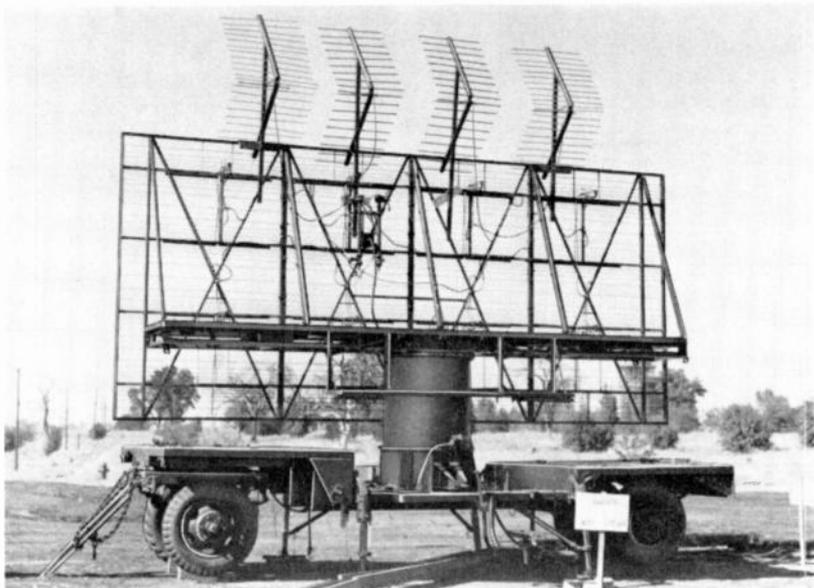


Figure 1. Modified SCR-527 Antenna

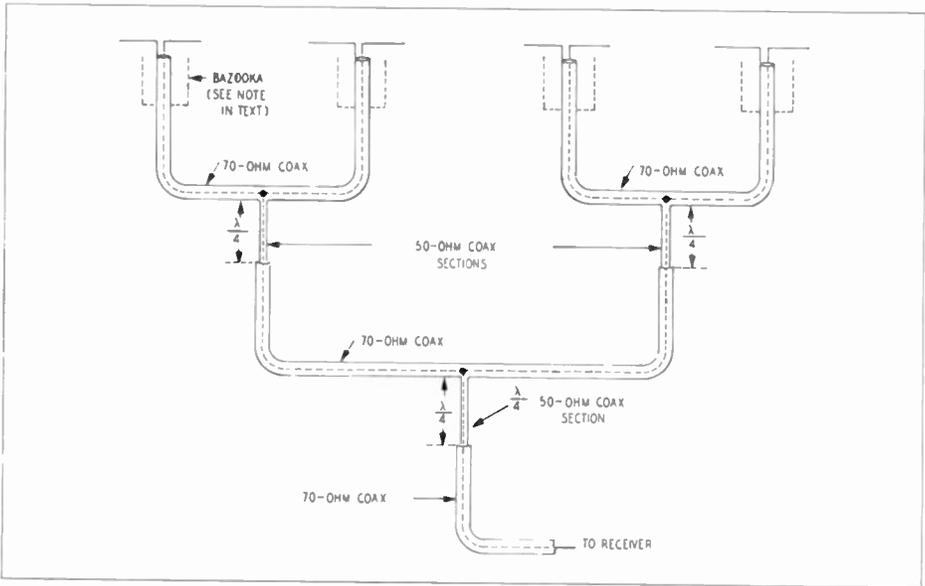


Figure 2. Schematic Diagram of Feed System, Showing Method of Connection for Modified Receiving Antenna

table 9-4. The exact frequency does not appear in the table, but satisfactory results were obtained when the maximum dimensions for the 220-mc. band were used. Matching of the four dipoles to a 70-ohm coaxial feed line was achieved by the use of 50-ohm matching transformers (commonly referred to as "Q-bars"); the array was connected as shown in figure 2. The matching transformers consisted of quarter-wave sections of 50-ohm coax.

(Editor's note: It is suggested that bazoorkas be added to the dipole end of the feed lines, as shown in figure 2. Each bazoorka is one-quarter wave-

length long, and is fastened to the outer conductor of the coaxial line. This balances the two halves of the dipole, and prevents signals from being received on the feed lines.)

The improvement in reception was very apparent when the two antenna arrays were compared. At the modified frequency, the corner-reflector antenna was much better than the old broadside array, and the amplitude of the signals on the "A" scope was twice as great as when the old antenna was used. At the design frequency, the performance of the corner-reflector antenna equaled the performance of the old antenna.

Letters to the Editor . . .

(Continued from page 2)

(The Major's method will work in all cases. So will the following.)

•
"Your problem in the October BULLETIN was, on the surface, quite an easy one to solve. It is, of course, a special case of what could be a somewhat more laborious problem. However, I have a hearty dislike for drawing a hasty conclusion, even though convinced of its validity, so I worked out the solution of the symmetrical network more or less rigorously,

and found that in five transformations, the cubical configuration could be resolved into simple parallel branches. It may be possible to do it in fewer steps, but the method is not restricted to the special case."

Dick McGough
 Technical Publications Department
 (Dick's letter was accompanied by his "more or less rigorous" solution. It filled several pages, and had 12 steps and 11 illustrations. He used wye-to-delta and delta-to-wye transformations. Unfortunately, space does not permit printing his solution.)

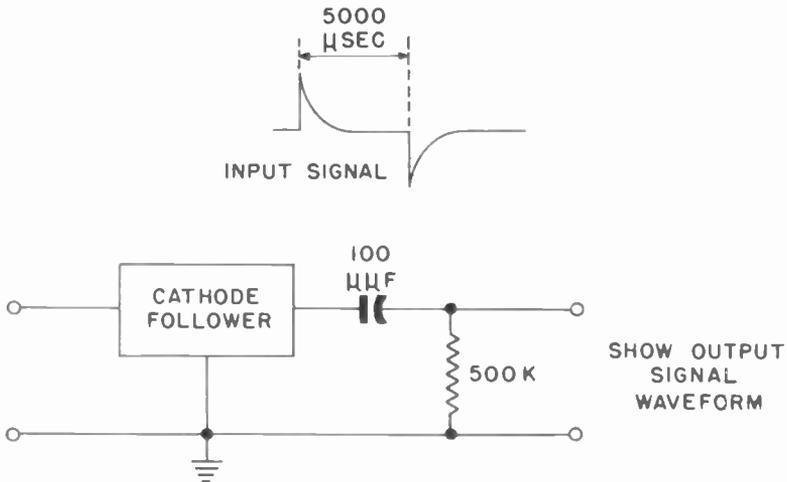
WHAT'S YOUR ANSWER?

The problem this month is an interesting one concerning the action of a differentiator. The objective is the prediction of what waveshape would result from feeding a peaky wave into a short-time-constant RC coupling circuit (see the figure).

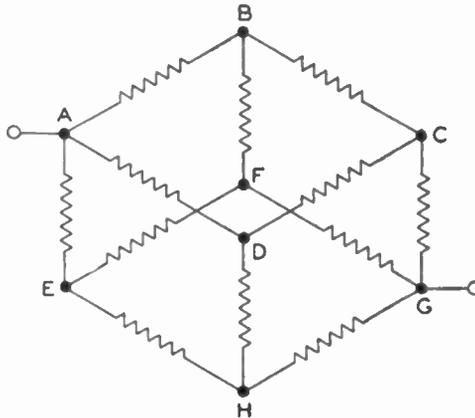
The only assumption is the use of a low-impedance signal source. This condition can be met in practice by feeding the peaky wave (which can be obtained by passing a square wave through an RC coupling network with a time constant of .1 times the period of the square wave) to a cathode follower. If the internal impedance of the cathode follower is very low in comparison with the resistor portion of the differentiator, no distortion will result from the signal source.

We suggest that you first figure out a theoretical answer to this problem; then, if you are not satisfied, try the circuit experimentally.

(Solution next month)



Solution to . . . Last Month's "What's Your Answer?"



ALL RESISTORS = 1 OHM

THIS PROBLEM can be solved by laborious methods (such as a series of "wye" to "delta" transformations) requiring a considerable length of time, but it can also be solved in a few minutes, by use of nothing more involved than Ohm's Law. (This is true only because the network is completely symmetrical; if the value of any resistor were changed, the more complex method of solution would be necessary.)

Assume a current of 1 ampere (any desired value could be used) flowing through the network from point A to point G. Since the network is symmetrical, the current will divide equally at point A, and branches AD, AB, and AE will each carry $\frac{1}{3}$ ampere.

At points B, D, and E, the current will again divide equally, with branches BC, BF, DC, DH, EF, and EH each carrying $\frac{1}{6}$ ampere. These currents will combine at points F, H, and C, so that branches CG, HG, and FG will each

carry $\frac{1}{3}$ ampere to point G, where they will again combine to total 1 ampere flowing out of the network.

Now, since the current flowing through each element of the network is known, and since the resistance of each element is known (1 ohm), the voltage across each element can be found. Adding the voltages along any direct path from A to G will then give the total voltage existing across the network. Finally, by knowing the current through and the voltage across the network, the total resistance can be found by use of Ohm's Law.

For example: $\frac{1}{3}$ ampere through branch AD will produce $\frac{1}{3}$ volt across AD; $\frac{1}{6}$ ampere through branch DC will produce $\frac{1}{6}$ volt across DC; and $\frac{1}{3}$ ampere through branch CG will produce $\frac{1}{3}$ volt across CG. Adding these voltages gives a total voltage across AG of $\frac{5}{6}$ volt. Using Ohm's Law: $R = E/I = \frac{5}{6} \div 1 = \frac{5}{6}$ ohm.

Telepathic Communication

According to Mr. R. S. Bibbero, in the March, 1951, issue of "Proceedings of the I.R.E.," telepathic communication, or thought transfer, would require a bandwidth of roughly 10,000 mc. This figure is based upon the required rate of transfer of intelligence, and on standard communications theory. Imagine the carrier frequency necessary to accommodate a large number of simultaneous telepathic messages.

In the August, 1951, issue of the same publication, Mr. Ted Powell explains communication between moths. The female moth radiates infrared energy at a wavelength of about 8 microns. Radiation is indicated by the fact that the temperature of a female moth is about 11 degrees above that of her surroundings. The male moth has an antenna system consisting of a series of hairs ranging from 40 to 80 microns in length, in 4-micron steps. These steps are the familiar half-wave intervals so common to h-f arrays.

