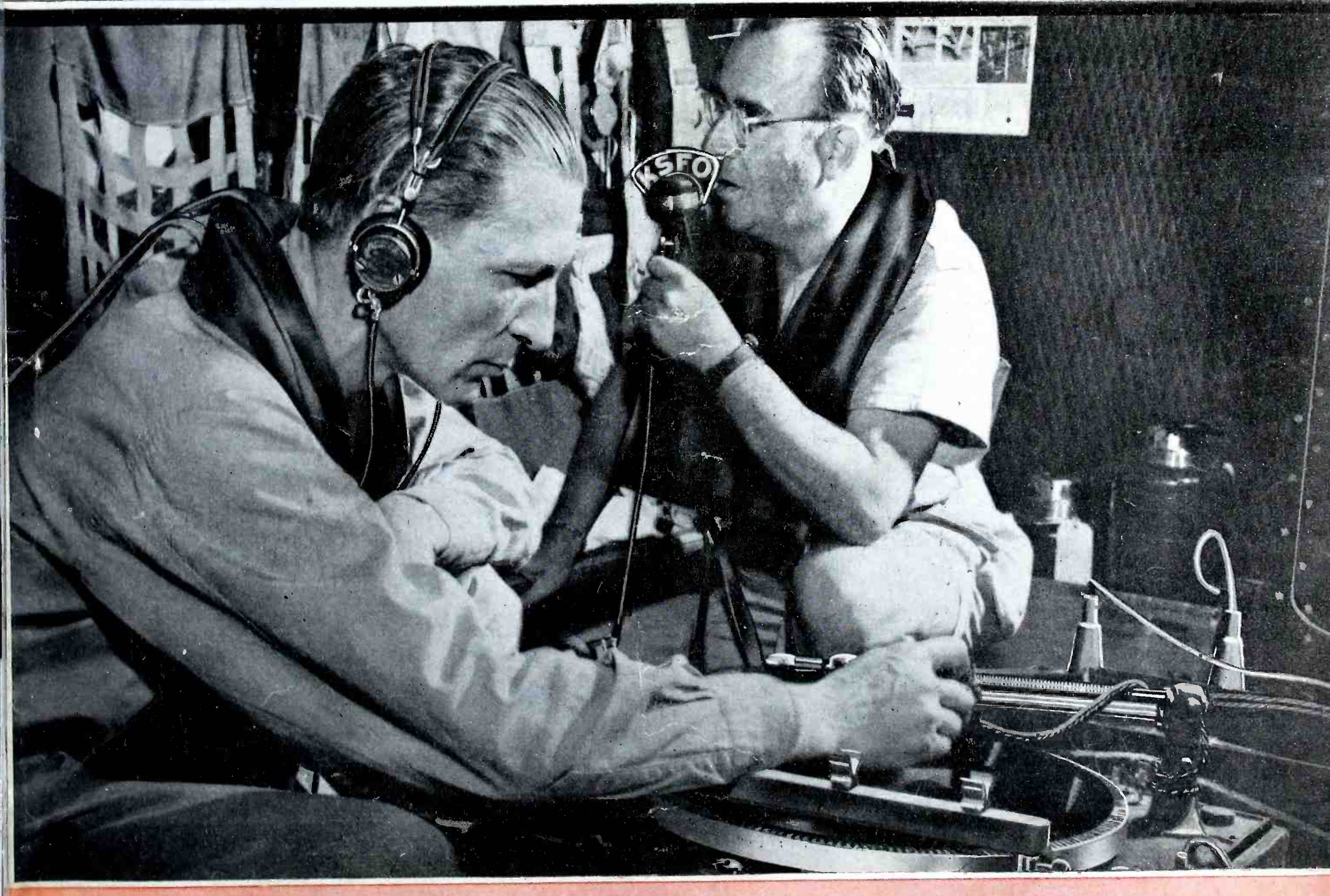
COMMUNICATIONS

INCLUDING "RADIO ENGINEERING" AND "TELEVISION ENGINEERING"

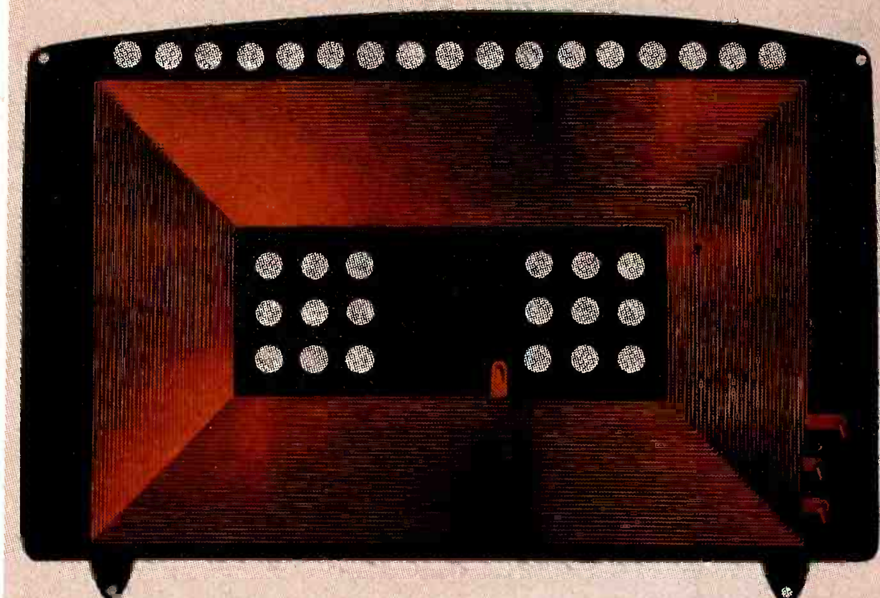


JULY

★ DIRECT F-M FREQUENCY CONTROL METHODS ★ DYNAMIC CHARACTERISTICS OF PENTODES

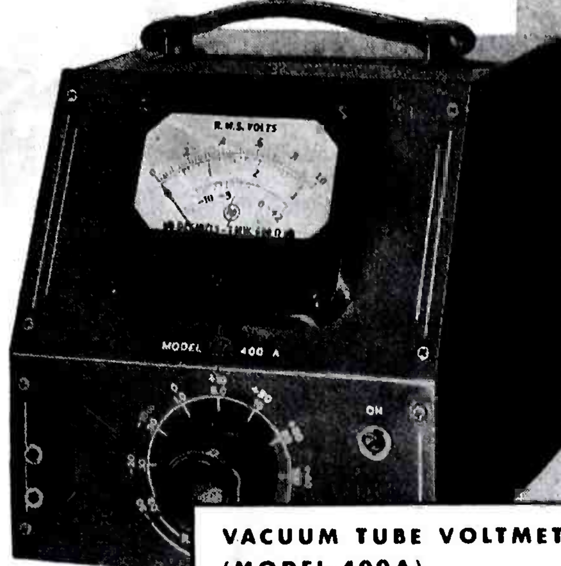
★ RECORDING AND BROADCASTING OF PREPARATIONS FOR BIKINI ATOM-BOMB TEST

1946



hp LABORATORY INSTRUMENTS FOR SPEED AND ACCURACY

BASIC EQUIPMENT FOR AUDIO MEASUREMENTS



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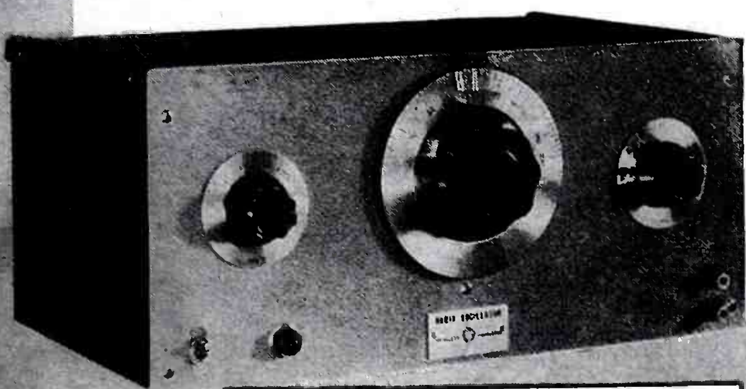

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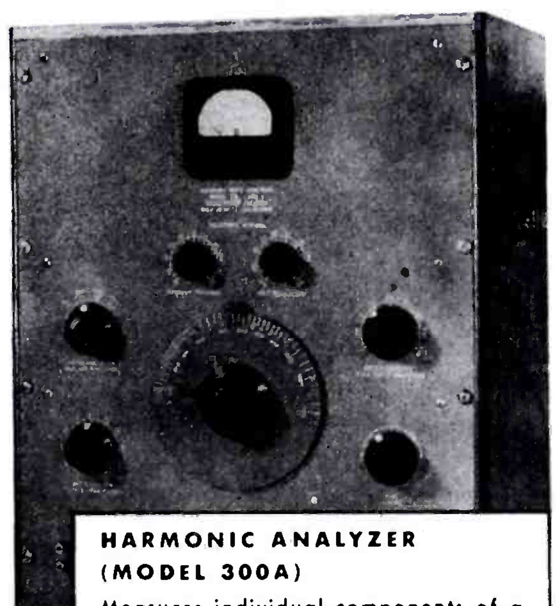
Wherever audio-frequency and supersonic measurements are made, whether in an electronics laboratory, a broadcast station, or on a production line, *-hp-* equipment will speed the job and guarantee the accuracy of the results. Measurements of frequency response, gain, power, and voltage level throughout the audio-frequency and supersonic range can be made with *-hp-* Resistance Tuned Oscillators, Audio Signal Generators, and Vacuum Tube Voltmeters. Total distortion, hum, and noise are conveniently measured with *-hp-* Distortion Analyzers, and individual components of complex waves may be studied with the *-hp-* Model 300A Wave Analyzer. Frequency measurements are readily made with the Model 100B Secondary Frequency Standard or the Model 500A Electronic Frequency Meter. For more data on *-hp-* measurement equipment, write direct to factory.



HARMONIC ANALYZER (MODEL 300A)
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Audio Frequency Oscillators — Signal Generators — Vacuum Tube Voltmeters — Noise and Distortion Analyzers — Wave Analyzers — Frequency Meters — Square Wave Generators — Frequency Standards — Attenuators — Electronic Tachometers

LEWIS WINNER, Editor

F. WALEN, Assistant Editor

We See...

THE NEXT FEW YEARS will see an unparalleled demand for all types of radio communications services, according to a recent FCC report. Stating that the wartime growth of communications has pushed the art ahead an entire generation, the government specialists predict that we'll have close to 5,000 broadcasting stations on the air within a few years, of which 1,400 will be a-m, 3,000 will be f-m and 300 television.

The demand for special facilities will be enormous, the report says, with over 200 cities requiring two-way service for autos, trucks, buses, emergency vehicles and taxicabs, and some 5,000 cities asking for radio systems for their utility and protection services. The aircraft requirements will be staggering, too, with 2,500 ground stations being required for some 50,000 radio-equipped planes soon to be flying about.

About 150 railroads are expected to use radio communications in one way or another, requiring thousands of various types of equipments.

The FCC also expects to license 200,000 for citizens walkie-talkie units and many other thousands for ship-to-shore, microwave relay links, point-to-point, radar and other special services.

So certain is the FCC that this expansion is really on its way that they have organized a new field engineering and monitoring division for traffic control, with ten primary and thirteen secondary monitoring stations in strategic cities throughout this country, Hawaii and Alaska, to operate continuously.

This expanded communications program will pose many engineering problems, for with the increased traffic, equipment will have to have unusually high sensitivity, selectivity and power efficiency factors. The projects are tough, but there'll be solutions . . . solutions that will further increase the services of radio communications.

IT WAS GOOD TO HEAR that the RTPB will continue its important coordinating activity for another year, with Haraden Pratt as chairman. Everyone will benefit by the continuance of this outstanding planning board, which served the war effort so effectively, and which now is mapping vital peacetime communications plans.

Congratulations to James L. Middlebrooks, recently appointed NAB engineering director, on being named RTPB vice chairman.

THERE'LL BE QUITE AN IMPORTANT engineering meeting in September. It will be the meeting of the Communications Section of the Association of American Railroads. The place . . . Detroit . . . and the date . . . September 10th to 13th.

As we pointed out last month, there'll also be five engineering conferences in October, and the all-important Winter Meeting in Rochester in November. Better make your conference plans now. COMMUNICATIONS will of course carry full reports on all of these meetings. Watch for them!—L. W.

COMMUNICATIONS

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JULY, 1946 VOLUME 26 NUMBER 7

COVER ILLUSTRATION

Allan A. Kees, chief of audio facilities for Universal Broadcasting Company, in Navy plane, recording news reporter Austin Fenger's description of the preparations for the Bikini *atom-bomb test.* [See Pages 11, 12 and 13 of this issue for a complete description of the recording and broadcasting of these preparations.]
(*Official Navy photo*)

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PACKAGED R. F. RADAR ASSEMBLY ELIMINATES DESIGN HEADACHES

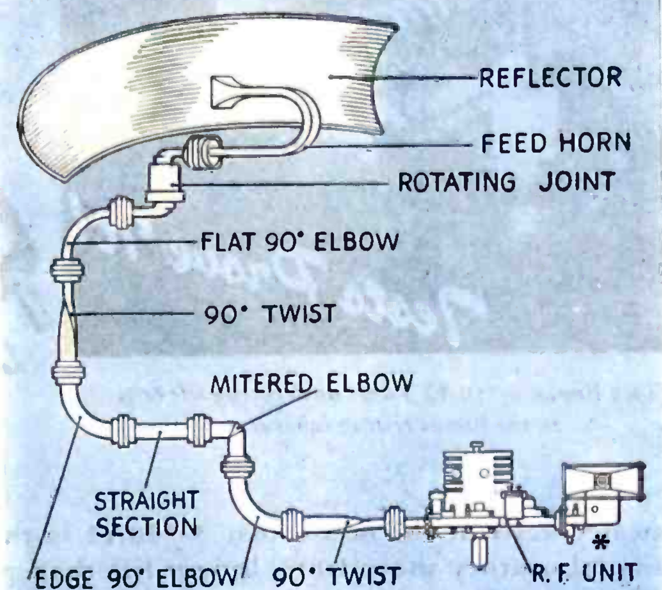
✱ R. F. RADAR UNIT #412

The DeMornay-Budd packaged R. F. Unit provides a complete R. F. assembly for microwave radar. It is now possible to obtain as standard items all the microwave R. F. components necessary in the fabrication of a complete radar—DeMornay-Budd Standard Transmission Line Components plus packaged R. F. Unit.

The R. F. Radar Unit is delivered complete and ready to operate. It is wired and contains all the necessary tubes and crystals. The unit uses a packaged magnetron capable of delivering 20 kw., peak power, at 9375 mc. Two type 2K25 local oscillator tubes are provided, one for receiver and A.F.C. and the other for beacon operation. A type 1B35 A-T-R tube, a type 1B24 T-R tube and the necessary type 1N21 crystals are included in the assembly. A 20 db. directional coupler permits accurate measurements to be made at any time with a maximum of convenience and safety.

Since the use of radar beacons is contemplated in the near future, the unit has been designed with a beacon cavity and crystal mount. The unit can be supplied without the beacon cavity and crystal mount and beacon local oscillator, and a termination supplied in their place so that it becomes a simple matter to convert to beacon operation when necessary.

We offer complete laboratory research facilities and have available such production test equipment as: Standing Wave Detectors, Calibrated Attenuators, Slug Tuners, Power Supplies, Square Wave Modulators, in addition to transmission line components shown in diagram above. Write for information or catalog.



R. F. Radar unit #412 (indicated by asterisk) used in conjunction with standard DeMornay-Budd transmission line components.

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Tests Prove 100% Longer Life

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made possible by:

NEW COOLER OPERATING PLATE
NEW NON-EMITTING GRID
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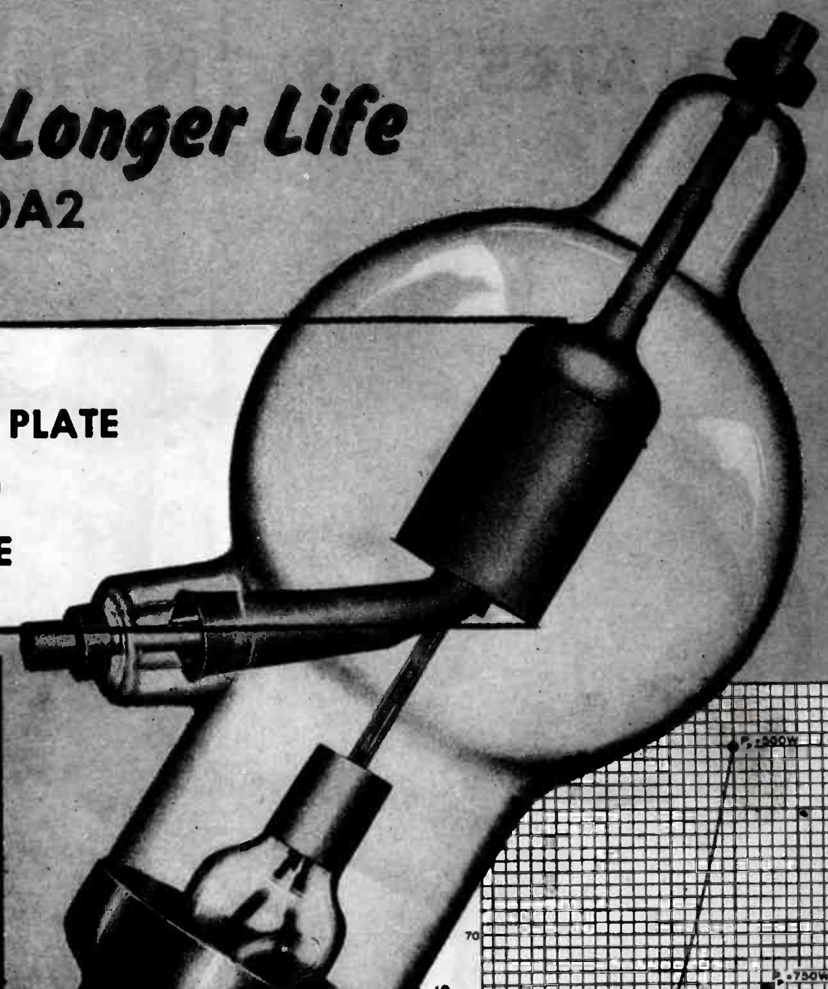
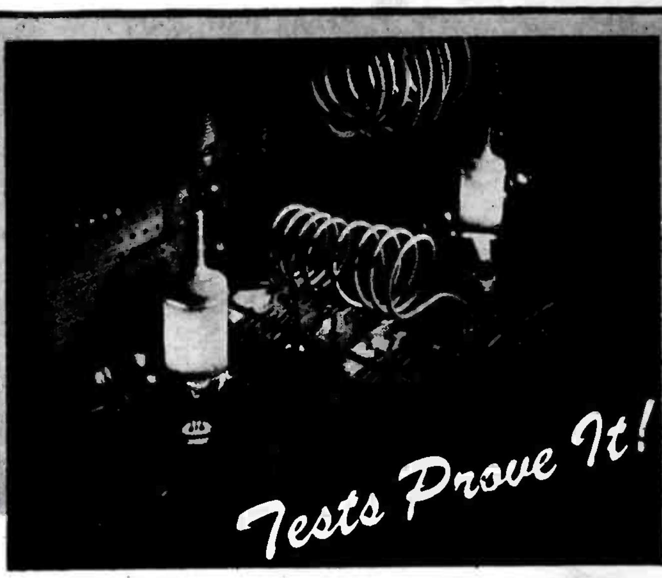
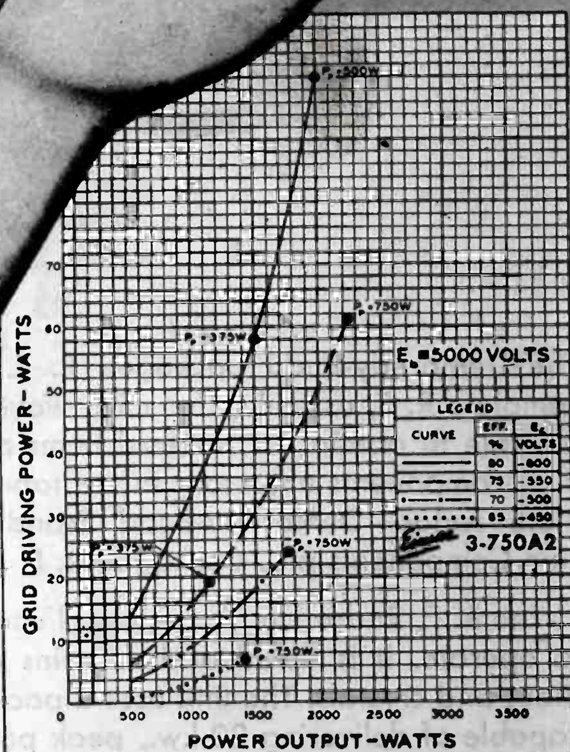




Two Eimac 3-750A2 Tubes undergoing life tests in the Eimac testing laboratory



Typical of the outstanding performance of this new triode is its high power gain. With 5000 volts on the plate, the new Eimac 3-750A2 will deliver 2000 watts output with only 50 watts driving power, at a plate efficiency of 75%. (See above chart.)

Repeated tests of the new Eimac 3-750A2 in the Eimac testing laboratory show 100% longer life than previous models operated under the same conditions.

This increase in life expectancy is a result of continuing research, culminating in this new version of the 750TL triode. Among its many new features are a new cooler operating plate, new non-emitting grid and a new filament structure.

The new 3-750A2 is a power triode, interchangeable with the previous model 750TL, and is but one example of the constant effort made at Eimac to furnish better tubes at lower cost. For further information and complete engineering data on Eimac tubes, write direct or contact your nearest Eimac representative.

ELECTRICAL CHARACTERISTICS

Filament: Thoriated tungsten	
Voltage	7.5 volts
Current	21.0 amperes
Amplification Factor (Average)	15
Direct Interelectrode Capacitances (Average)	
Grid-Plate	5.8 uuf
Grid-Filament	8.5 uuf
Plate-Filament	1.2 uuf
Transconductance (I_b=1.0 amp., E_b=5000, e_c=−100)	3500 umhos
Frequency for Maximum Ratings	40 mc

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ADOLPH SCHWARTZ (W2CN), 220 Broadway, Room 2210, New York 7, New York. Phone: Courtland 7-0011.
HERB BECKER (W6QD), 1406 S. Grand Ave., Los Angeles 15, California. Phone: Richmond 6191.
TIM COAKLEY (W1KKP), 11 Beacon Street, Boston 8, Massachusetts. Phone: Capitol 0050.

Good News!...

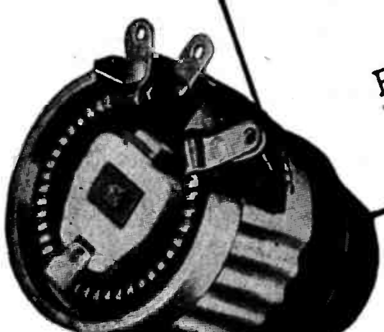
INTER-OFFICE MEMO

To: Harry A. Ehle, Vice-pres., Sales
Date: 4/20/46

Production capacity on all types and ranges of All-Metal Rheostats has now been increased to provide additional production for scheduling during last week of May and following months, as per your request of 2/20/46.

From: O. J. Greenway
Works Manager

IRC



PR-25

PR-50

PRT (AN3155)

CONTACT YOUR IRC REPRESENTATIVE FOR COMPLETE DETAILS

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RHEOSTATS

. . . Increased Quantities Now Available on Short Delivery Cycle!

TYPE PR-25—25-watt rating. Temperature rise, 140°C. Standard resistance values, 1 ohm to 5,000 ohms. Diameter, $1\frac{21}{32}$". Depth behind panel, $\frac{31}{32}$".

TYPE PR-50—50-watt rating. Temperature rise, 170°C. Standard resistance values, 0.5 ohm to 10,000 ohms. Diameter, $2\frac{23}{32}$". Depth behind panel, $1\frac{3}{8}$".

TYPE PRT-25—(AN3155-25). 25-watt rating. Fulfills AN3155 specifications. Totally enclosed. Heat-radiating black finish. Rear terminals Standard values, 10 ohms to 200 ohms. To 5,000 ohms on special order. Temp. rise, 140°C.

TYPE PRT-50—(AN3155-50). 50-watt rating. Same construction as PRT-25, to AN3155 specifications. Standard values, 5 ohms to 200 ohms. To 10,000 ohms on special order. Temp. rise, 170°C.

All IRC Rheostats operate at about half the temperature rise of equivalent units and can be operated at full load on as little as 25% of the winding with only a slight increase in temperature rise.

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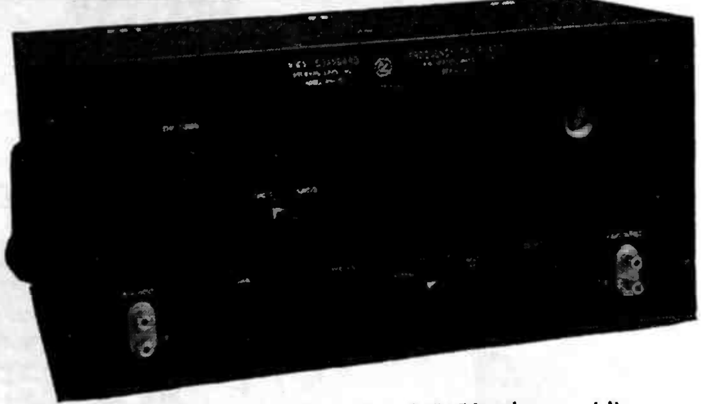
TWO GREAT NEW LABORATORY INSTRUMENTS



BROWNING MODEL RH-10 STANDARD FREQUENCY CALIBRATOR

Full, accurate use of station WWV, the world's finest primary frequency and time standard, is obtained from the Browning Model RH-10 Standard Frequency Calibrator. The standard Browning RH-10 is pre-tuned for 5 and 10 megacycles per second reception, at sensitivities better than ½ microvolt on either band. A dual filter system provides selection of either the 440 or 4000 cycle modulation of WWV for use as a primary frequency standard.

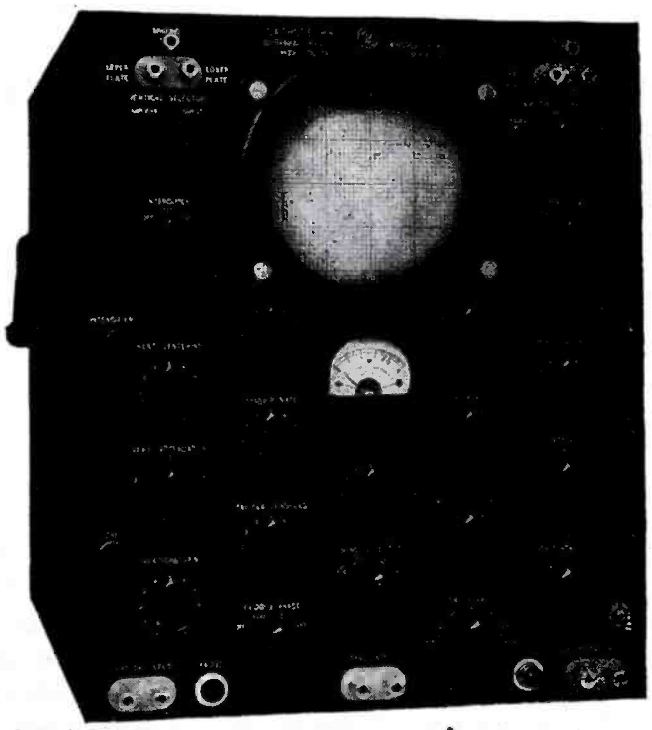
Checking equipment against station WWV, at accuracies up to one part in five million, the Browning Frequency Calibrator enables comparisons to be made in three general categories:

1. Precision radio frequency standards measurements.
2. Precision audio frequency standards measurements.
3. Precision time and pulse standards for physical measurements.

The Browning RH-10 consists of a high Q antenna transformer, a sharply tuned R-F amplifier, converter, oscillator, two IF stages, detector, selective amplifier output stages and a cathode ray zero beat indicator. Although normally supplied for 5 and 10 megacycles per second operation, any two combinations of 2.5, 5, 10, or 15 megacycles may be had on special order.

WRITE FOR DESCRIPTIVE LITERATURE

BROWNING MODEL OL-15 OSCILLOSCOPE



Designed for observing phenomena requiring extended range amplifiers and a wide variety of time bases, the Browning Model OL-15 Oscilloscope incorporates improvements that make it useful in numerous applications where ordinary oscilloscopes are inadequate.

For instance, the Browning OL-15 is particularly adaptable to television, radar and facsimile work, as well as with radio-frequency equipment where it is desirable to know actual r.f. waveform composition. The low repetition sweep gives visual observation when recurring phenomena of a few sweeps per second are encountered.

Suitable time base facilities for studying signals with a constant time difference, or those with an inconstant time separation between consecutive phenomena, are provided by the Browning OL-15. In general, the improved design and superior construction of the Browning OL-15 make it a highly flexible instrument for use in all laboratory work, production testing, or research applications.

WRITE FOR DESCRIPTIVE LITERATURE

BROWNING LABORATORIES, INC.
WINCHESTER, MASS.

COMMUNICATIONS

LEWIS WINNER, Editor

JULY, 1946

Recording and Broadcasting of Preparations for BIKINI ATOM-BOMB TEST

Unique Methods Used to Prepare "On Locale" Recordings in Planes, at Sea and on Land for Rebroadcasting. Amplifier and Recording Correction Factors Developed to Overcome Extreme Temperature Variations Encountered in Traveling 15,000-Mile Route to South Pacific

by **ALLAN A. KEES**

Chief, Audio Facilities,
Universal Broadcasting Company

Allan Kees at Bikini with recording equipment use to prepare recordings of *atom-bomb tests.* (*Army-Navy Joint Task Force No.* 1 *photo*)

ONE OF THE MOST INTERESTING, technically, and exciting of all radio broadcast station operations is the *special events division.* Fire, floods, wrecks, parades, sports—all jam into this classification. But the one to end them all probably was the recently-completed 15,000 mile trip by the *special events department* of KSFO and the Universal Broadcasting Company of San Francisco to the Marshall Islands, some 5,000 miles out in the Pacific, for a program giving a preview to the *atom-bomb tests.*

To provide not only a glimpse of the preliminary work being done for the *atom-bomb tests,* but also word pictures of the site of the test and other neighboring Marshall islands, the natives, their customs and activities, and their reactions to the preparations being made, it was decided to make on-the-spot recordings.

With this in mind, our special events department received permission from Joint Task Force One to proceed to the Bikini area to make recordings of these preliminaries attendant to the *atom-bomb tests.* The crew of three was made up of: Ray V. Hamilton, executive vice president; Austin Fenger, West Coast radio reporter; and the writer.

It was the intent of the operation to take this basic program material, recorded *on locale,* and then fly them back to our main studios in San Francisco. These recordings were to be assembled, some voicing added where necessary for station and commercial tie-ins, timed, and duplicate recordings cut from the master assemblage. They were then to be shipped via air to nearly 100 stations scattered all over the United States, who were subscribers to a series of 15 programs. While such a system has been applied before, this was probably the largest and longest of its type.

It was expected that all kinds of engineering problems would be en-

Austin Fenger, UBC news reporter, in cockpit of U. S. Navy PBM, describing arrival at Bikini. Recording equipment was in forward bunk compartment where vibration was minimized.

The right hand man of Chief Judah being interviewed by Austin Fenger for the *atom-bomb test* preview programs. Left to right: Ray V. Hamilton, UBC executive vice president; Mr. Fenger; native interpreter, and the councilor. (*Army-Navy Joint Task Force No. 1 photo*)

countered on a trip of this nature and they were.

Much experience had been accumulated on a recent, similar-style trip to Hilo, Hawaii to cover the disastrous tidal wave which struck there. Thus we had a working knowledge of the type of equipment that might be needed. Applying this information we decided to take along three 6-volt storage batteries, a 350-watt rotary converter with adjustable speed control, a portable disc recorder (112-line feed), standard dynamic microphones, special audio amplifiers, filters, recording discs, etc. Total weight was approximately 500 pounds.

Land and Sea Planes Used

The crew and equipment was flown by Naval Air Transport Service to Kwajalein (in a four-motor R5D (C54)), almost 3,000 miles west of Honolulu. Here, headquarters were established and plans mapped out to cover as many interesting operations as possible.

The next hop, in a Navy PBM flying boat, was to Rongerik Island, where the first recording was to be made. This island, a small, small dot in the Pacific, is the one to which the natives of Bikini had been transported out of harm's way. It lies about 12 degrees north of the equator and has an extremely hot and humid climate. Everything had to be taken ashore from the PBM anchorage in a rubber life raft through the surf and onto the beach. It required seven round trips in this bouncing raft to get all the equipment ashore. (Here, the need for less and lighter equipment tipped its hat to us.) The recording equipment was set up in the Government House, it being the only place that was dry and had a floor.

The first programs cut consisted of interviews with Judah, the head man of Rongerik, the Magistrate, and recordings of some of their native songs.

Test Cuts

Upon making a test cut and inspecting the records, it was found that they were so soft, that the audio recording level had to be reduced about 8 vu under normal. Because the weight of the play-back pickup spoiled the test cuts, due to the record softness, it was impossible to check the final programs in the field. Even with an 8 vu reduction, the microscope revealed that the audio level was still high, so the gain was reduced by another 4 vu for the next recording. Even so, San Francisco wired for even further reduction. Four more vu's were dropped. This made the total 16 vu down under normal.

Vibration Problems

The equipment was then packed up and seven more round trips made back, through the surf, to the PBM. Just before take-off, the equipment was set up in the forward bunk room of the plane so as to be able to record a description of the first sight of the Island of Bikini. It was in the PBM that the first real difficulty occurred. The vibration from the twin motors of the plane was worse than anything which had previously been anticipated, and no amount of padding beneath the recorder reduced the vibration to a point where a satisfactory cutting could be made.

With a length of rubber exerciser cord, a cradle was made, and the recorder set into it. This arrangement resulted in reducing the vibration to a point where, while there was considerable shaking, there was not enough pattern on the disc to spoil the recording. To reduce the roar of the motors, a high-pass filter was used with a cut-off frequency of 125 cycles. A frequency of 90 cycles would probably have proven a better compromise, as it would have cut off less of the voice frequencies and still reduced the motor noise.

Corrective Adjustments

Further, to illustrate the wide range of difficulties encountered, cutter adjustments were made just before take-off; however, on approaching Bikini at about 5,000 feet, it was noticed that the records had hardened, due to the change in temperature, to such an extent that the recording needle made very light grooves in the disc. Three flight runs had to be made until frantic corrective adjustments secured a satisfactory recording. The temperature change from sea level to 5,000 feet was approximately minus 35 degrees.

At Bikini, the crew and equipment was transferred by small boat to the USS Orca, a Navy sea-plane tender, where the very first effort by the tired crew was to get the batteries charged. Due to the temperature and humidity, each piece of equipment had to be wiped off, oiled, and the microphones and recording heads packed with bags of moisture absorbent. As another result of the high humidity, exposed metal parts rusted badly overnight. To prevent this, four 100-watt lamps were installed in the case which housed the recorder and were burned continuously whenever the recorder was not in use. This heat kept the moisture out of the recorder and amplifier. These precautions paid dividends, as only two cathode resistors were lost due to moisture in thirty days of operation.

Power Supply

Fortunately, it was possible to obtain 110-volt, 60-cycle a-c on board all the Naval ships at Bikini, except aboard the Japanese target battleship, the Nagato, where it was necessary to string a long extension line to another ship alongside to obtain power. Preciseness in the power supply frequency or constancy is not always obtainable, and constitutes one of the big problems in recording.

Humidity Problems

The only real trouble at Bikini was with the records themselves. Again, due to high humidity, the records sweat, and upon being dried or wiped off, a hard, thin film formed on some parts of the record, causing thin cuts on these portions. Apparently the best way to combat this was to put four sacks of the moisture absorbent in the record-carrying cases and, upon taking a disc out of this case, to use it within an hour.

The next stop was at Kwajalein. It will be recalled that, during the war, Kwajalein had been almost denuded of palm trees by the pre-invasion bombardment of the U. S. Fleet (only 12 palm trees remained standing), and consequently there was no protection from the sun for either the equipment or the staff. Since Kwajalein, further South, lies only 8 degrees north of the Equator, it was even warmer than Bikini, and greater care had to be taken to protect the equipment. It was found that the equipment had to be cleaned and oiled twice a day, and the electric lights previously referred to, were kept burning all the time the equipment was not actually in use.

After a short stay at Kwajalein, the crew went to the island of Majuro via PBM, and from Majuro to Laura Island by *crash boat* for a two-day recording session. Aboard this *crash boat,* the equipment had to be covered with tarpaulins to keep out the salt water spray. This was a constant problem.

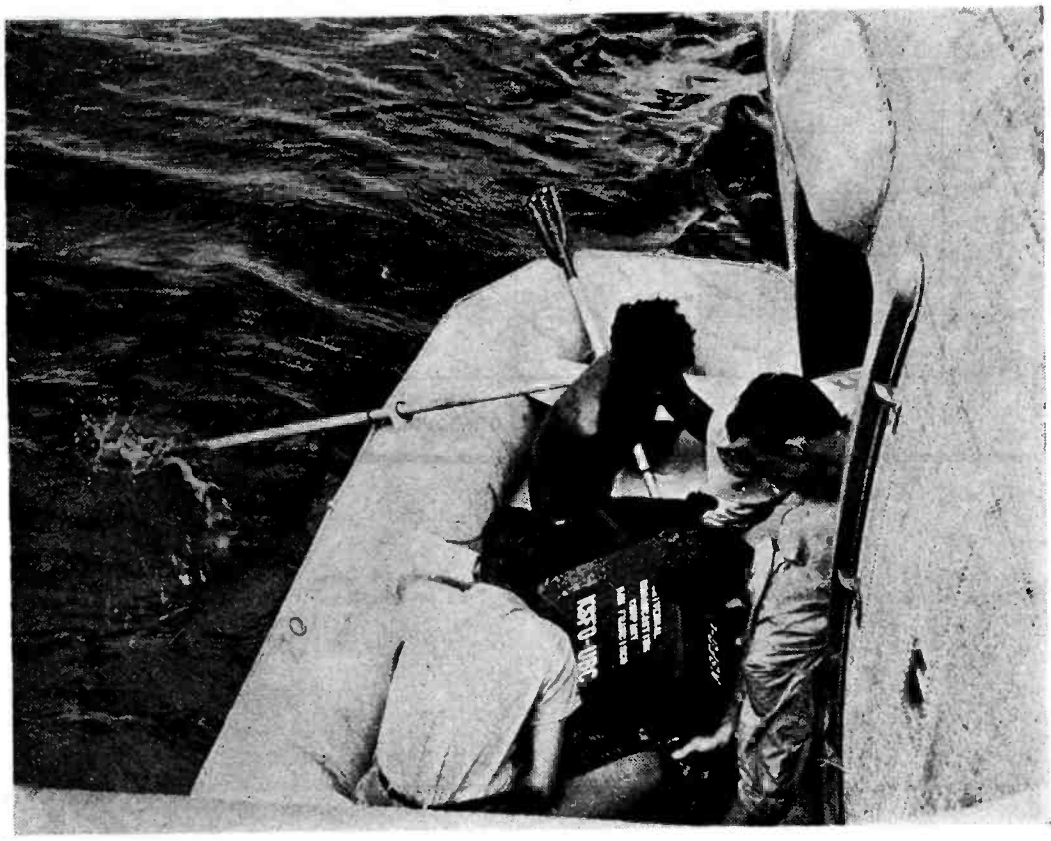
Packing our equipment, we made the return trip to Majuro, again by *crash boa,* and from Majuro to Bikini via the Navy flying boat. The main point here is that during this two-day period, the 500 pounds of equipment were transferred from one conveyance to another, 22 times. After this experience, many notes on methods of lightening the equipment were made!

Trial Runs

Back at Bikini, two more plane recordings were made, the first aboard a four-motored C54 photographic ship on a trial run over Bikini. It was in this plane that some of the most difficult recording conditions were encountered. The plane had been stripped of all interior soundproofing, and holes had been cut in the side of the ship to accommodate all the cameras installed to photograph the results of the *atom-bomb* explosion. The wind whistled through and the motors roared, and with the flight over Bikini at an altitude in excess of 10,000 feet, again, the difficulties of rapid record hardening due to temperature drop were encountered. A cradle of rubber exerciser cord for the recorder again saved the day.

Landing at Eniwetok, some 350 miles northwest of Bikini, arrangements were made for a show from a pilotless B-17, one of the aircraft to be guided by a *mother* ship flying from ten to twenty miles away through the *atomb-bomb cloud,* immediately after the explosion. The recording equipment was set up just back of the radio room with the announcer in the nose of the ship. A jeep stationed at the end of the runway took the plane off the field by remote control and when airborne and 400 feet up, the mother ship took over. After a half-hour demonstration, the plane and crew were landed by remote control by the same jeep at the end of the runway. In making the recording on this pilotless plane, the worst vibration pattern possible was encountered, but by the use of a filter, the rumble was eliminated. As a personal item, it might be said that there was considerable banter as to whether some of the vibration on this pilotless ride might have been caused by the recording crew's knees knocking together.

Various other broadcasts were made on Carlos and other islands in the Pacific, and then the crew was flown home by Naval Air Transport Services.



Transferring equipment from plane to rubber life raft during the recording tests. As many as twenty-two trips of this nature were required in a day. (*Army-Navy Joint Task Force No. 1 photo*)

Summary

In summary, the main technical problems encountered were those caused by climatic conditions and excessive vibration in planes. Because of high temperature, recording levels had to be decreased by approximately 12 to 16 vu due to the recording head damping, thinning and softening of the disc materials. Equipment had to be continually wiped and oiled, microphones protected from the moisture by *Protec-Sorb* bags, equipment cases kept dry by burning light globes in them, microphone cable plugs enclosed in sacks made of parachute silk, the recorder slung in a cradle of rubber exerciser cord to overcome plane vibration, high-pass filters used to reduce motor roar, and an advance ball used to keep the recorder head from skipping due to excessive vibration. The crew isn't joking when they say, "The equipment will be lighter, next trip"!

DYNAMIC

The dynamic characteristics of a pentode, in which a resistance load is inserted in the plate circuit, is of particular importance in the design of high signal level resistance-coupled amplifiers. This characteristic will be found more convenient for calculations, when maximum output voltage is desired, than the plate characteristics generally supplied.

If only a small output voltage with maximum gain is required there is considerable latitude in the choice of the operating point without the occurrence of perceptible distortion and the usual plate characteristic curves are applicable.

In studying pentode dynamic characteristics, a family of plots for sharp cut-off pentodes, 6SJ7, 6SH7 and 6AG7 were prepared, Figures 1 to 7. In these plots a family of characteristics for a particular plate load and supply voltage is shown. The plate current and the plate voltage were plotted as a function of the control grid voltage using the screen voltage as a parameter. In each case the tube chosen for measurement was the average of six tubes tested.

The shape of these curves for different screen-grid voltages will be found somewhat similar, with a nearly straight portion at the middle, gradual

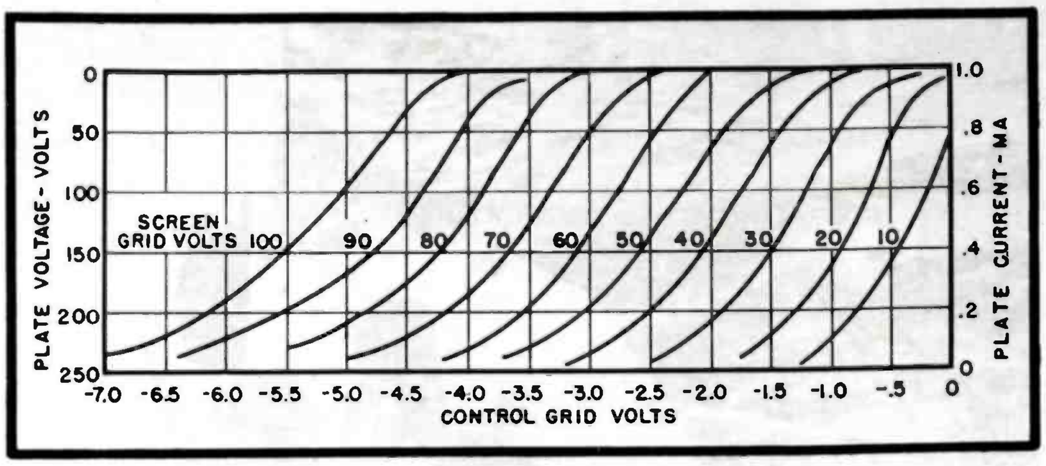


Figure 1

Dynamic characteristics of 6SJ7. Supply voltage, 250; load resistance, .25 megohm; heater voltage, 6.3.

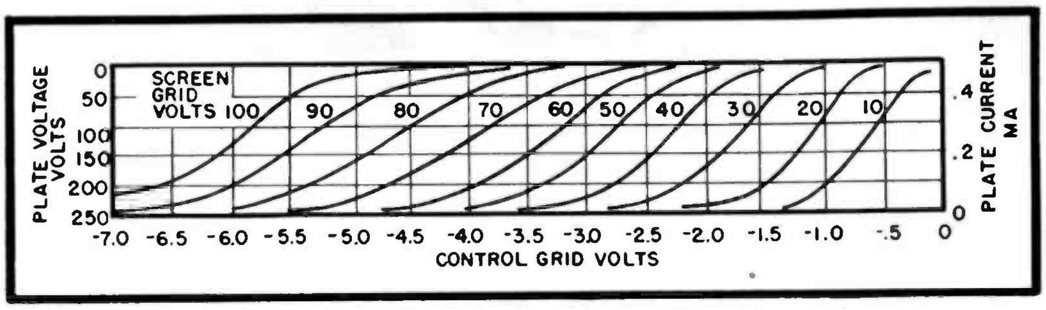


Figure 2

Dynamic characteristics of 6SJ7. Supply voltage, 250; load resistance, .5 megohm; heater voltage, 6.3.

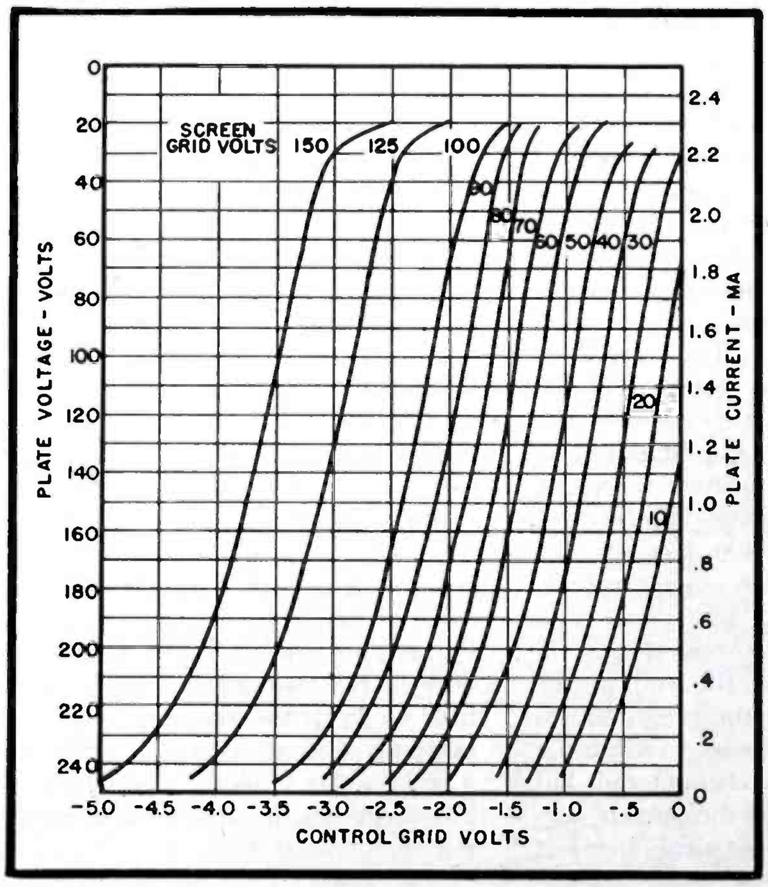
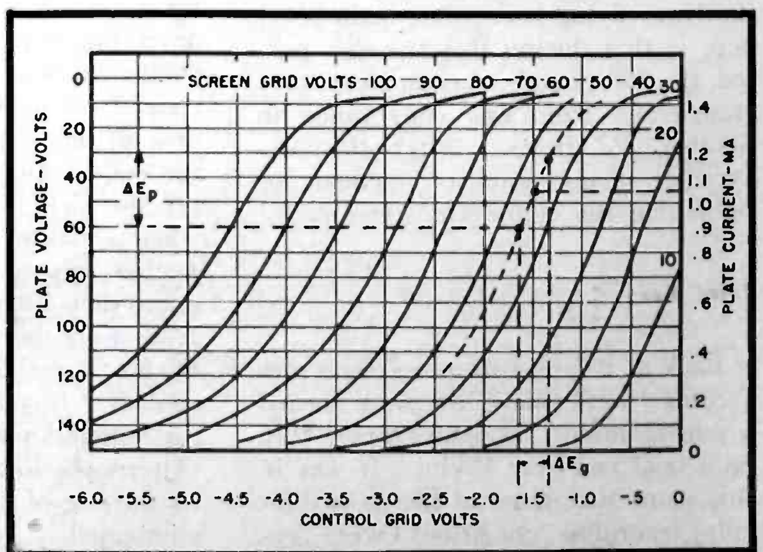


Figure 4 (left)

Dynamic characteristics of 6SH7. Supply voltage, 250; load resistance, .1 megohm; heater voltage, 6.3.

Figure 3

Dynamic characteristics of 6SJ7. Supply voltage, 150; load resistance, .1 megohm; heater voltage, 6.3.



CHARACTERISTICS OF PENTODES

Analysis of the Use of Dynamic Characteristics of Pentodes in Designing High Signal Level Resistance-Coupled Amplifiers. Measurements Made with 6SJ7, 6SH7 and 6AG7 Sharp Cut-Off Pentodes Offered in a Group of Plots.

by S. J. HAEFNER

Development Supervisor of Electronic Design and Measurements
U. S. Navy Underwater Sound Laboratory

curvature at the lower end and a fairly sharp top bend.

Prepared also were a screen-grid current family of curves (Figures 8 to 14) for the 6SJ7, 6SH7 and 6AG7, to study the function of control grid voltage using the screen grid voltage as a parameter. These curves should prove useful for estimating the portion of the total tube current drawn by the screen grid.

Plate and Dynamic Characteristic Design Procedures

To analyze the usefulness of the dynamic characteristics as a design approach, design steps using plate and dynamic characteristics were studied.

Design Steps Using Plate Characteristics: It is first necessary to choose the plate load resistance, supply voltage, and plate and screen voltages of, let us say, a 6SJ7.

The value of the load resistance is determined from frequency response considerations. For this example let us suppose a load resistance equal to .1 megohm; supply voltage, 150; plate and screen grid voltages, 45.

In the next step the plate current must be calculated. Since the voltage drop in the load resistance is equal to the supply voltage minus the plate voltage, the plate current is $\frac{150-45}{100,000} \times$ 1,000, or 1.05 ma.

The receiving tube characteristics (Figure 15) are then entered on the plot of the operating plate and screen voltages for the 6SJ7 tube and we find the grid bias voltage and screen current. We note, for example, that at a plate current of 1.05 ma the bias would be −1.5 volts, and the screen current at this bias voltage would be 0.35 ma.

In the next step the cathode current and bias resistance is calculated.

The cathode current is the sum of the plate and screen grid current and is equal to 1.05 + .35 or 1.40 ma. The bias resistance is equal to the bias voltage divided by the cathode current or $\frac{1.5}{1.4} \times 1,000 = 1,070$ ohms. A commercial value of 1,000 ohms would be used.

It is then necessary to compute the screen grid voltage dropping resistance, if one is used, to give the correct screen grid operating voltage.

The voltage drop in this resistance

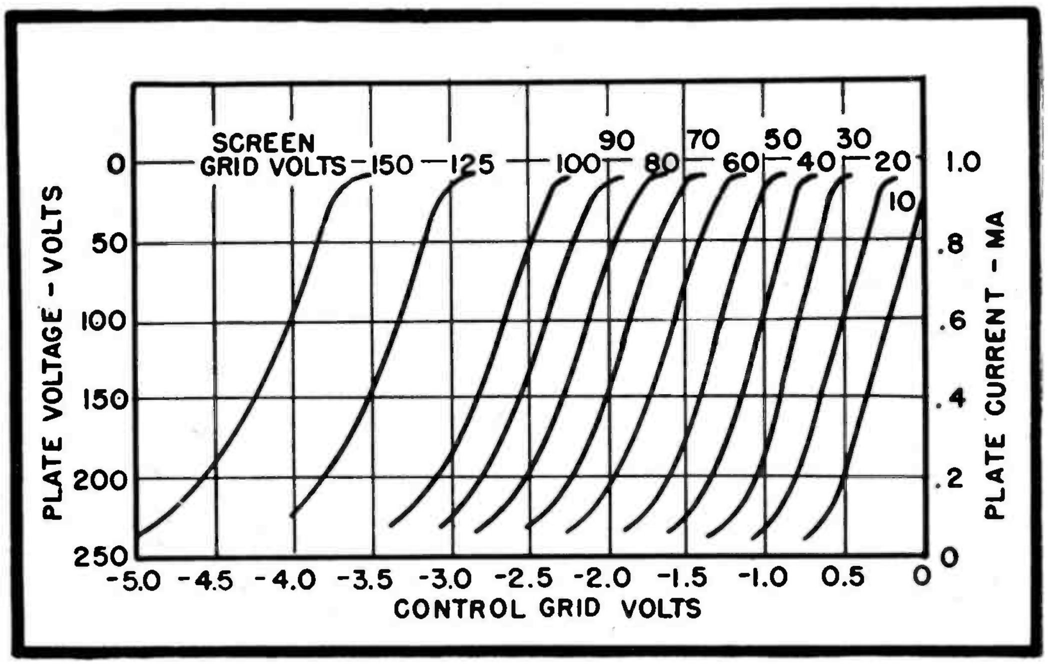
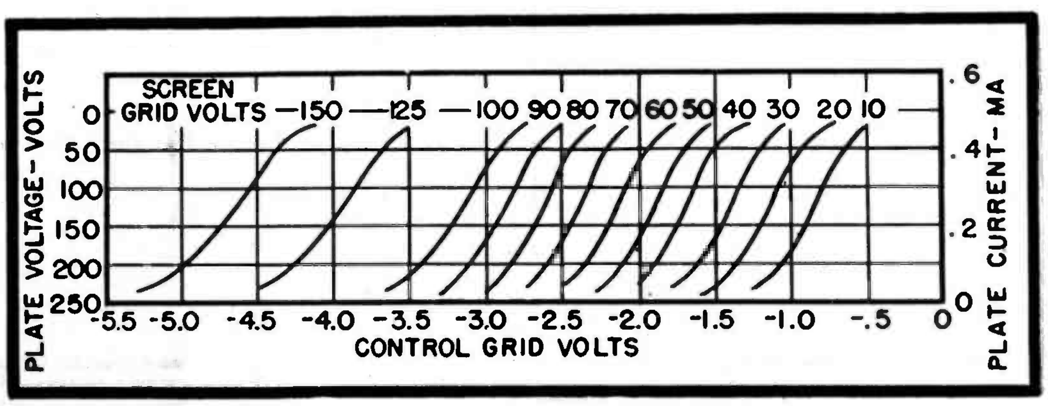
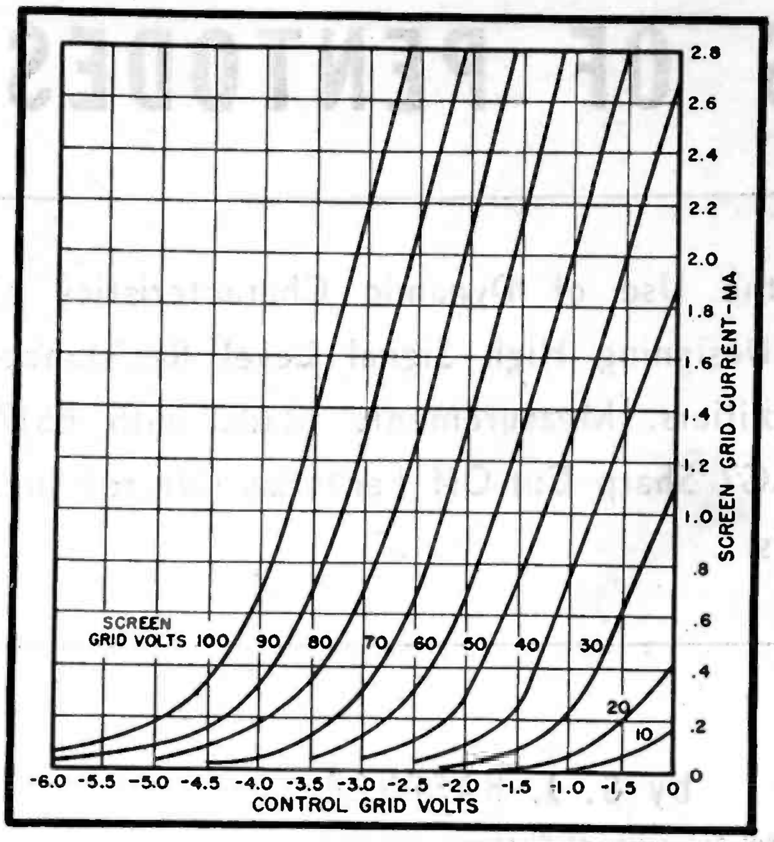


Figure 5
Dynamic characteristics of 6SH7. Supply voltage, 250; load resistance, .25 megohm; heater voltage, 6.3.

Figure 6
Dynamic characteristics of 6SH7. Supply voltage, 250; load resistance, .5 megohm; heater voltage, 6.3.





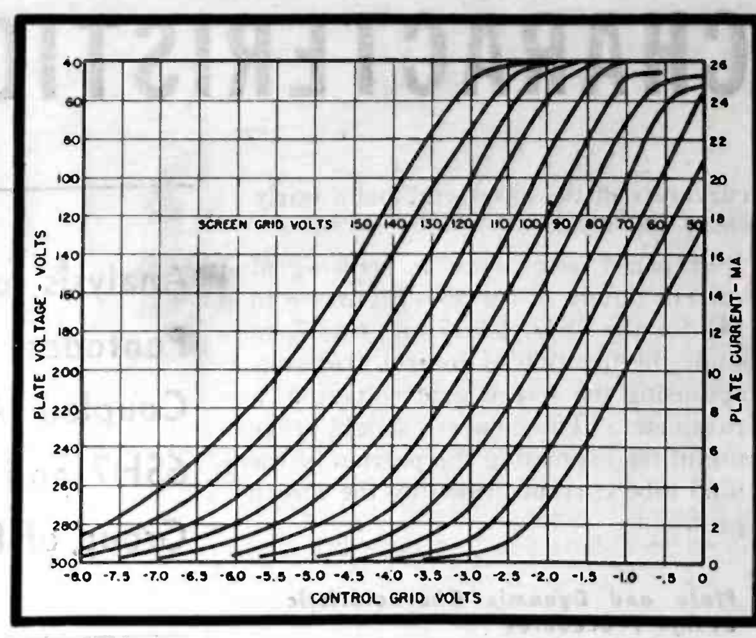


Figure 7 (above)
Dynamic characteristics of 6AG7. Supply voltage, 300; load resistance, 10,000 ohms; heater voltage, 6.3.

Figure 8
Dynamic characteristics of 6SJ7. Supply voltage, 250; load resistance, .25 megohm; heater voltage, 6.3.

is equal to the supply voltage minus the screen grid operating voltage and is numerically 150 − 45 or 105 volts. The resistance is equal to the voltage drop divided by the screen grid current

or $\frac{105}{.35} \times 1{,}000$, or .3 megohm.

From the plate-characteristic curves (Figure 15) we then have to determine the G_m, μ and R_p at the operating bias voltage.

From the curves, at −1.5 volts grid bias voltage, $G_m = 1{,}050$, $\mu = 1{,}350$, and $R_p = 1.3$ megohms.

In the final step the voltage gain of the tube is computed. This is nearly equal to G_m times the parallel resistance of the load resistance and the grid resistance of the following tube.

Assuming a grid resistance of .25 megohm, the voltage gain of the tube is approximately $1{,}050 \times \frac{.25 \times .1}{.35}$ or 75, with the cathode resistance sufficiently bypassed.

The maximum possible undistorted output voltage of the 6SJ7 pentode is of the order of 10 volts rms (obtained from dynamic characteristics plot) with the assumed supply voltage of 150 volts, operating voltages of 45 on the screen grid and plate, and a bias voltage of −1.5 volts.

It is well known that minimum distortion occurs with any triode when the control grid voltage is as small as possible without any risk of running into grid current. For a pentode, however, due to the control of the voltage on the screen grid, it is possible to adjust the operating conditions so that the working part of the characteristic (the *straight* portion) is well away from the grid current region. Since with a pentode the operating point can be arranged not to enter the grid-current region, the control-grid voltage swing is only limited by the curvature at each end of the dynamic characteristic.

Although the plate characteristic of a resistance-coupled pentode is the basis of calculation, it is more convenient to use the dynamic characteristic to determine the maximum output voltage.

Design Steps Using Dynamic Characteristic Curves: Now let us take the foregoing example and solve it by using the dynamic characteristic curves.

First we select the plate load resistance and supply voltage: for the illustrative example the load resistance is .1 megohm and the supply voltage is 150.

Finding Plate Current

From the dynamic-characteristic plot we find the plate current. This is applied to the plot with the supply voltage and load resistance for the tube used, and we select the curve from the family of curves corresponding to the value of assumed screen grid voltage. For maximum output voltage we should select a bias voltage in the middle of the *straight-line* portion of the particular curve chosen and read the plate current corresponding to this voltage.

In this example (from Figure 3) $I_p = 1.05$ ma at a bias of −1.5 volts and a screen grid voltage of 45.

Calculating Tube Gain

The gain of the tube is then calculated. Since the plate current is also the current flowing through the load resistance, there is a linear relation-

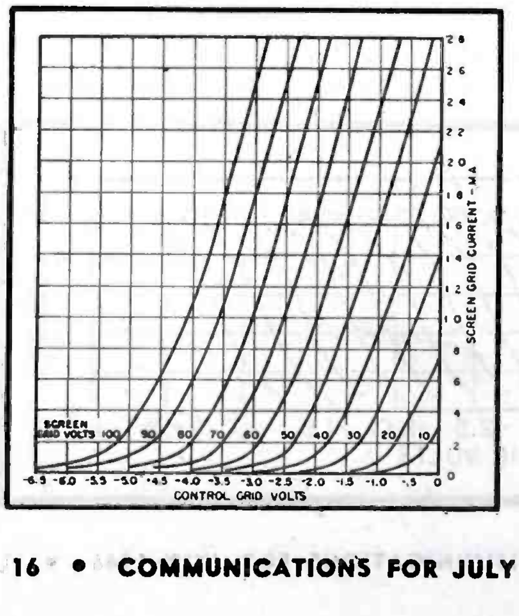
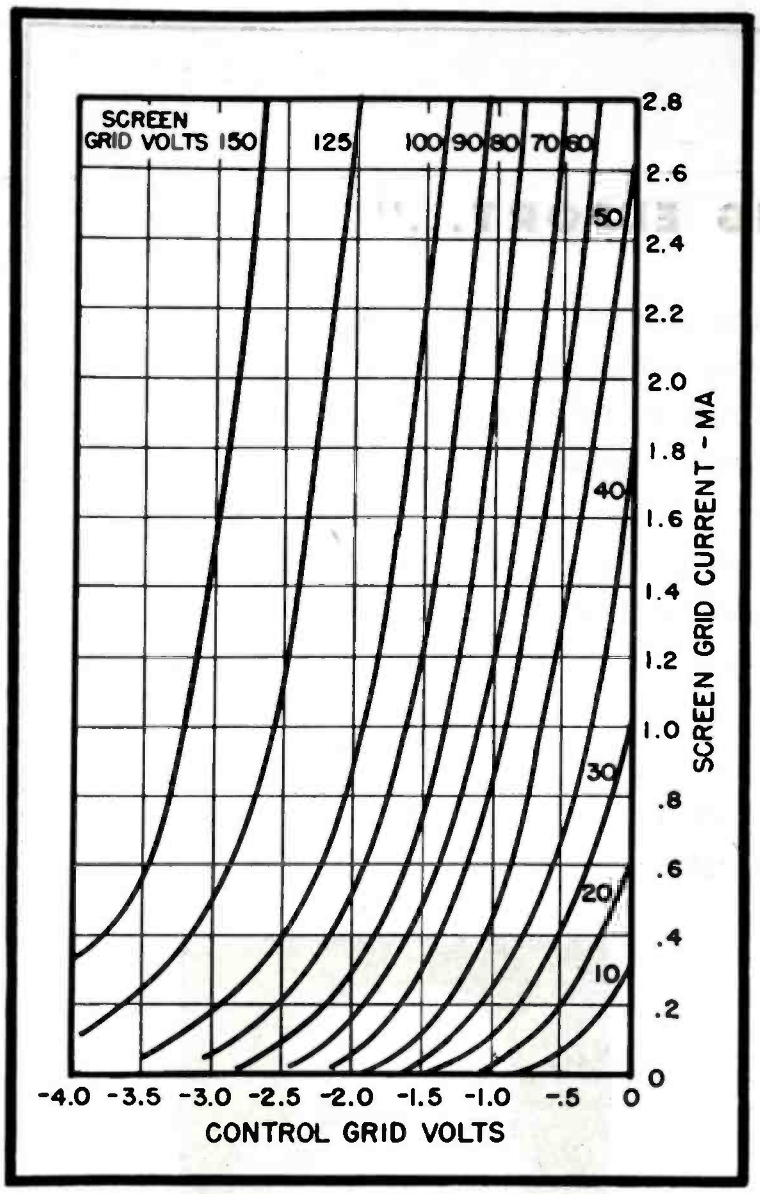


Figure 9
Screen-grid current characteristics of 6SJ7. Supply voltage, 250; load resistance, .5 megohm; heater voltage, 6.3.



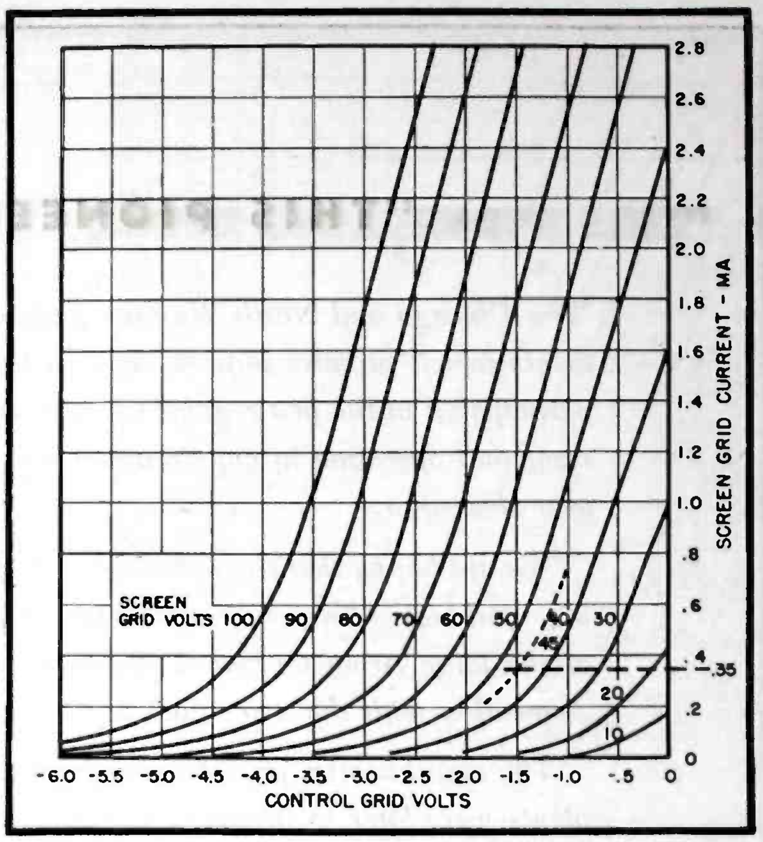


Figure 10 (above)
Screen-grid current characteristics of 6SJ7. Supply voltage, 150; load resistance, .1 megohm; heater voltage, 6.3.

Figure 11
Screen-grid current characteristics of 6SH7. Supply voltage, 250; load resistance, .1 megohm; heater voltage, 6.3.

ship between the plate current and the plate voltage. A plate voltage scale is shown on the left-hand side of the plot. The gain of the tube is $\Delta E_p/\Delta E_g$ or the slope of the dynamic characteristic curve. Since the load resistance is shunted by the grid resistance, R_g, of the following tube, the gain will be reduced to approximately $R_g/(R_g + R_L)$ of the gain just calculated.

For the 6SJ7, the gain from Figure 3, $\frac{\Delta E_p}{\Delta E_g}$ is $\frac{30}{.3} = 100$, and the net gain is $100 \times \frac{.25}{.35}$ or 71.5, with the cathode resistance sufficiently bypassed.

The screen grid current is then found by referring to the proper curve of Figures 8 to 14. The screen-grid dropping resistor is equal to the supply voltage minus the screen-grid voltage divided by the screen grid current.

Numerical Values for 6SJ7

The numerical values for the 6SJ7 example are, from Figure 10: Screen grid

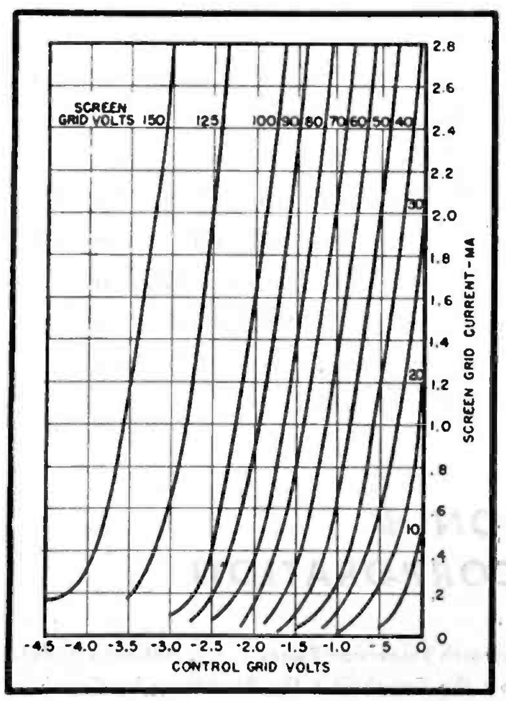
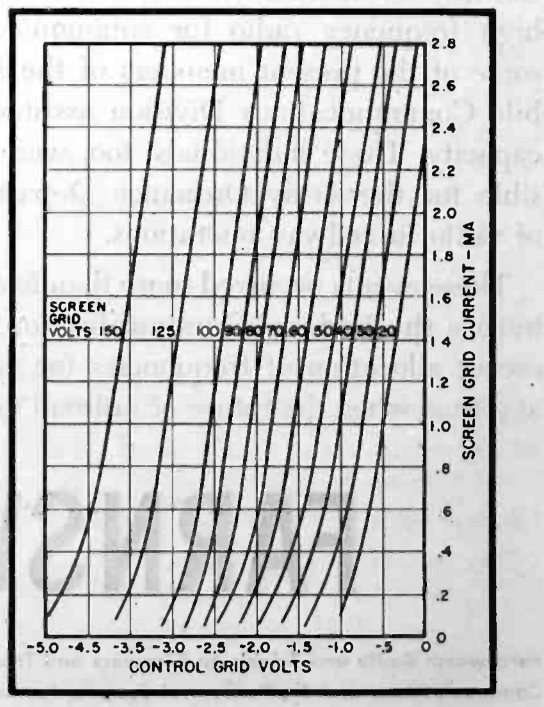


Figure 12 (left)
Screen-grid current characteristics of 6SH7. Supply voltage, 250; load resistance, .25 megohm; heater voltage, 6.3.

Figure 13
Screen-grid current characteristics of 6SH7. Supply voltage, 250; load resistance, .5 megohm; heater voltage, 6.3.



current, 0.35 ma; screen grid dropping resistor, $\frac{150 - 45}{.35} = .3$ megohm.

The bias resistance is then calculated. This resistance equals the bias voltage divided by the sum of the plate and screen currents.

The total cathode current is 1.4 ma.

The cathode resistance is $\frac{1.5}{1.4} \times 1{,}000 = 1{,}070$ ohms.

Plate Distortion

Referring to Figure 3 it is evident that the peak plate voltage swing on the straight part of the dynamic-characteristic curve, with the operating point assumed in the above example, is about 15 volts. Therefore, the maximum undistorted output voltage is approximately 10 volts rms.[1] An output voltage of about $25/\sqrt{2}$ rms volts can be obtained however with a small (in most cases unobjectionable) amount of distortion by allowing the swing to extend part way into the curved upper portion of the dynamic characteristic.

A good working rule for maximum possible output voltage is to select the working point at a current of approximately $\frac{0.56 \times \text{Supply Voltage}^2}{\text{Load Resistance}}$

Substituting Numerical Values

Substituting numerical values for the problem in question we have $I_p = \frac{.56 \times 150}{100{,}000} \times 1{,}000$ or 0.84 ma.

At the bias voltage of −1.5 the operating plate and screen voltages are 66 and 41 from Figure 3. It is apparent from the curves that the maximum plate-voltage swing and hence the output voltage will be larger than that at the operating plate voltage of 45 volts. An estimated maximum output rms voltage from the curves with a small amount of distortion is $46/\sqrt{2}$ volts.

[1] See reference to this value in plate-characteristic distortion data.

[2] *Radiotron Designer's Handbook*, Amalgamated Wireless Valve Company, Pty., Ltd., Australia, p. 273.

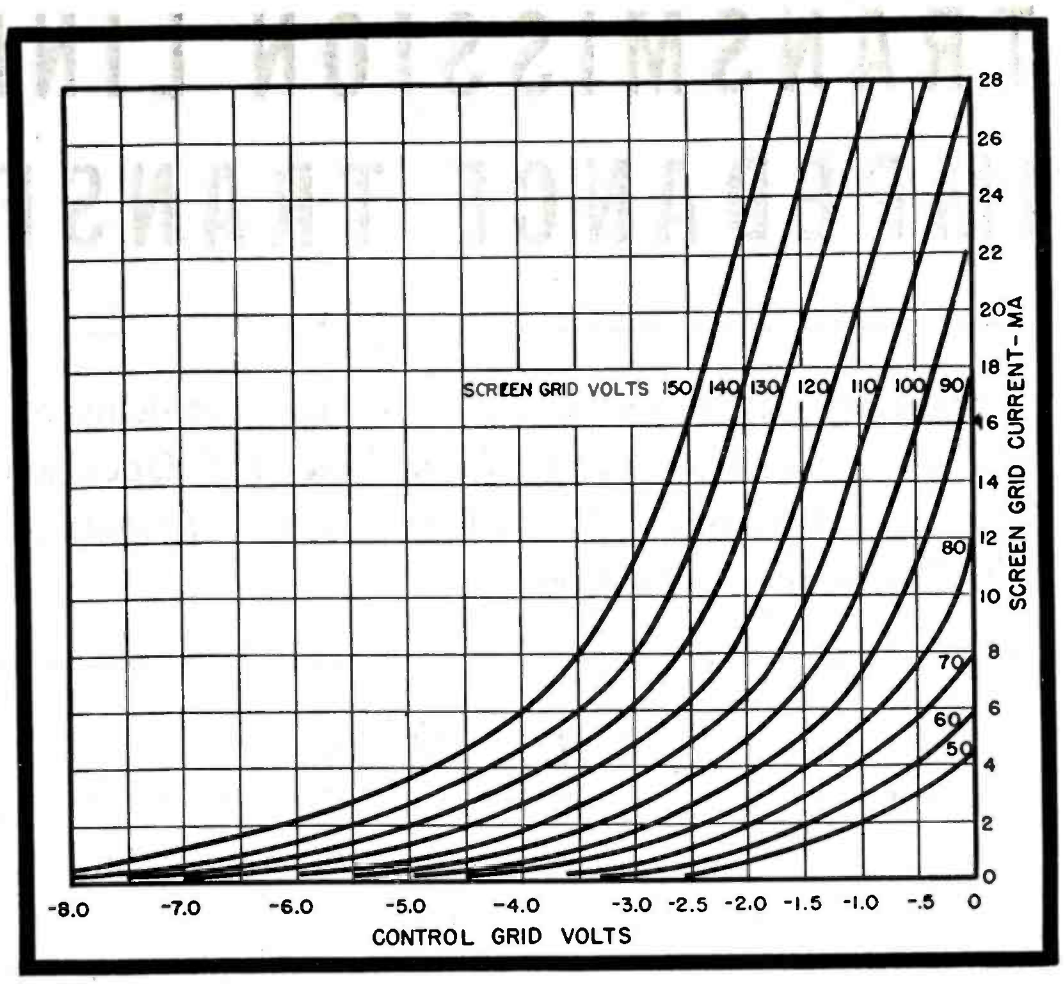
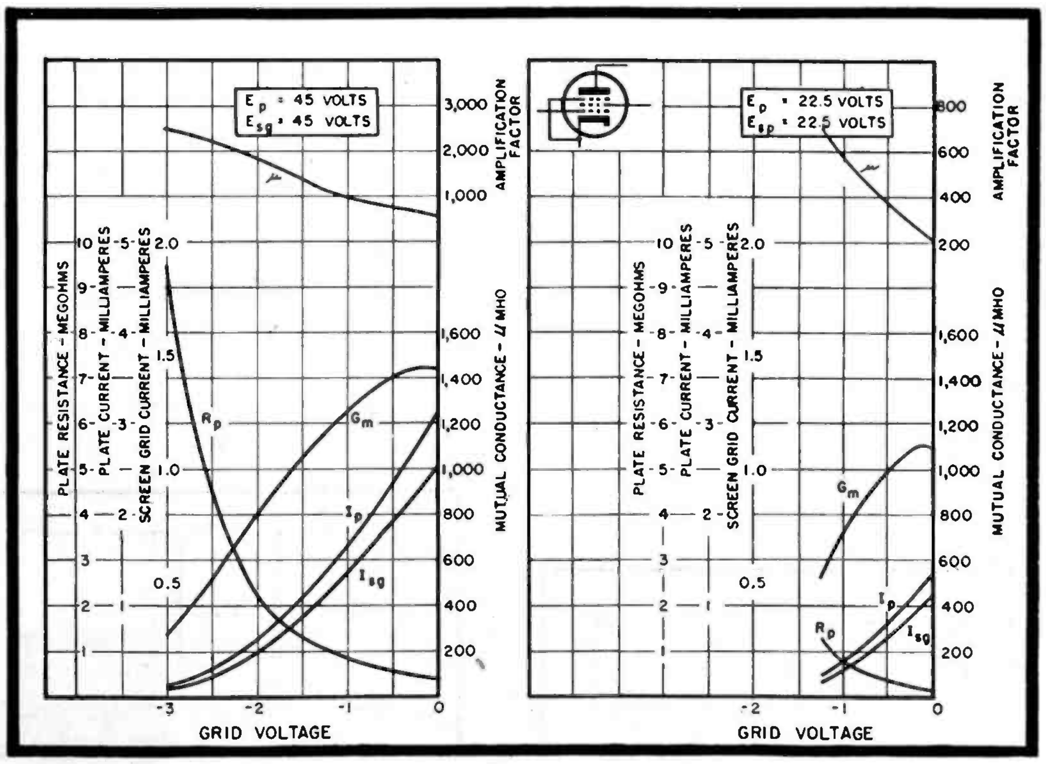


Figure 14

Screen-grid current characteristics of 6AG7. Supply voltage, 300; load resistance, 10,000 ohms; heater voltage, 6.3.

Figure 15

Characteristic curves of 6SJ7 used in design procedures employing plate and dynamic characteristics.



TRANSMISSION LINES as IMPEDANCE TRANSFORMERS

Concluding Installment Presents Typical Problems and Solutions Involving Quarter-Wave Line, and Open and Shorted-Stub Matching. Circle Diagrams for Transmission-Line Solutions Also Explained.

by L. R. QUARLES

Associate Professor of Electrical Engineering, University of Virginia

THE QUARTER-WAVELENGTH LINE is the simplest application of the transmission line as an impedance transformer.

Let us consider the equations for the current and voltage in a line having negligible losses. These are[1]

$$E_s = E_r \cos \beta l + j\, I_r Z_o \sin \beta l \qquad (1)$$

and

$$I_s = I_r \cos \beta l + j \frac{E_r}{Z_o} \sin \beta l\,, \qquad (2)$$

where E_s and I_s are the input, voltage and current, while E_r and I_r are similar quantities at the receiving end. Z_o is the characteristic impedance of the line and βl is the angular length of the line. For a quarter-wave line (i. e., $\beta l = \pi/2$) these reduce to

$$E_s = j\, I_r Z_o \sin \pi/2$$

and

$$I_s = j \frac{E_r}{Z_o} \sin \pi/2\,.$$

Hence we have the relations,

$$\frac{E_s}{I_s} = \frac{Z^2_o}{E_r/I_r}\,,$$

or

$$Z_s = Z^2_o/Z_r\,. \qquad (3)$$

Here Z_s is the impedance presented across the input terminals, which, for a match, should be equal to the generator impedance, while Z_r is the terminating impedance. Thus a quarter-wavelength line transforms the terminating impedance, Z_r, to a value, Z_s, given by equation (3). Since a line of negligible losses as assumed here has a characteristic impedance which is a pure resistance, the section will transform a terminating resistance, R_r, to a pure resistance value at the input. If the terminating impedance is complex, the input impedance, because of the reciprocal relation between Z_s and Z_r in equation (3), will have the opposite type reactance, i. e., capacitance is transformed to inductance and vice versa. These relations are shown in Figure 1. Here a load, Z_r, is matched to a generator impedance, Z_s, by inserting a line one-quarter wavelength long and of the proper characteristic impedance between them. Best results are obtained when the impedances to be matched are of the same order of magnitude. However, widely different values may be satisfactorily matched by a series of quarter-wave sections, Figure 2.

[1] *Transmission Lines as Resonant Circuits*, COMMUNICATIONS; May 1946.

Q Antenna Matching

A familiar example of a quarter-wave matching section is the *Q* antenna used by many amateurs. Suppose we wish to match a 500-ohm open-wire transmission line to the center of a half-wave antenna whose impedance at this point is 72 ohms. From equation (3) we have

$$Z_o = \sqrt{Z_s Z_r} = \sqrt{500 \times 72} = 190 \text{ ohms.}$$

For mechanical reasons such a section would normally be constructed of parallel rods, so let us assume the use of ½" diameter tubing. Then, since

$$Z_o = 276 \log \frac{D - a}{a}\,,$$

D being the spacing and *a* the radius of the rods, we get

$$190 = 276 \log \frac{D - .25}{.25}.$$

Thus D is 1.46". A section of ½" diameter rods spaced 1.46" and a quarter-wavelength long, connected as shown in Figure 3, will thus match our line and load.

It is interesting to note the effect of letting βl equal π (half-wavelength section) in equations (1) and (2). This gives, upon clearing,

$$\frac{E_s}{I_s} = \frac{E_r}{I_r}\,, \quad \text{so} \quad Z_s = Z_r\,.$$

A half-wave line will therefore act as

Figure 1
Quarter-wave matching section.

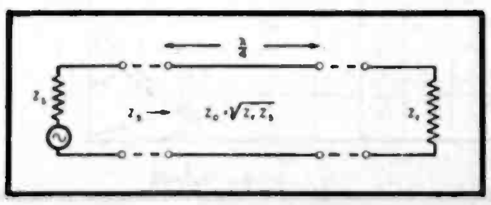


Figure 3
Line-to-antenna matching with quarter-wave line.

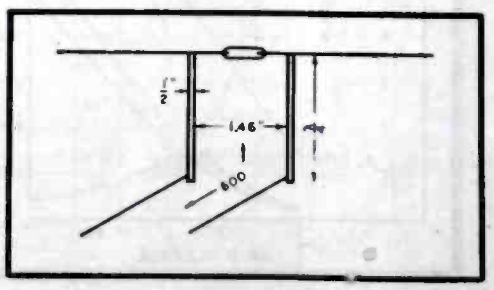
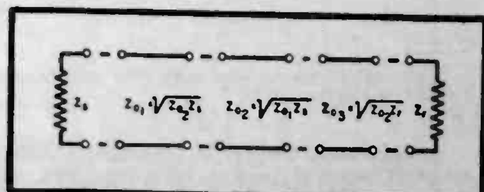


Figure 2
Quarter-wave sections to match widely different impedances.



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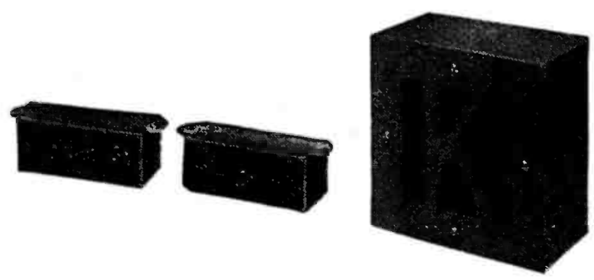
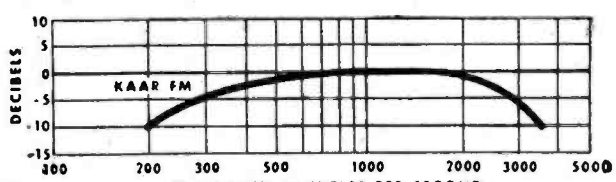


KAAR LOUD SPEAKER, remote controls for transmitter and receiver (illustrated above) and the famous Type 4-C push-to-talk microphone are among the accessories furnished with the equipment.

IMPROVED OVER-ALL FREQUENCY RESPONSE THROUGH KAAR FM TRANSMITTER AND RECEIVER



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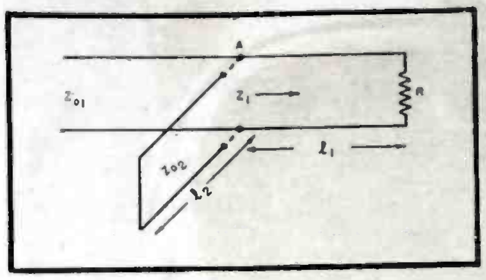
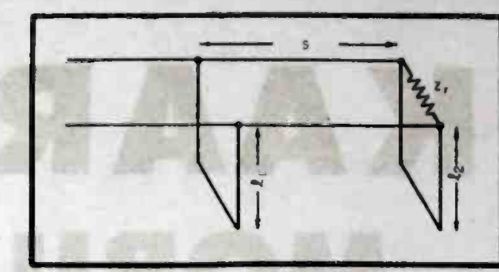


Figure 4 (left)
Single stub matching.

Figure 5
Double stub matching.



a unity ratio impedance transformer.

Stubs

A still more flexible system of matching is obtained by using short sections, called stubs, of line across the main line. By properly adjusting the position and length of the stub or stubs a line may be readily matched to the load. From (*1*) and (*2*) we get the relation

$$Z_s = \frac{E_s}{I_s} = Z_o \frac{Z_r \cos\beta l + j Z_o \sin\beta l}{Z_o \cos\beta l + j Z_r \sin\beta l}, \qquad (4)$$

from which we see that for a given load, Z_r, the input impedance, Z_s, is a function of the length of the line. Thus, referring to Figure 4, if we terminate the line in a resistive load, *R*, there will be some length, l_1, where the impedance, Z_1, looking to the right has a resistive component, R_1, equal the characteristic impedance, Z_{o1}, of the line. However, the impedance to the right from the point *A* (that is, the point at which R_1 is equal Z_{o1}) will also have, in general, a reactive component. In other words, it will be of the form $R_1 + j X_1$. We can cancel this reactance term by connecting an equal and opposite type reactance in parallel with it at point A. We have already seen[2] that an open or short-circuited line will present practically pure reactance across its input terminals except when the line is a multiple of a quarter-wavelength long. Such a section of line, may, therefore, be connected at *A* and its length adjusted so the combination of the line to the right and the stub presents only a resistance, $R_1 = Z_{o1}$, to the line to the left of *A*. Thus there is a match at this point. From point *A* to the load we have standing waves but since this is a short length the losses are small.

The necessary working equations may be obtained from (*4*) by applying the appropriate restrictions[3]. These equations may be simplified if we use admittances expressed in terms of the ratio Y/G_o, where *Y* is the admittance being considered and G_o is the characteristic admittance (a pure conductance) of the line. We further assume that Z_{o1} is equal to Z_{o2}. The terminating admittance is given by the expression

$$\frac{Y_r}{G_o} = \frac{Z_o}{Z_r} = g_{1r} - j\,b_{1r} \qquad (5)$$

For an open stub the equations, after considerable manipulation, reduce to

$$\tan\beta l_2 = \sqrt{\frac{(g_{1r} - 1)^2 + b_{1r}}{g_{1r}}}, \qquad (6)$$

and

$$\tan\beta l_1 = \frac{g_{1r} - 1}{g_{1r}\tan\beta l_2 - b_{1r}}, \qquad (7)$$

where βl_1 and βl_2 are the angular lengths of the section l_1 and the stub respectively. If these are in degrees we have

$$l_1 = \frac{\lambda\beta l_1}{360}, \text{ and } l_2 = \frac{\lambda\beta l_2}{360}, \qquad (8)$$

λ being the wavelength. For a short-circuited stub the equations yield

$$\cot\beta l_2 = \sqrt{\frac{(1 - g_{1r})^2 + b^2_{1r}}{g_{1r}}}, \qquad (9)$$

and

$$\tan\beta l_1 = \frac{1 - g_{1r}}{g_{1r}\cot 2 - b_{1r}}. \qquad (10)$$

For stubs shorter than a quarter-wavelength the short-circuited stub gives the lowest value of l_2 if $g_{1r} < 1$, while an open stub gives the lowest value of l_2 if $g_{1r} > 1$.

As an example of such an application let us reconsider the foregoing problem for a frequency of 100 mc. The terminating admittance gives the equation,

$$Y_{1r} = g_{1r} - j\,b_{1r} = \frac{500 + j0}{72 + j0} = 7 + j0.$$

Since g_{1r} is greater than unity an open stub will be closer to the load and hence will give the lowest losses in the unmatched section. Equations (*6*) and (*7*) give the following values:

$$\tan\beta l_2 = \sqrt{\frac{(7-1)^2 + 0^2}{7}} = 2.27$$

$$\beta l_2 = 66.2°$$

$$\tan\beta l_1 = \frac{7 - 1}{7(2.27) - 0} = .38$$

$$\beta l_1 = 20.8°$$

Substituting in (*8*) we have, since $\lambda = 3$ meters,

$$l_1 = (20.8/360) \times 3 = .17 \text{ meter},$$

and

$$l_2 = (66.2/360) \times 3 = .55 \text{ meter}$$

Because of the effect of the shorting bar of an open wire stub, this value for l_2 should be corrected by subtracting a value of *D*/2, where *D* is the spacing of the stub wires, if such a stub is to be used. No correction is necessary for coaxial stubs.

Where the impedances are not known the length of the stub and its position may be determined experimentally by measuring the maximum and minimum voltage on the line with the load, Z_r, connected. If we let *Q* be the ratio of the maximum voltage to the minimum voltage, then, for a closed stub,

$$\cot\beta l_2 = \pm\frac{Q - 1}{\sqrt{Q}} \qquad (11)$$

and

$$\tan\beta d = \pm\sqrt{Q} \qquad (12)$$

where *d* is the distance to the stub measured from a voltage maximum towards the generator. If the distance is measured towards the generator from a voltage minimum, *d* is given by the equation,

$$\tan\beta d = \pm\frac{1}{\sqrt{Q}} \qquad (13)$$

The values obtained from the foregoing equations will usually need a little experimental adjustment. Experimental variation of the distance l_1, Figure 4, for a coaxial line is somewhat difficult. This trouble may be avoided by the use of two stubs, one at the load and the other across the line as shown in Figure 5. Here the

---

[2]COMMUNICATIONS; May, 1946.

[3]Ware and Reed; *Circuits*, p. 161; John Wiley. King, et al, *Transmission Lines and Wave Guides*, p. 46; McGraw-Hill.

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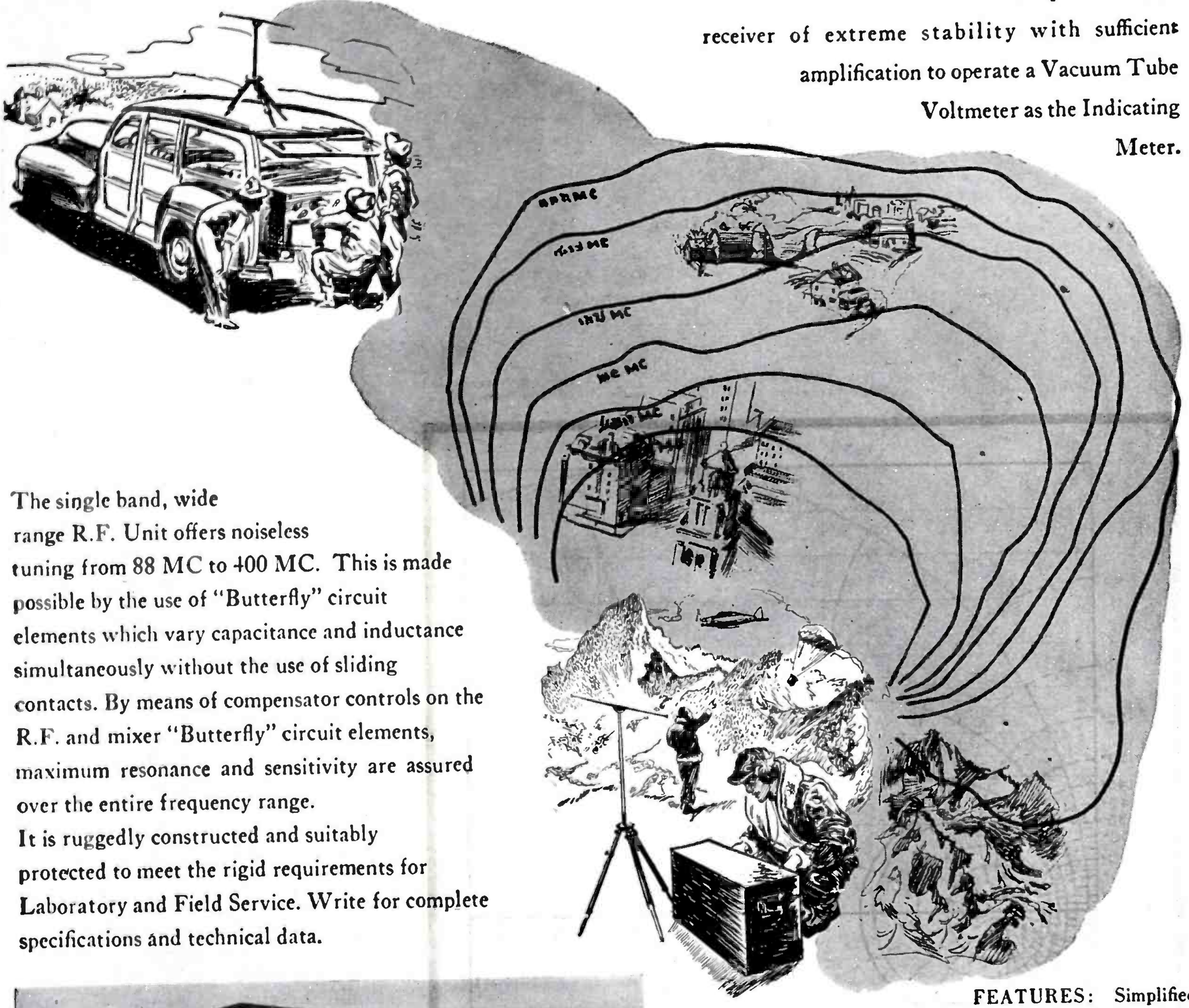

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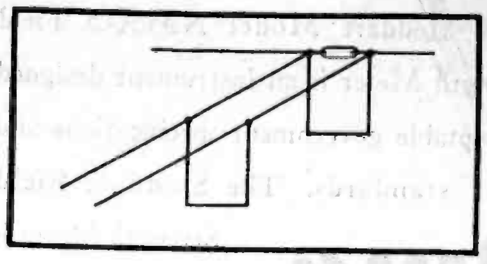


Figure 6
Line-to-antenna matching with double stubs.

stub at the load is adjusted so the impedance presented by it and the load in parallel will cause a match at the other stub. A solution of the equations yields, for closed stubs,

$$\cot \beta l_1 = \pm \frac{\sqrt{\cot^2 \beta S - g_{1r} + 1}}{\sqrt{g_{1r}}} - \cot \beta S, \qquad (14)$$

and

$$\cot \beta l_2 = \pm \sqrt{g_{1r}}\sqrt{\cot^2 \beta S - g_{1r} + 1} - \cot \beta S - b_{1r}. \qquad (15)$$

Since the quantity under the radical in these equations must be positive, the spacing of the stubs for a given value of g_{1r} is limited by the condition,

$$\cot^2 \beta S - g_{1r} + 1 \geq 0. \qquad (16)$$

However, for any given value of g_{1r} we can find some spacing, S, which will permit a match by adjusting the lengths of the stubs.

Double Stubs

Now let us solve our previous problems of matching the feeder to an antenna by means of double stubs. Since g_{1r} has been found to be 7, condition (*16*) gives,

$$\cot^2 \beta S \geq 6, \quad \text{or} \quad \cot \beta S \geq 2.45.$$

Hence

$$\beta S \leq 22.2°, \quad \text{or} \quad S \leq \frac{22.2}{360} 3.$$

Let us use a distance, S, of .15 meter and find the other necessary lengths. Equation (*14*) gives

$$\cot \beta l_1 = \frac{1}{\sqrt{7}} \sqrt{\cot^2 18° - 7 + 1} - \cot 18°$$

$$= -2.38$$

$$\beta l_1 = 157.2°$$

$$l_1 = \frac{157.2}{360} 3 = 1.31 \text{ meters.}$$

From equation (*15*)

$$\cot \beta l_2 = \sqrt{7}\sqrt{\cot^2 18° - 7 + 1} - \cot 18° - 0$$

$$= 1.87$$

$$\beta l_2 = 28.1°$$

$$l_2 = \frac{28.1}{360} 3 = .23 \text{ meter.}$$

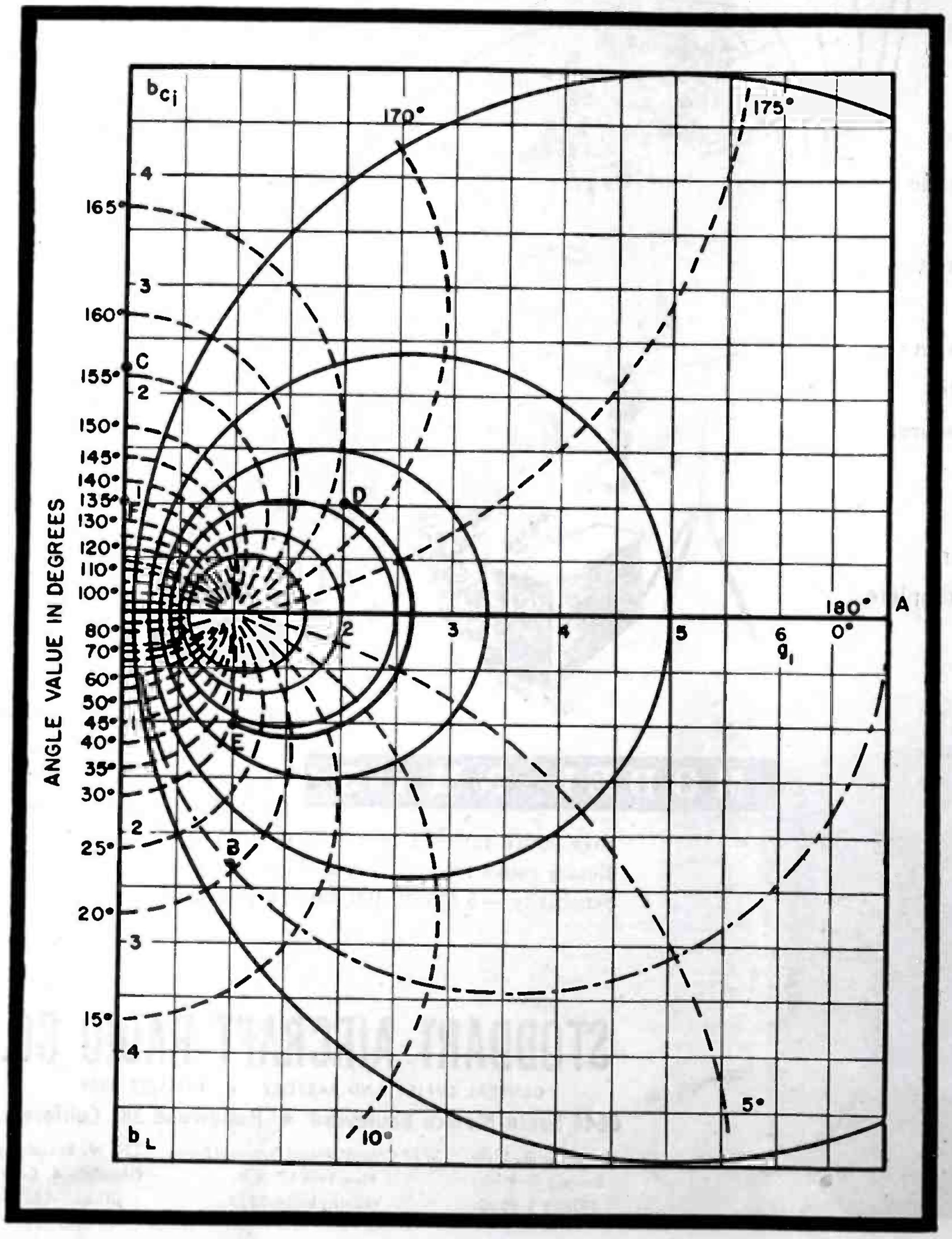
The construction of this matching arrangement is shown in Figure 6. The stubs have the same spacing and conductor size as the feeder.

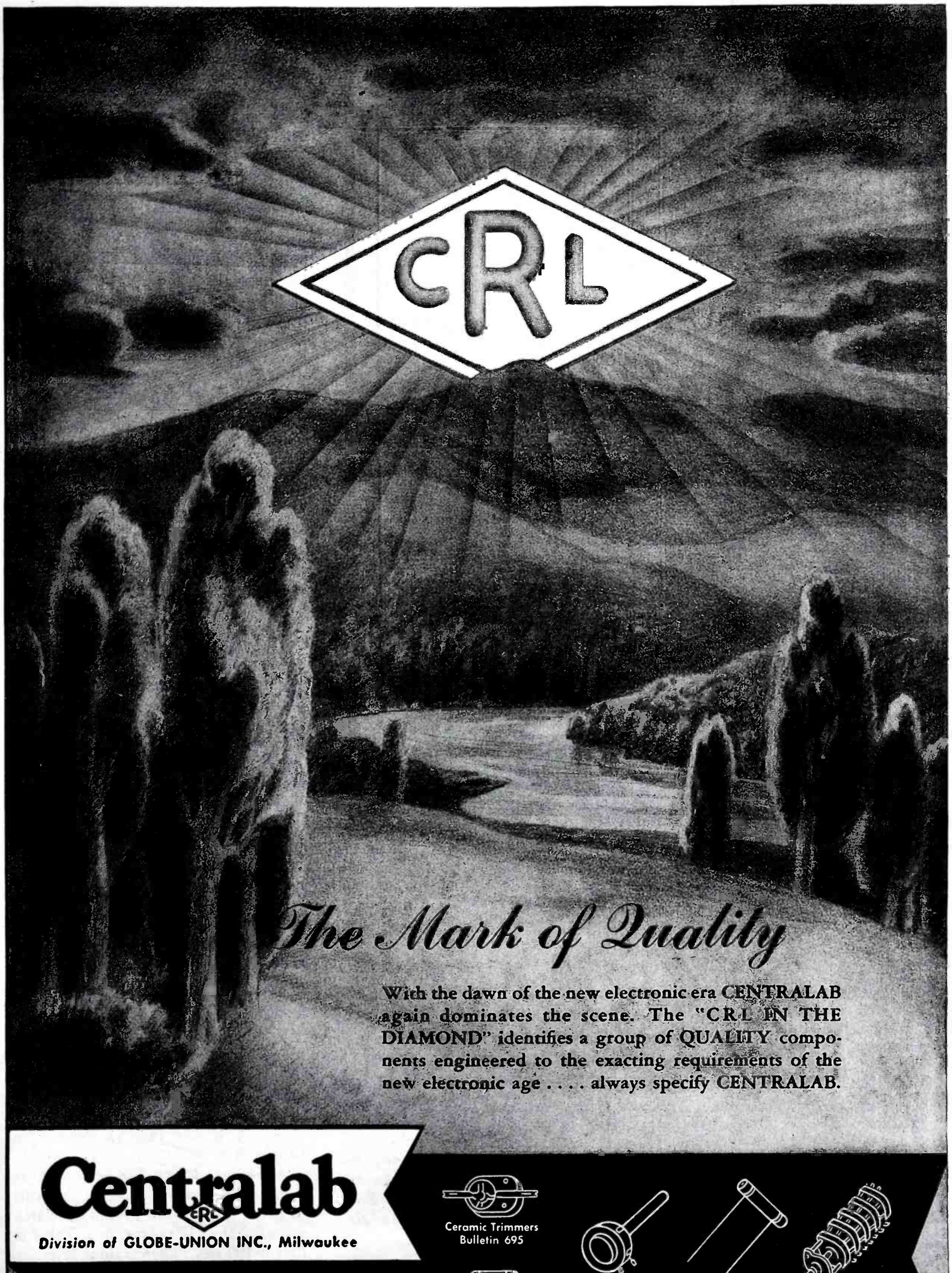
Circle Diagram

The solution of these matching stub problems as well as many other line problems, may be greatly simplified by the use of a circle diagram. No attempt will be made here to develop the diagrams, but we shall confine our efforts to their use. If we plot the complex input impedance, Z_s, of a line terminated in a load, Z_r, as the length of the line is varied, we will get a circle. The process repeated for different values of Z_r will yield a family of circles. Again, if we use the ratio, $\frac{Z_o}{Z_s} = g_1 + j\,b_1$, we can construct a diagram as shown in Figure 7, the circles surrounding the point (1, 0) being the result for various values of Z_r. In this diagram g_{1r} is plotted along the x-axis and b_1 along the y-axis. If we fix the length of the line and vary the value of Z_r we get another family of circles whose centers are on the vertical axis. These are shown dotted in Figure 7.

We may now use the chart of Figure 7 to solve our matching stub problems. As an example let us solve

Figure 7
Circle diagram used to solve matching stub problems. The ratio $Z_o/Z_s = g_1 + j\,b_1$ was used to construct this diagram. Circles surrounding the point (1,0) are the result for various values of Z_r.

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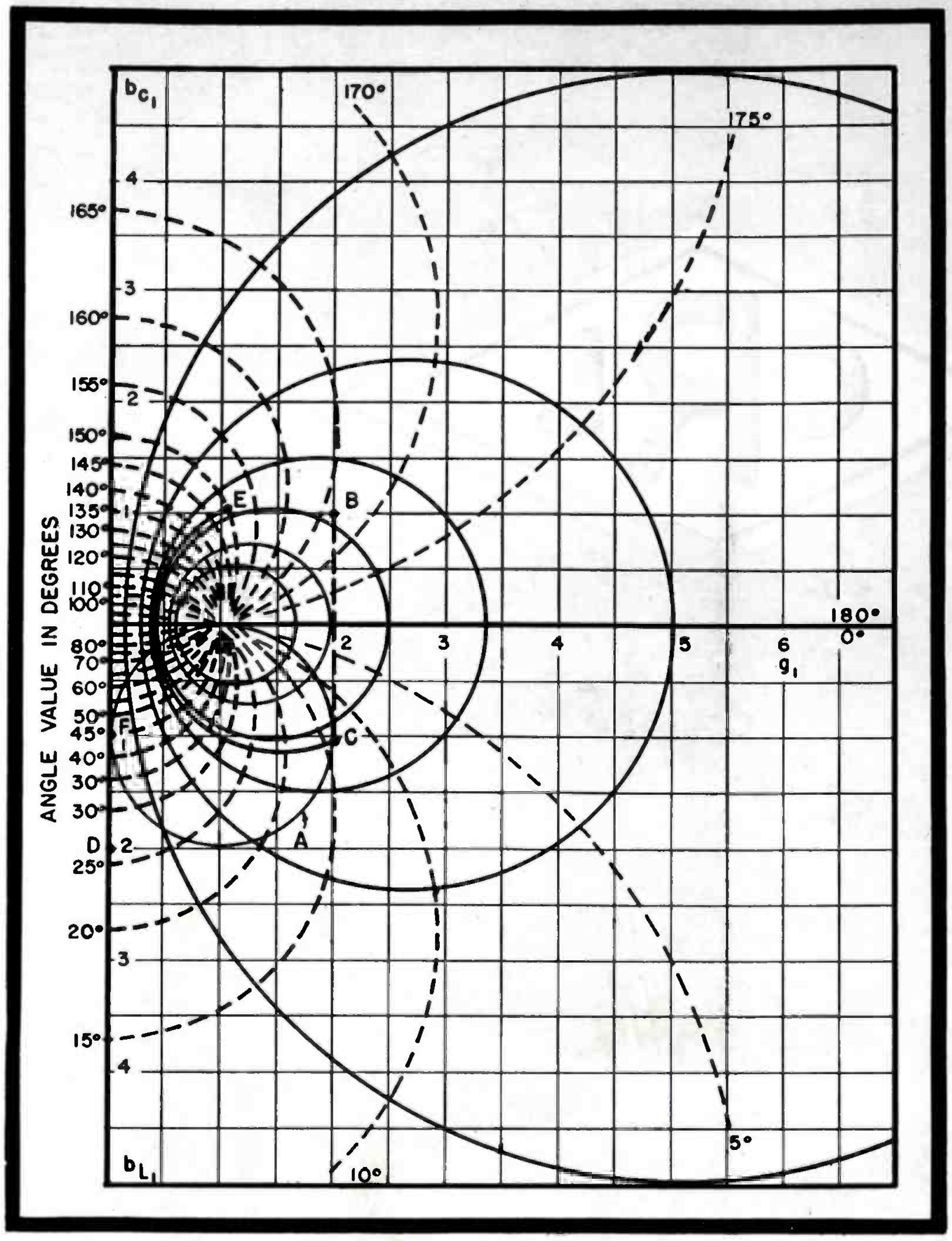

Figure 8

Circle diagram, where *A* is for 3/8λ spacing. This circle, used to get a double-stub system to match a load, 200 — *j* 100 ohms, to a 500-ohm line at 100 mc, provides the values $Y_{1r} = R_o/Z_r = 2 + j\,1$. This is located at point *B*.

our previous problem by this method. First we find the circle passing through the point Y_r/G_o, which for our problem is the point *A* (7, 0). This requires interpolation between two circles of the chart. When a matched condition is obtained Y_s/G_o, i. e., the input admittance divided by the characteristic admittance, will be unity so we follow the circle (shown as a dot-dash circle in the figure) through point *A* clockwise to its intersection with the vertical line through the point (1, 0). The angle passed through, as denoted by the dotted circles, is the angular distance βl_1. Our circle cuts this vertical line at point *B* (1, −2.25). By interpolation between the dotted circles for 20° and 25° we get 21° for our angle circle. We started on the zero angle circle (the *x*-axis is 0 or 180°), so our angle is 21° which checks our previous solution. As before, the distance l_1 is 17 cm. The *y* coordinate, −2.25, of point *B* is the unit value of this susceptance which the stub must cancel. This requires a value of + 2.25. As the stub is pure susceptance, we find a third point *C* on the *y* axis and with an ordinate of 2.25. The angle circle (again obtained by interpolating between two of the diagram circles) which passes through this point gives the angular length of the stub as 156°, hence

$$l_2 = \frac{156}{360} 3 = 1.3 \text{ meters.}$$

For an open stub, such as we used in our previous solution, we subtract 90° from the angular length of the short-circuited stub. Thus, using an open stub, βl_2 is 156° − 90° = 66°, checking the value found by computation. As before, l_2 is 55 cm.

To get a more general type solution let us use Figure 7 to find the necessary data for matching a 500-ohm line to a load impedance of 200 − *j* 100 ohms. This gives

$$Y_{1r} = \frac{R_o}{Z_r} = 2 + j\,1.$$

We find the point with coordinates (2, 1) as shown at *D* in Figure 7. We then follow the circle through this point clockwise to the vertical line through the point (1, 0) as before. This is the point *E* (1, −1). To cancel the susceptance of −1 requires a positive susceptance of unity, hence the third point, *F*, is located at (0, 1). Our lengths are now found from the angle circles. Point *D* is on the circle for 167° (by interpolation) and *E* is on the one for 32°. We have therefore covered the angular range from 167° to 180°, hence to 32°. Thus our angular length, βl_1, is

$$(180 - 167) + 32 = 45°,$$

hence

$$l_1 = \frac{45}{360} 3 = .375 \text{ meter.}$$

The point *F* is on the 135° circle, so βl_2 is 135° for a closed stub, or 135-90 = 45° for an open one. For the open stub, then

$$l_2 = \frac{45}{360} 3 = .375 \text{ meter.}$$

By adding to Figure 7 other circles determined by the following conditions we can use the diagram for double-stub problems. The centers of these new circles are located by the equations,

$$g_1 = \frac{1}{2 \sin^2 \beta S} \qquad (19)$$

$$b_1 = \cot \beta S,$$

and the radii are given by $\dfrac{1}{2 \sin^2 \beta S}$, where *S* is the stub spacing as in Figure 5.

A circle, *A*, for 3/8 λ spacing is shown in Figure 8. Let us use this to get a double stub system to match a load, 200 − *j* 100 ohms, to a 500-ohm line at 100 mc. These values give

$$Y_{1r} = \frac{R_o}{Z_r} = 2 + j1.$$

This is located as point *B* of Figure

(*Continued on page* 38)

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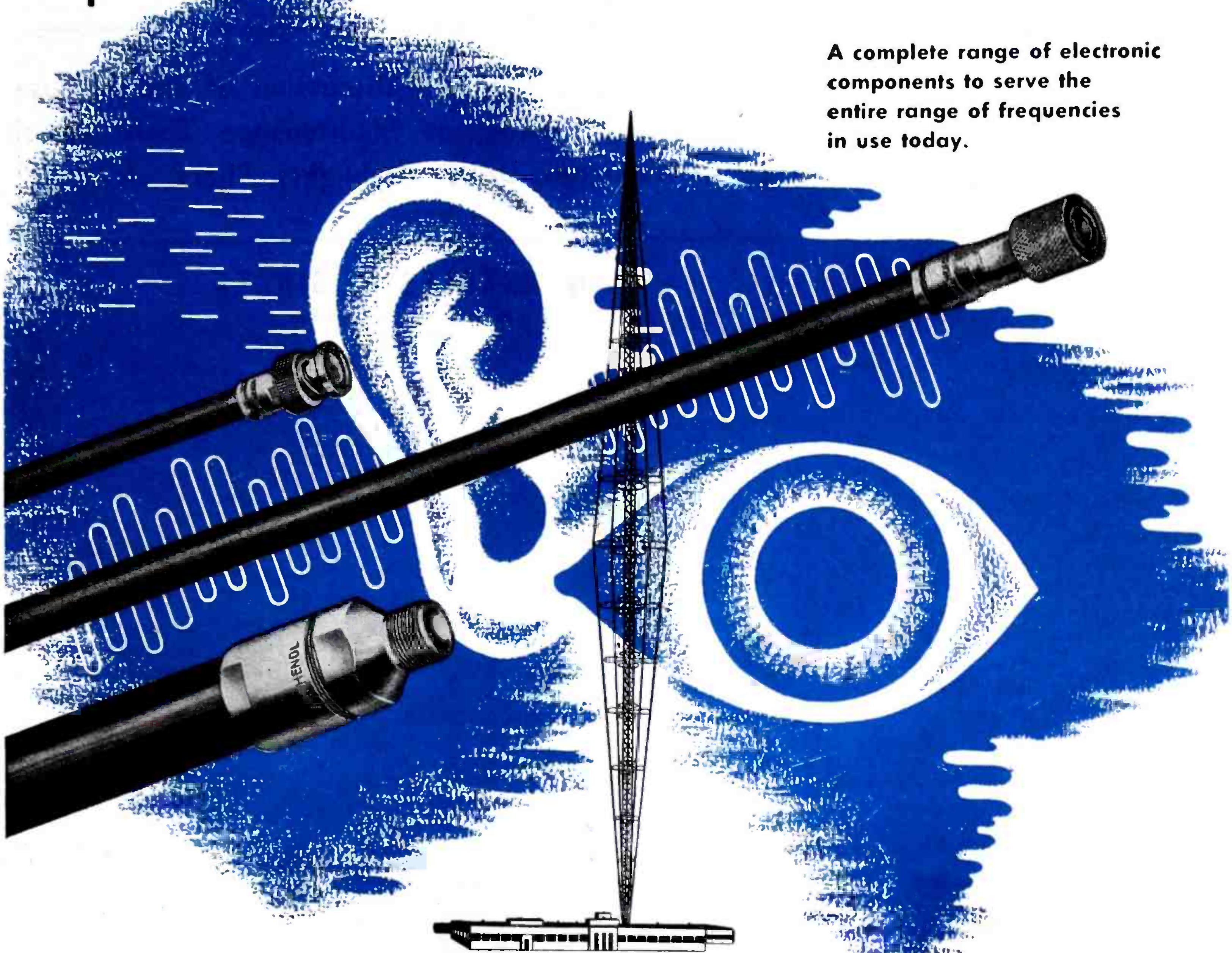

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PREVENTIVE MAINTENANCE for Broadcast Stations

Part II of Series Offers a Discussion of the Purpose, Handling and Packing of Maintenance Tools Which Include Wrenches, Drills, Flashlights, Pliers, etc.

by CHARLES H. SINGER
Assistant Chief Engineer
WOR-WBAM

THE IMPORTANCE OF A WELL kept tool kit cannot be over-emphasized. Since the preventive maintenance program is a regular part of the daily schedule, the required tools not only must be available, but they must always be in satisfactory working condition.

Too much stress cannot be placed upon the need for careful handling and storing of tools. Missing or broken tools cause delays. The use of a substitute tool or one that is not exactly suitable for the work at hand, in place of a broken or lost tool, may cause unnecessary damage. The proper care of tools is just as much a responsibility as the proper care of the equipment itself.

Use and Care of Tools

Allen wrenches. These wrenches are used to tighten or loosen the set-screws on fan blades, pulleys, etc. They are small and easily lost and should be kept in a small cloth bag. After use, they should be wiped with an oily rag, replaced in the bag, and stored in the tool box.

Electric drills. Electric drills must be handled carefully. They are built for light work only and should be used with caution. The chuck-key should be attached to the drill with a stout string so that it will not be lost. Bits should not be allowed to over-heat as a result of prolonged drilling. Excessive heat will burn the metal and make it necessary to redress the drill. Care must be exercised to see that the bits do not jam in the holes being drilled. If a bit jams, the drill motor should be stopped, the bit withdrawn and replaced. Electric cords must not be pulled; drills should be handled by lifting body.

Flashlights. Flashlights must be kept clean and ready for use at all times. Burned-out batteries should not remain in the case; they are apt to swell, making it difficult to remove them. Flashlights should be stored in the top tray of the tool box if possible.

Pliers. Several types of pliers are used. Although they have different shapes and sizes, all must be cared for in the same way. They should be kept clean, and be oiled occasionally to keep the joints free, with excess oil being removed with a cloth. The pliers should be stored in the tool box, not in trouser pockets.

(1) Diagonal pliers should be used to cut copper wire up to size No. 14, not iron wire or thick wire.

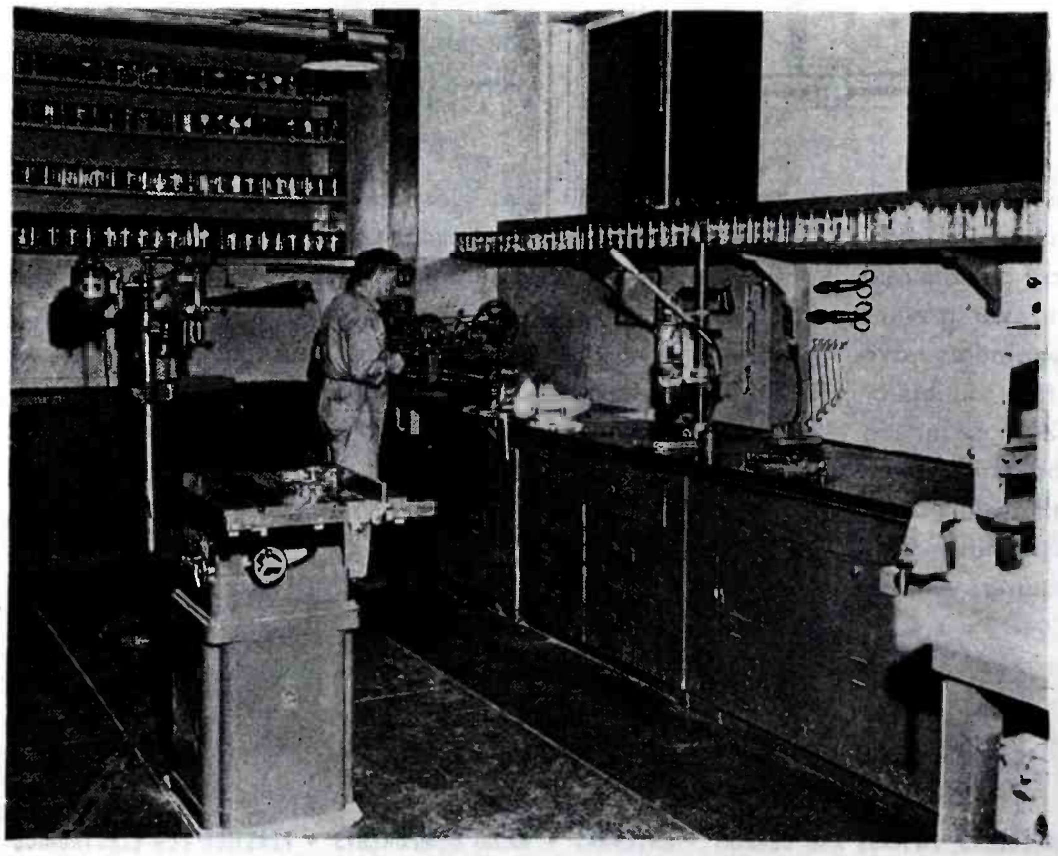
(2) Side cutters or lineman's pliers should be used for all sizes of wire up to No. 6, and to twist wire when making connections. They will serve wherever a heavy pliers is needed.

(3) Gas pliers should be used to hold round tubing, round studs, and round metal objects which do not have a screw-driver slot or flat sides for wrenches. Tubing must not be gripped too tightly; it may be crushed. Gas pliers are designed for use on round pipe and will damage any soft metal or wrench-type fitting; they should not be used on nuts or screw heads.

(4) Long-nose pliers should be used to hold and bend small wires, grip very small parts, and service delicate apparatus. They

(*Continued on page* 52)

Figure 1
Machine and carpenter shop of WOR's technical facilities division.



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Type	Input Voltage	Output Voltage	Watts	Maximum Amps.	Figure	Net Price
V-O	115 volts	0-130	230	2	A	$10.10
V-O-B	230 volts	0-260	230	1	A	12.45
V-1	115 volts	0-130	570	5	B	14.25
V-1-M	115 volts	0-130	570	5	C	23.80
V-2	115 volts	0-130	570	5	A	11.90
V-2-B	230 volts	0-260	570	2.5	A	14.85
V-3	115 volts	0-130	850	7.5	A	17.85
V-3-B	230 volts	0-260	850	3.75	A	23.80
V-4	115 volts	0-130	1,250	11	A	26.15
V-4-B	230 volts	0-260	1,250	5.5	A	33.30

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Universal Varitrans have two 110 volt Primary windings (110 or 220V connection) and a 28 volt variable secondary winding. This winding can be used as a 0-28 volt low voltage source. It can also be used in autotransformer connection with the primaries to effect . . . 115 in/87 to 143 out, 220 in/192 to 248 out, 220 in/82 to 138 out, 115 in/202 to 258 out.

Type	Max. Amps. Output	Approx. Dimensions	Approx. Weight, Lbs.	Figure	Net Price
VL-O	1.5	4½x6½x2½	5	A	$ 8.30
VL-1	3.5	4½x6½x3	7	A	9.50
VL-2	6	4½x6½x4	10	A	11.90
VL-3	11	5x7x5	15	A	19.00

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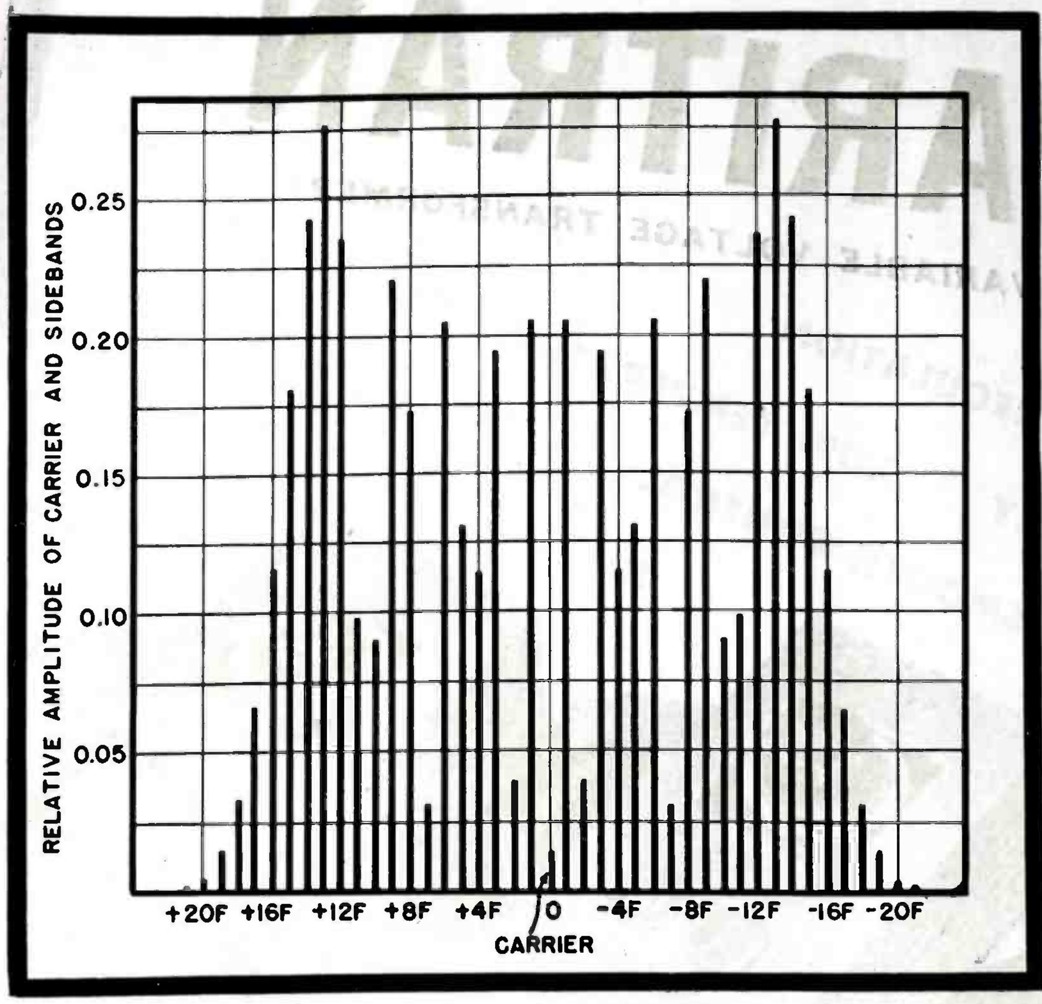


Figure 1
Relative amplitudes of an f-m wave carrier and sidebands when an audio frequency *F* is used, and the ratio of frequency deviation to the audio frequency is only 15. It will be noted that even at this small value the carrier is extremely small.

An f-m transmitter employing the direct f-m method has to have, as a primary source of oscillations, an oscillator circuit capable of modulation. However, to abide with the FCC rulings the center frequency of the oscillator has to be stabilized. The output center frequency must be held within ± 2,000 cycles of the assigned frequency. This does appear puzzling at first glance inasmuch as it is well known that in order to have a stable oscillator high-*Q* circuits should be employed, but if high-*Q* circuits are used in this case the oscillator will be incapable of proper modulation. In the case of amplitude modulation the high-*Q* circuit consists of a crystal which, as previously stated, is not useable as a primary source of direct f-m oscillations.

The logical solution is to employ some method of automatic-frequency control. The frequency however is continuously varying and it is necessary to pick out the center frequency for comparison. Let us suppose now that the center frequency can be filtered out by means of a narrow band filter, inasmuch as it was shown previously[1] that an f-m signal consists of a center frequency and sidebands. It was shown, too, that the amplitude of the carrier was equal to the Bessel function of the first kind, of order zero, of the frequency deviation over the modulating frequency. Thus no carrier will exist at the point where this ratio is equal to 2.40 and other zero points and it will be very small in the neighborhood of those values. With no carrier input to the filter there will be no frequency available for control purposes. For instance, even at the low value of ratio of frequency deviation to audio frequency equal to *15*, the carrier amplitude falls to *.014* of the peak amplitude as shown, Figure 1. An audio frequency of *F* is used with a frequency deviation of Δf where $\frac{\Delta f}{F}$ is equal to *15*.

Actually for an audio frequency of *30* cycles and a deviation of *75* kc this ratio goes up to *2,500*, the carrier becoming of course extremely small. If the deviation should be reduced to a much smaller value, for instance a ratio of $\frac{\Delta f}{F}$ equal to *.2*, the amplitude of the carrier will increase tremendously, Figure 2. In this case most of the energy is in the carrier whereas in the other case most of it was in the sidebands.[2]

The first important point then is to obtain a signal with the smallest deviation possible. At the oscillator itself, which in many cases operates at about *5* mc, the frequency deviation ratio is usually under *200* for all modulating frequencies. Using a portion of this signal for control purposes the deviation may be reduced to any desired value with the use of frequency-divider circuits. Thus both the frequency and the deviation are reduced in the same ratio. To reduce a frequency deviation ratio of *200* to *.2* it would be necessary to divide the frequency by *1,000*. This would result in a final frequency of

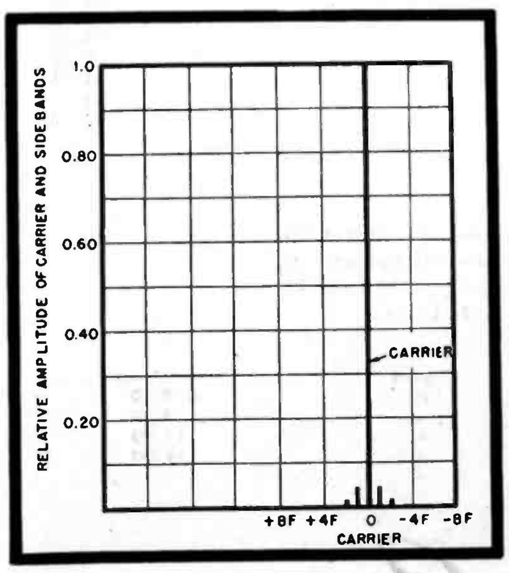


Figure 2
Relative amplitudes of an f-m wave carrier and sidebands when an audio frequency *F* is used, and the ratio of frequency deviation to the audio frequency has been reduced to .2. The amplitude of the carrier is now adequate for use in an afc circuit.

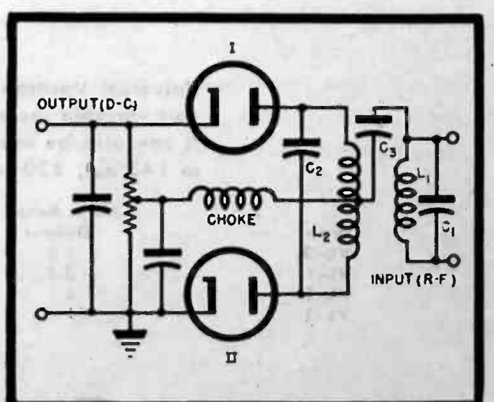


Figure 3
A frequency discriminator circuit which is tuned to the mid r-f frequency. The polarity and amplitude of the d-c output voltage is dependent on the deviation of the input frequency from this mid r-f frequency.

F-M Frequency-Control Methods

Methods Employed to Stabilize the Center Frequency of an F-M Transmitter Which Uses a Direct System of F-M Modulation Are Described in This, Part Seven of a Series of Papers on F-M Transmitter Design and Operation. Basic Circuits for Each of the Methods Discussed Are Presented and Analyzed.

by N. MARCHAND*

Consulting Engineer

Lowenherz Development Company

about *5,000* cycles for use in the frequency regulating circuit.

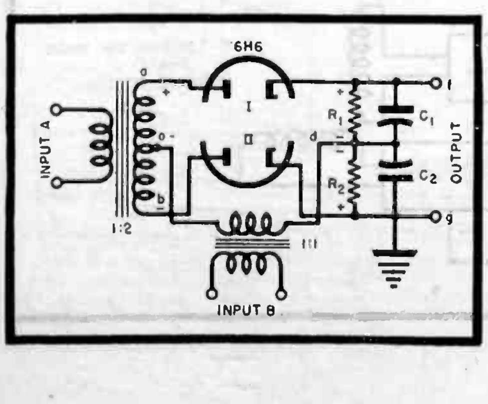
Discriminator Control

One type of circuit that can be used for automatic frequency control is shown in Figure 3. This is the standard discriminator circuit[3] which is often used as an f-m detector in receiver circuits. A d-c voltage is obtained at the output which is dependent on the frequency of the input signal. L_1, C_1 and L_2, C_2 are tuned to the mid frequency of the r-f signal. C_3 is a coupling capacitor which adds the voltage across L_1, C_1 to half the voltage induced in L_2, opposite halves being used for each diode. As the frequency varies, the amplitudes of the signals introduced across the two diodes varies, giving rise to a voltage which is proportional to the frequency deviation. If a circuit like this were to be used for the frequency regulation of a direct f-m transmitter the circuits would have to be extremely stable. This has not proved practical in the ordinary broadcast transmitter.

The other method of discriminator control is to employ a crystal oscillator and compare the frequency with that of the mid frequency of the modulated oscillator. However in this case it is actually a phase comparison that is used and the circuit is referred to as a phase discriminator, Figure 4[1]. One signal is applied at input *A* and the other at input *B*. In a transmitter circuit one would be a signal obtained from a crystal-oscillator source and the other would be the signal obtained from the f-m modulated oscillator after sufficient frequency division has been applied. It will be noted that the voltage from input *A* is applied in push-pull to the two diodes, while the voltage from input *B* is applied in parallel to the two diodes. At one instant of time if the two voltages add at diode *I* they will subtract at diode *II*. The output from diode *I* appears as a d-c voltage across R_1, while the output from diode *II* appears across R_2 as a d-c voltage. The resistors are so connected that the difference between the two voltages is taken as the output. In other words the difference in the amplitudes of the voltages applied to diodes *I* and *II* appears as a d-c voltage across the output.

Figure 4

Circuit of a phase discriminator where the output voltage is dependent on the phase between the two input voltages at *A* and at *B*.



To analyze the operation of this type circuit, let us study phasor diagrams, as we have in Figure 5. Here the input *B* is applied through an untuned transformer to points *d* and *o*, and is shown as V_{do}. Inasmuch as V_{do} is in the common cathode circuit of both diodes, it is applied to both diodes *I* and *II* in parallel. Input *A*, on the other hand, is applied to a center tapped transformer, half of whose output voltage is applied to diode *I* and the other half to diode *II*. Calling the voltages V_{oa} and V_{ob}, it can be seen that at any instant of time V_{oa} is the negative of V_{ob}. This is indicated by the polarity signs in Figure 4 and is so drawn in Figure 5. Tracing the circuit for each of the diodes, the voltage applied to diode *I* is equal to the phasor sum of V_{do} plus V_{oa}. Similarly the voltage applied to diode *II* is equal to the phasor sum of V_{do} and V_{ob}.

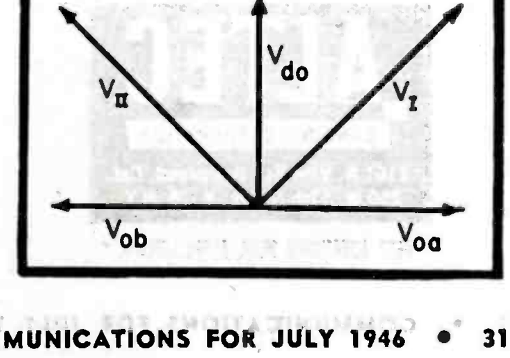
In Figure 5 appears the resultant voltages which are applied to the diodes when V_{do} is 90° out of phase with V_{oa}. These voltages are labeled V_I and V_{II}. It will be noted that for this condition the two resultant voltages are equal in magnitude. This means that after they are detected the two voltages appearing across R_1 and R_2 will be equal and opposite so that the output voltage across *f-g* will be zero. It is interesting to note that this will be true even though the relative amplitudes of V_{do} and V_{oa} should vary.

Let us suppose now that the frequency of V_{do} should decrease slightly. The difference in frequency will cause the phase angle between V_{oa} and V_{do} to decrease. The effect of this decrease is shown in Figure 6. V_I has increased and V_{II} has decreased. The voltage across *f-g* in Figure 4 will now assume a positive value which can be applied to the modulated oscillator to correct the drift. Similarly if the frequency of V_{do} should increase, the angle between V_{do} and V_{oa} would increase resulting in an increase in the magnitude of V_{II} and a decrease in the magnitude

(*Continued on page* 32)

Figure 5

Phasor diagram of the operation of the phase discriminator shown in Figure 4. Since V_I is equal to V_{II} in amplitude in this case, the output of the discriminator is zero.



*Instructor in Graduate Electrical Engineering courses, Columbia University.

[1]Federal Telephone and Radio Corp.

DIRECT F-M

(Continued from page 31)

of V_I. This will result in a negative voltage appearing across *f-g* which can also be used to correct the drift.

Calling the angle between V_{do} and V_{oa}, θ, the resultant difference in amplitudes V_R is

$$V_R = \sqrt{(V_{do}\sin\theta)^2 + (V_{oa} + V_{do}\cos\theta)^2} - \sqrt{(V_{do}\sin\theta)^2 + (V_{oa} - V_{do}\cos\theta)^2} \qquad (1)$$

allowing both V_{do} and V_{oa} to equal V.

$$V_R = 2V(\cos \tfrac{1}{2}\theta - \sin \tfrac{1}{2}\theta) \qquad (2)$$

A curve of equation (*2*) is shown in Figure 7. The control voltage available at the output is practically linear between 0° and 180° but control is lost beyond those points. However the phase only varies beyond that point if a voltage of $2V$ is insufficient to pull the oscillator back to the mid frequency desired. The capacitors C_1 and C_2 should provide enough filtering action to prevent degeneration of the modulation being put on the wave.

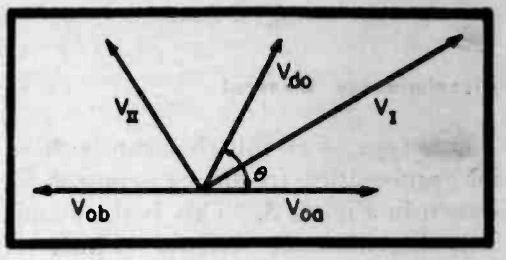
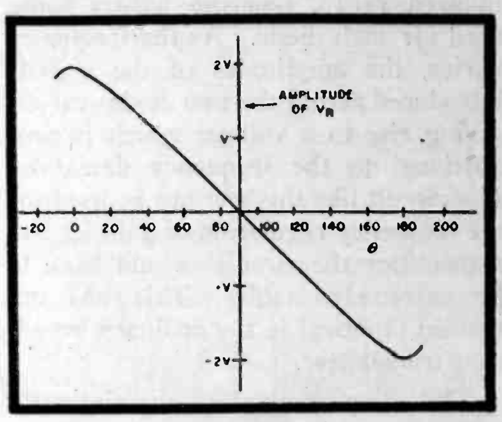


Figure 6

A phasor diagram showing how V_I increases and V_{II} decreases when the phase angle between V_{do} and V_{oa} is decreased.

Figure 7

A curve of equation (*2*) showing the difference in amplitude between V_I and V_{II}. It will be noted that control is lost at θ = 0° and 180°.



Motor Control

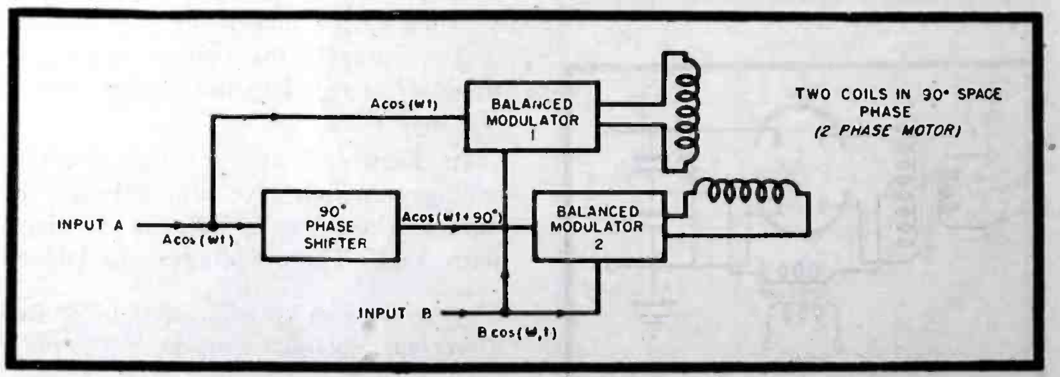
The use of a bias control on the reactance tube or similar device in an f-m modulator necessarily limits the excursion of the frequency caused by the audio voltage; allowance has to be made for the variation in bias by the control source. In other words enough linearity of the modulating source has to be allowed above and below the audio voltage excursion to permit the control source to shift the bias and correct any deviation of the center frequency. By the use of a motor control this can be eliminated. Instead of varying the bias on a reactance device the motor control actually varies a capacitor in the oscillator circuit and corrects the center frequency in that manner.[2]

In Figure 8 appears a block diagram illustrating the method of obtaining a controlling voltage for the motor by comparing two frequencies, one at input *A* and the other at input *B*. In a normal transmitter circuit input *A* would be from a crystal oscillator and input *B* from the modulated oscillator which is to be controlled. Let us suppose the voltage at input *A* be $A \cos \omega t$. It is split into two parts, one of which is applied directly to a balanced modulator, *1*, and the other part is shifted 90°. This voltage $A \cos(\omega t + 90°)$ is applied to balanced modulator *2*, as shown. The voltage input at *B*, $B \cos \omega_1 t$, is applied directly to both balanced modulators.

The process of modulation usually

Figure 8

Block diagram of a method of obtaining a rotary field for a two-phase motor used for control purposes by comparing two frequencies, one at input *A* and the other at input *B*.



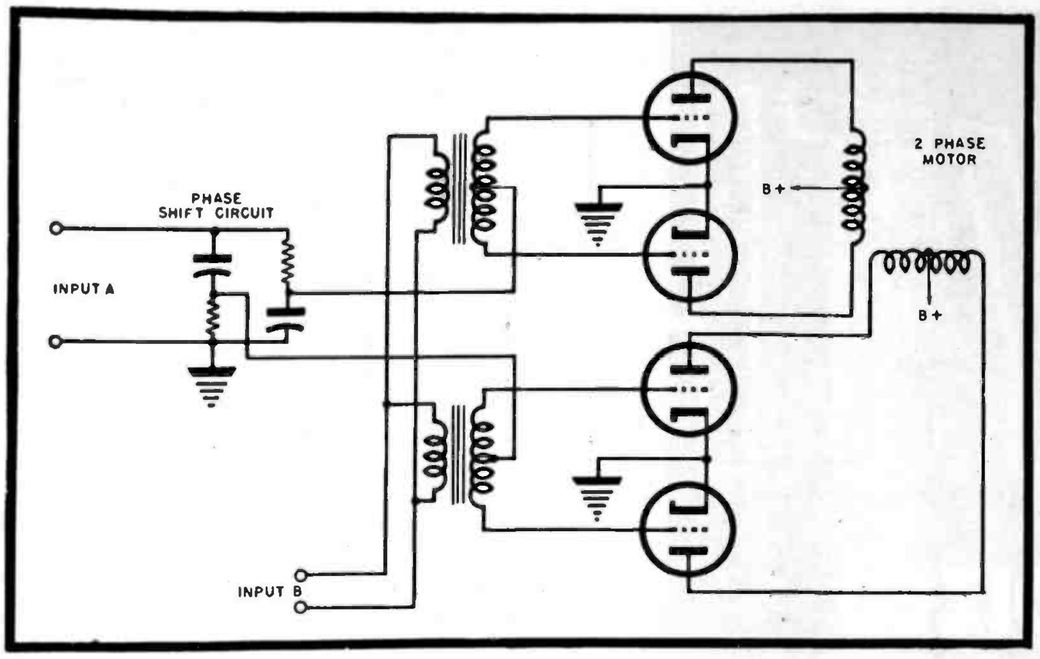


Figure 9
Stabilizing circuit for use with motor control of a variable capacitor in the oscillator circuit.

involves all of the frequencies obtained by taking the product of the two frequencies plus, of course, the original frequencies. Those frequencies which are not desired are eliminated by means of a selective filter. However, in a balanced modulator the carrier frequency is not present in the output. Even though the two frequencies involved in this case are very close together it can still be treated as an ordinary modulation case. Assuming now that low-pass filters, which are usually the output coils themselves, are employed, only the lower sidebands will be obtained. For clarification this sideband can be considered the beat frequency between the two input frequencies. Calling the output voltage from modulator *1*, V_1, and the output voltage from modulator *2*, V_2, we have

$$V_1 = V \cos(\omega - \omega_1)t$$
$$V_2 = V \cos[(\omega - \omega_1)t + 90°] \quad (3)$$

It will be noted that the two outputs are 90° out of phase. If they are now impressed on two coils, which are at 90° space phase (placed at right angles to one another), a rotating field will result. It will rotate at a speed equal to the difference between the two frequencies. By inserting an armature, we obtain a two-phase motor. This is actually used in the application of this system. The armature of the motor is connected to a variable capacitor which is in the oscillator circuit. As the motor turns it varies the frequency of the oscillator until the difference frequency is zero. When the difference frequency is zero the lower sideband or beat frequency will also go to zero so that the motor rotation will stop at that point. As seen from (*3*) if ω_1 is larger than ω, V_2 will lag V_1 and the direction of rotation of the motor will reverse, tending to correct for that condition also.

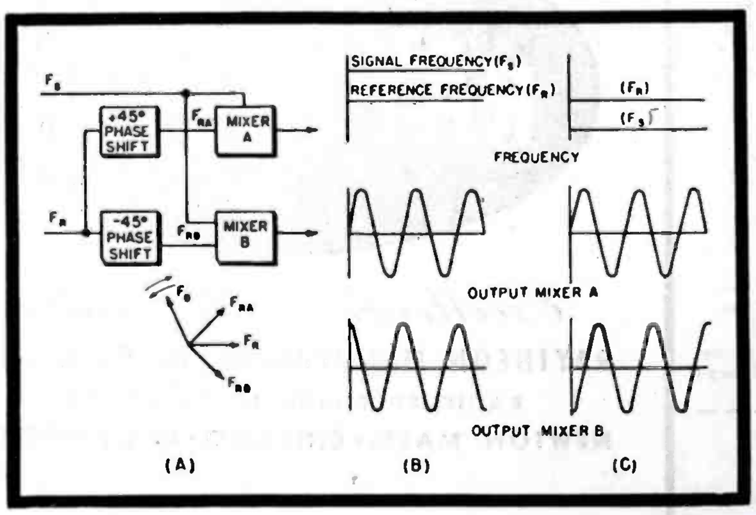
In Figure 9 appears a circuit which can be employed with a motor control of the oscillator frequency. In this case instead of keeping the phase of one of the inputs from input *A* constant and shifting the other input 90°, one of the inputs is shifted plus 45° and the other is shifted minus 45° with resistor-capacitor networks. The net result, of course, is the same.

Integrated Pulse Control[4]

The foregoing systems of regulation depend on maintaining the correct center frequency of the modulated oscillator. Other systems of frequency control have also been suggested. One of these would correct to a point where the total time that the frequency was above the assigned frequency would be equal to the total time that it was below. If the modulation was a pure sine wave, such a system would correct to the assigned frequency. With unsymmetrical modulation, however, some of the sidebands would often spill over into the adjacent channel. Another system proposed would provide adjustment of the frequency so that the maximum excursion above the assigned frequency would be equal to the maximum excursion below the assigned frequency. Such a system would keep the sidebands within the assigned spectrum under steady state conditions, even though the wave form of the modulation was not symmetrical. Under transient conditions, where one non-symmetrical waveform quickly follows an-

[4] *Westinghouse Electric Corp.*

Figure 10
Block diagram of mixer circuits showing the phasor diagram and the two voltage outputs (*B*), when the signal frequency is higher than the crystal frequency and (*C*) when it is lower.



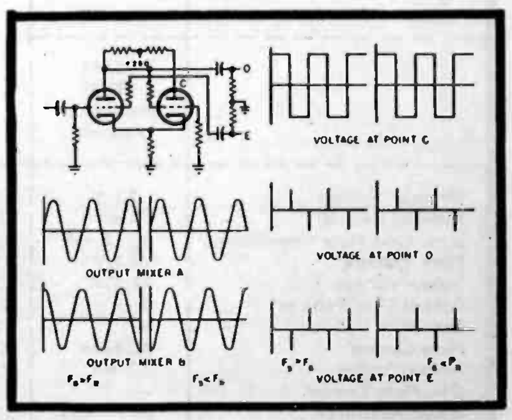


Figure 11
A direct-coupled multivibrator driven from the output of mixer *A* in Figure 10. The square-wave output is differentiated to yield a series of pulses.

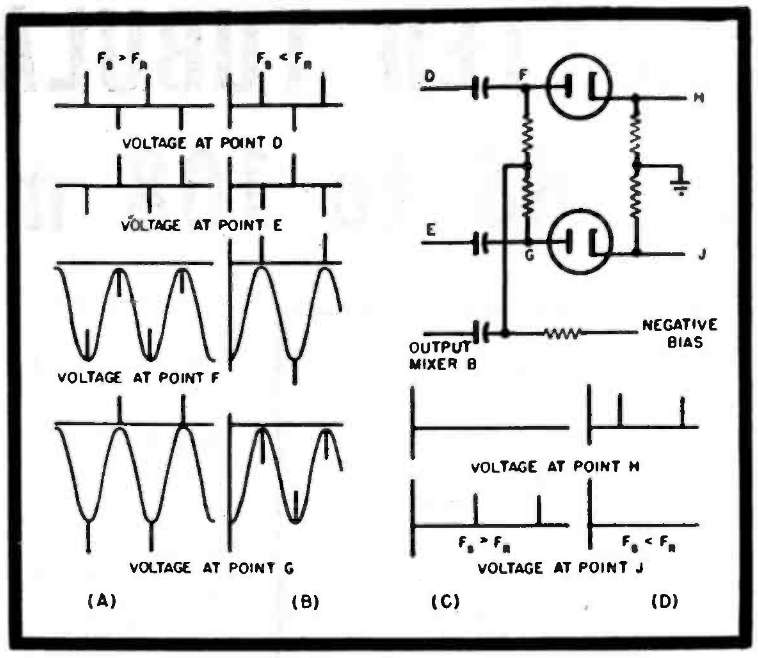


Figure 12
The resultant voltages obtained when the pulses obtained from the multivibrator of Figure 11 are mixed with the output of mixer *B* of Figure 10.

other, considerable spilling over would occur if the correction were not rapid enough.

Another method of correction is based on the area enclosed on each side of the assigned frequency. If a crystal oscillator is built to operate on the assigned center frequency and mixed with the output of the modulated oscillator into a non-linear impedance, we'll have a beat note which has an instantaneous frequency equal to the instantaneous excursion of the modulated signal. The total number of cycles of beat note produced while the oscillator is on one side of the assigned frequency will be exactly proportional to the area enclosed by that part of the curve. Therefore, if the total number of cycles produced while the oscillator is on the high side of the assigned frequency is equal to the total number of cycles produced while the oscillator is low in frequency, the transmitter would be operating at the correct mid-frequency.

The integrated pulse system operates on this latter fact. Each cycle of beat frequency between the modulated oscillator frequency and the reference frequency is used to generate a pulse. The pulses are separated into two circuits, one receiving the pulses when the oscillator frequency is high and the other when the oscillator frequency is low. A pulse counter circuit is so arranged that when a pulse appears on one of these circuits a definite charge is transferred from a point of fixed potential to a storage capacitor. When the pulse appears on the other circuit the same charge is removed from the capacitor. The voltage across the capacitor will be proportional to the difference in the number of pulses appearing in each circuit and will be zero when the number of pulses are equal.

Referring now to Figure 10(*A*), the signal from the modulated oscillator is designated by F_S, and the crystal oscillator frequency by F_R. The crystal frequency input is fed through two phase shifting circuits, one shifting part of it +45° and the other –45°. Mixers *A* and *B* are used to mix the two resultant voltages with the signal frequency. Figure 10(*B*) shows the relative output of the two mixers when the frequency of the modulated oscillator is higher than that of the crystal. The output of mixer *A* lags the output of mixer *B* by 90°. In (*C*) the signal frequency is lower than that of the crystal oscillator and consequently the output of mixer *B* lags the output of mixer *A*.

The output of mixer *A* is fed into a direct-coupled multivibrator whose output is differentiated off both plates to yield two series of pulses, as shown in Figure 11. In Figure 12, (*A*) and (*B*), appears the result when these pulses are superimposed on the output of mixer *B*. It will be noticed that when the pulses appearing at point *D* are superimposed on the output of mixer *B*, the pulses subtract from the sine wave, if the signal frequency is higher than the reference frequency, and add if the signal frequency is lower. In the case of pulses appearing at *E*, the pulses add to the sine wave if the signal is higher in frequency and subtract if it is lower. The two signals appearing at *F* and *G* are passed through biased diodes that act as pulse discriminators. Thus only those pulses which add to the sine wave are passed, and the pulses are separated into the two proper groups.

Figure 13 shows two pulse counters arranged back to back so that the resultant voltage output across the capacitor at *P* is determined by the difference in the number of pulses in each circuit. If the average frequency of the modulated oscillator is different from the reference frequency, the charge on the storage capacitor is changed in the direction required to overcome that difference. This difference voltage is used to correct the center frequency of the modulated oscillator.

References

[1]N. Marchand, *Fundamental Relationships of F-M Systems*, COMMUNICATIONS; January 1946.

[2]J. F. Morrison, *A New Broadcast-Transmitter Circuit Design for Frequency Modulation*, Proc. IRE; Oct. 1940.

[3]Hans Roder, *Theory of the Discriminator Circuit for Automatic Frequency Control*, Proc. IRE; May 1938.

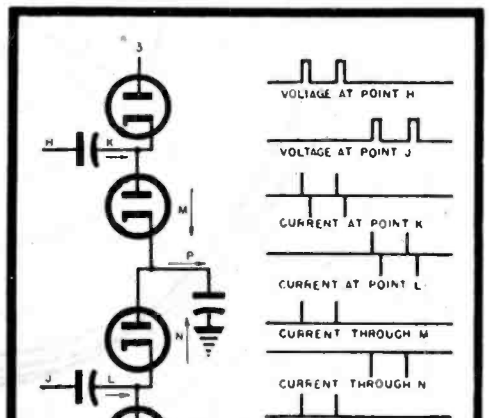


Figure 13
Two pulse counters arranged back to back to give a voltage output at *P* which is determined bv the difference in the number of pulses.

SLOTTED TUBULAR ANTENNA for 88 to 108 mc

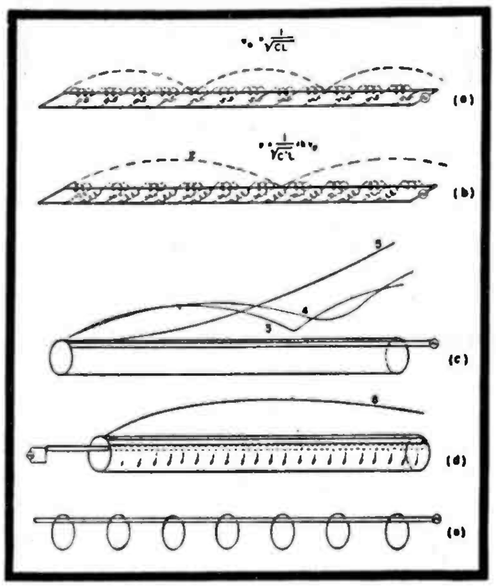
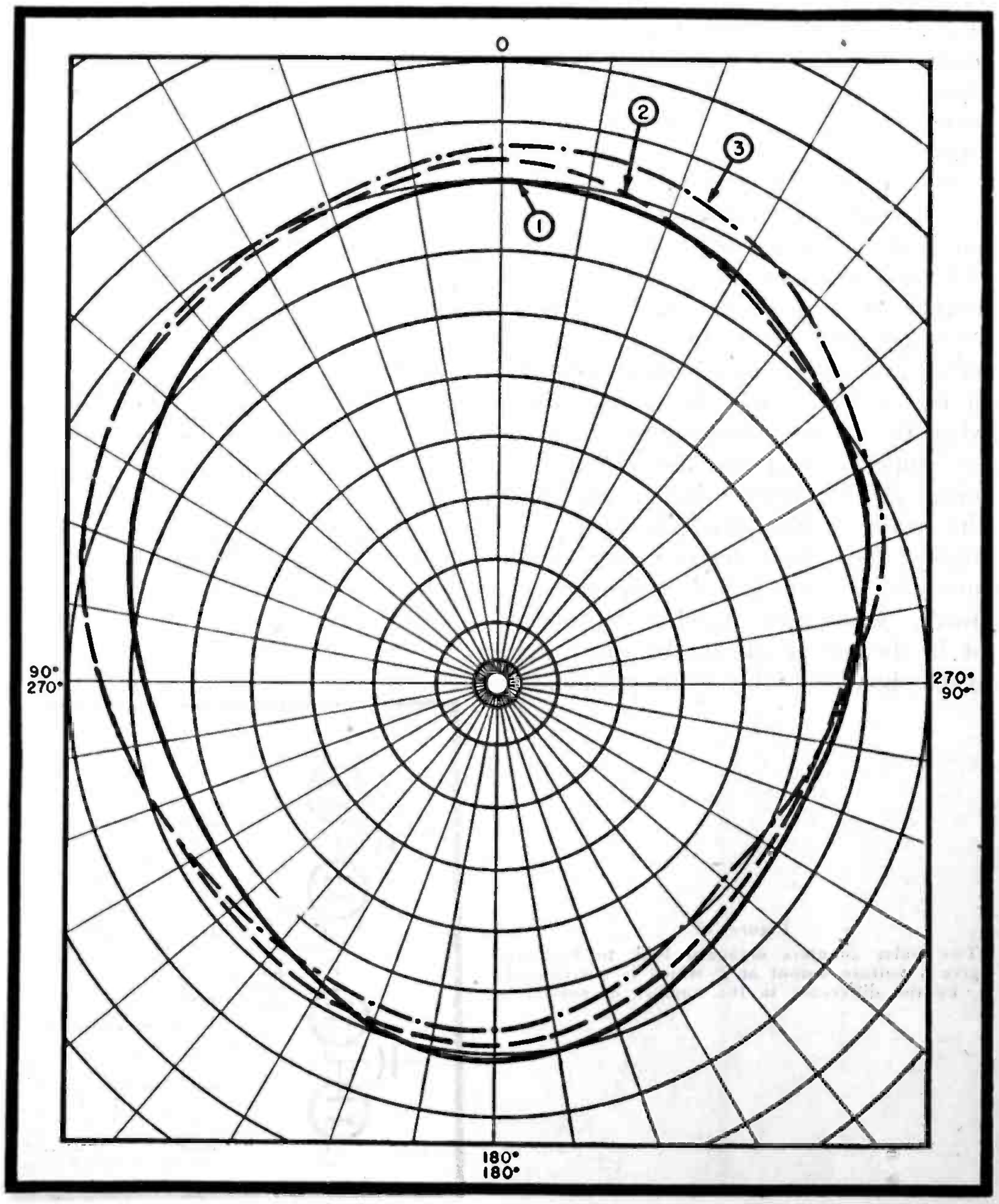


Figure 1
Illustrations, showing construction of tubular antenna, standing wave patterns and voltage distribution characteristics. In (*a*) appear curves of voltage along a standard dual line; (*b*) shows a line loaded with inductance; (*c*) shows line loaded by means of tubular sheet connecting both lines, with resultant standing waves; (*d*) and (*e*) illustrate voltage distribution and equivalent circuit of slotted tube, indicating that it is similar to a stack of loop antennas.

Hollow Metal-Cylinder Slotted-Type Antenna, Rocket-Like in Appearance, Designed for Horizontal Polarization at V-H-F. Uses Coaxial Feed Line

by CHARLES R. JONES
Engineer
Finch Telecommunications, Inc.

Figure 3
Horizontal radiation pattern, plotted in millivolts per meter. Patterns 2 and 3 show effect of supporting round metal.



A METAL CYLINDER-TYPE V-H-F antenna, with a metal bottom and open top, recently developed by Dr. Andrew Alford[1] of the Radio Research Laboratory at Cambridge, Mass., is now being effectively used by WGHF for f-m and facsimile transmissions on 88 to 108 mc.

The antenna is cut longitudinally so that there is a straight narrow slot extending the full length of the cylinder from the bottom plate to the top. To exclude weather, the open top is covered with a molded fibre-glass dome, and the slot is closed by a fibre-glass strip.

A coaxial feeder is brought into the clinder through the bottom plate and is continued along one side of the slot to the top of the antenna where it is

[1]IRE Report, p. 22, COMMUNICATIONS; February, 1946.

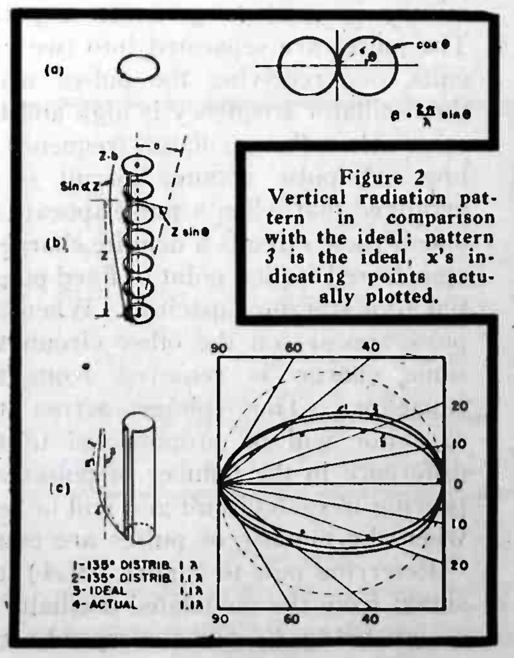


Figure 2
Vertical radiation pattern in comparison with the ideal; pattern 3 is the ideal, x's indicating points actually plotted.

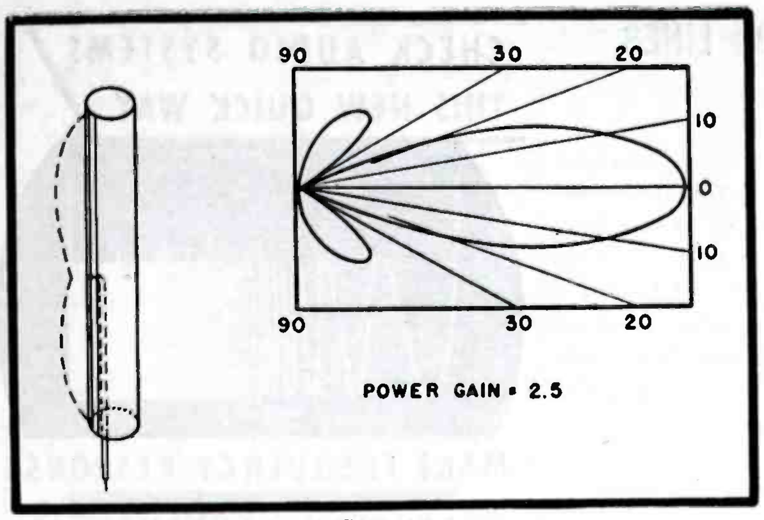


Figure 4
Vertical antenna pattern of a dual tubular antenna at right with open ends joined as shown at left.

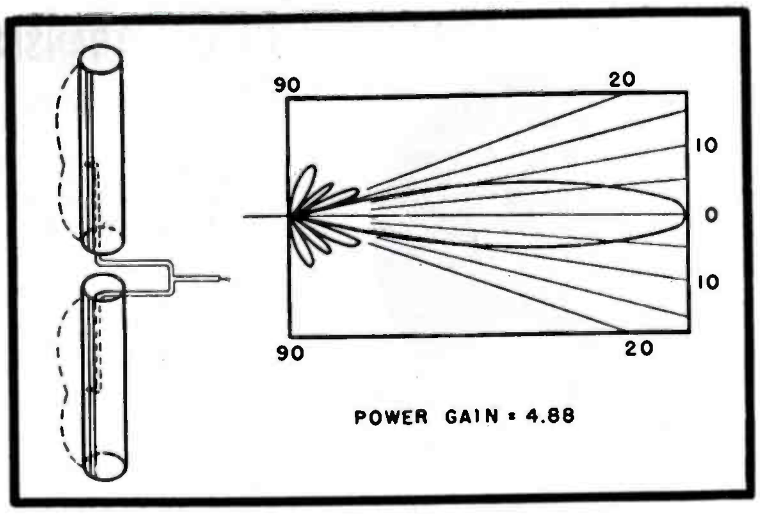


Figure 5
Double rocket arrangement energized in the same plane. Vertical pattern at right.

terminated with an end-seal insulator. The outer conductor is metallically connected to the cylinder at the end seal and at several equally-spaced points. The inner conductor is brought out through the end seal and is connected to the opposite edge of the slot. The potential between the inner and outer conductors is thus applied between the opposite edges of the slot, Figure 1*d*.

The potential difference across the slot is distributed as is indicated by *6* in *d* of Figure 1. This difference of potential produces a flow of circumferential currents around the cylinder. These circumferential currents, being very nearly in phase throughout the length of the cylinder, radiate a field which is similar to that which would be radiated by an array of a large number of small loops stacked one above another, Figure 1*e*.

Potential distribution dictates the diameter of the cylinder, distribution being obtained with the overall length of the cylinder equal to approximately one wavelength at the operating frequency. The voltage distribution is not sinusoidal, as it is along cylinders of large diameters, but comes closer to the ideal uniform distribution.

With a cylinder of this length we obtain a vertical radiation pattern shown in Figure 2. Horizontal radiation pattern appears in Figure 3 (plotted in millivolts per meter).

Since the horizontal pattern is not perfectly circular the comparison between the gain of this type of antenna and a standard half-wave antenna is made on the basis of the equivalent circular pattern. This equivalent pattern has a radius equal to 1/1.24 of the maximum of the actual pattern. On this basis the power gain of the antenna is 1.6. The power gain in the direction of maximum radiation is $1.6 \times (1.24)^2 = 2.46$. The power gain in the direction 180° from maximum is $1.6/(1.07)^2 = 1.39$. In the direction of the minima the power gain is $1.6/(1.2)^2 = 1.11$. When calculated according to the FCC *Standards of Good Engineering Practice*, the variations from the circular almost disappear, and the patterns appear to be circular.

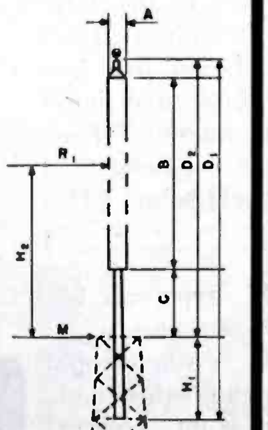
The effects of the supporting round-metal mast may be seen in patterns 2 and 3 of Figure 3. There is a critical mast diameter beyond which the dis-

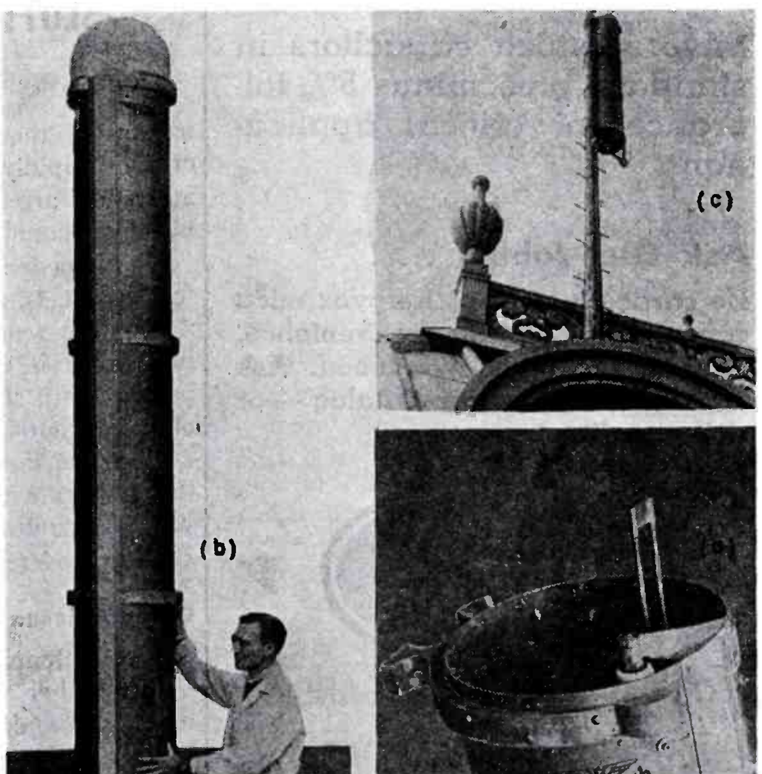
(*Continued on page 38*)

Figure 7 (right)
Interior of the slotted antenna is shown at (*a*); (*b*) shows completed antenna; (*c*), antenna installed.

Figure 6
Installation data for slot antennas.

SECTIONS	SINGLE	DUAL	DOUBLE-DUAL
A	16 1/2"	16 1/2"	16 1/2"
B	10 1/2'	21'	44'
C	5'	5'	5'
D_1	20 1/2'	35'	58'
D_2	16 1/2'	27'	50'
H_1	4'	8'	8'
H_2	10 1/2'	15 1/2'	27'
R_1	454	908	1816
BENDING MOMENT M	4653.5	14074	49032
POLE DIAMETER	5"-18"	5"-18"	5"-18"
WEIGHT	360	550	1,100
POWER GAIN	1.6	2.5	4.88
FIELD GAIN	1.27	1.58	2.21
FREQUENCY BAND	88-108 MC	88-108 MC	88-108 MC





TRANSMISSION LINES

(*Continued from page 26*)

8. The stub added across the load must make the total terminating admittance fall on circle A, so we drop vertically to the circle at point C. This is a change of -2 (from $+1$ to -1), so our stub must give a susceptance of -2. Plotting this along the y-axis we get point D, giving an angular length of 26.5°. Hence

$$l_2 = \frac{26.5}{360} 3 = .368 \text{ meter}$$

for a closed stub. To find l_1 we follow the solid circle through C (again obtained by interpolation) an angular distance of 135°, which corresponds to our spacing of $3/8\lambda$, giving point E on the vertical line through the point (1, 0). The ordinate of E is 1.05 so we need a susceptance of -1.05 to balance it. Plotting this on the y-axis, as before, we get point F, and hence from the angle circle through this point we get βl_1 as 44°. This gives l_1 as .367 meter.

It is obvious that all terminating impedances will not give points such that an added susceptance will locate a point on our $3/8\lambda$ circle, A. These loads cannot be matched with this spacing of stubs, but other circles for other spacings may be drawn by using equations (*19*). The solution is then similar to the one presented here.

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SLOTTED ANTENNA

(*Continued on page 37*)

tortion of the horizontal pattern increases rapidly. At 100 mc, this diameter is around 22", with a recommended diameter of 16".

The impedance of the antenna at the feed point is around 165 ohms with a negative reactive component. This impedance is transformed to the impedance of a standard 70-ohm or 51.5-ohm concentric transmission line by a line transformer incorporated into the feeder within the antenna. The voltage standing wave ratio along the 70-ohm feeder is to be held below 1.15.

Other Antenna Setups

Two antennas of this type can be used together and built as a unit, with their open ends joined. A single concentric feeder entering the bottom and connected to the mid-point (corresponding to two open ends) serves the entire antenna. A metal cone seals the top. The vertical pattern of such an antenna is shown in Figure 4. The horizontal pattern is the same as for the single unit. The double unit has a power gain of 2.5 on the basis of the equivalent circular pattern. The power gain in the direction of maximum is 3.85; power gain in the direction 180° from the maximum is 2.18, and in the direction of the minima, 1.70.

The impedance of the antenna at the feed point is about 100 ohms with a negative reactive component. It is transformed to the impedance of a standard line in the same manner as is used in the single unit antenna.

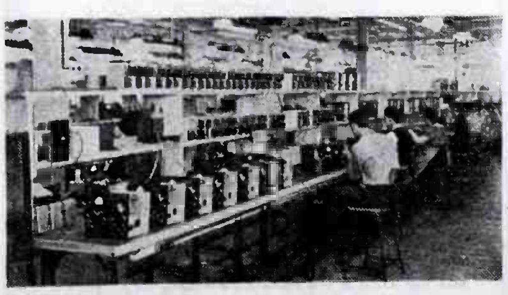
In another arrangement an array was used. This consisted of two double rocket antennas, mounted one above the other and connected so that they are energized in the same phase. For connection convenience the lower antenna was turned upside down so that the feeders after making 90° turns could be brought together in a special four-way junction fitting.

The double rocket array has a power gain of 4.88 on the basis of the equivalent circular pattern. The power gain in the direction of the maximum is 7.5; power gain in the direction 180° from the maximum is 4.12, and in the direction of minima, 3.33.

The transmission lines of this array of antennas were joined at a special three way 90° junction box, from which a third line was connected to a similar junction box at the top end of the main transmission line. The third line on this second junction box was a short circuited stub. A short section of the main feeder below the junction box contained a line transformer matching the impedances of the main line and the antenna array. This transformer had to be adjusted so that the voltage standing wave ratio on the main line feeder was below 1.15. Transformers can be furnished to match either 1⅝" or 2⅝" line.

•

FTR INSTRUMENT PRODUCTION LINE



Field intensity meters covering the 200 to 400 kc, 530 to 1600 kc, 1600 to 3600 and 3600 to 7000 kc range, now in production at Federal Telephone & Radio Corporation.

NEWS BRIEFS

MBS COMPILES STATION ATLAS

A 160-map atlas covering assignments of United States, Mexican, Canadian and Cuban standard broadcast stations, together with their power, hours of operation, and the shape of antenna pattern which they use, has been compiled by the engineering department of MBS.

Pages are 11"x17".

Standard FCC abbreviations are used to indicate power and hours of operation. The directional antenna patterns—some one thousand—have been pantographed from the original directional patterns on file with the FCC.

Atlas is available for $25 a copy from the Mutual Broadcasting System, 1440 Broadway, New York City.

* * *

BUREAU OF STANDARDS LAB BEGINS PROPAGATION SERVICE

The Interservice Radio Propagation Laboratory was recently absorbed by the Central Radio Propagation Laboratory of the National Bureau of Standards to centralize and coordinate basic research and prediction service in the field of radio wave propagation.

Data compiled by the Lab will appear in "Basic Radio Propagation Predictions" which will be available from the Superintendent of Documents at 15 cents a copy.

Information in each issue will permit calculation of the best sky-wave operating frequencies over *any* path at *any* time of day for average conditions for the month of prediction. Predictions are issued three months in advance.

Each issue will also contain charts of extraordinary-wave critical frequency for the F2 layer and charts of maximum usable frequency under average conditions for a transmission distance of 4,000 km. These charts are provided for each of the three zones into which the world is divided for the purpose of taking into consideration the variation of the characteristics of the F2 layer with longitude. There will be a chart of maximum usable frequency for E-layer transmission over a path length of 2,000 km, and charts showing the highest frequency of sporadic-E reflections as well as percentage of time occurrence for sporadic-E in excess of 15 mc. In addition issues will contain various maps, charts, diagrams and nomograms needed to make practical application of the world-contour charts, together with examples of their use.

* * *

MAYER NOW V-P OF ST. LOUIS MICROPHONE CO.

Rollin H. Mayer has been elected vice president and general manager of the newly organized St. Louis Microphone Co., 2726-28 Brentwood Blvd., St. Louis, Mo.

R. M. Bennett has been named chief engineer. The company will produce dynamics, aircraft noise-cancelling dynamics, noise-cancelling differentials, cardioids, etc.

* * *

FARNSWORTH RADIO CENTER NEAR COMPLETION IN FORT WAYNE

The Farnsworth radio center, designed to provide Northeastern Indiana with television, f-m and a-m broadcasting services, from newly built central studios in downtown Fort Wayne, is now nearing completion, according to E. A. Nichols, Farnsworth president.

* * *

GERMAN WAR DEVELOPMENT REPORTS

A German war-development report recently issued by the office of the Publication Board, Department of Commerce, described a simple recording system developed by the Germans for registering the performance of radio transmitters in terms of frequency, strength of signals, and time on the air.

The recorder consists of an optical system, a photosensitized film, and a light source. A driving mechanism, controlled by a precision clock, actuates the movement of the light source, the recording film, and the tuning of the receiver in such a manner that the film is scanned in time and in frequency.

In another report appeared further details on high frequency models of the German-developed Magnetophone, using magnetic tape for recording sound.

The report, made by Captain James Z. Menard for the U. S. Army's Field Information Agency, Technical, contains design information on the mechanical systems, electrical circuits, recording processes, and the recording tape.

A dual purpose meter that measures both resistance from zero to 50 ohms and resistance in megohms from zero to infinity, was described in another war report.

The weight of the instrument, without batteries, leads, and resistor, is 3 pounds and 11 ounces. The unit has an ohmmeter circuit and an insulation measuring meter circuit. It is energized by two 4½-volt cells.

Other features are: batteries to energize the meter coils; and internal circuit continuity indicated by a small resistor containing a glow lamp.

* * *

PYRAMHD JOINS RMA

The Pyramid Electric Company, 415-21 Tonnele Avenue, Jersey City 6, N. J., has become a member of the RMA.

* * *

LEE WINS THOMPSON MEMORIAL PRIZE

Dr. Gordon M. Lee, technical director of the Central Research Laboratories, Inc., Red Wing, Minnesota, has been awarded the Browder J. Thompson Memorial Prize for 1946 by the IRE. Dr. Lee's winning paper discussed "A Three-Beam Oscillograph for Recording at Frequencies Up to 10,000 Megacycles."

This is the first award from the fund established by friends of Mr. Thompson following his death in 1944 in the Mediterranean area while conducting flight tests of electronic equipment for the Secretary of War. At the time he was on leave from his duties as associate research director of RCA Laboratories, Princeton, N. J.

The prize was established to stimulate research in the field of radio and electronics by scientists under 30 years of age and to encourage the careful preparation of papers describing such research.

* * *

LEITNER BECOMES LEAR CHIEF ELECTRONICS ENGINEER

Richard G. Leitner has been named chief electronics engineer of Lear, Inc., of California. Mr. Leitner will make his headquarters in Los Angeles.

* * *

PRESTO ON EXHIBIT IN SPANISH FAIR

Recorder and transcription turntable products of Presto Recording Corporation, 242 West 55th St., New York City, are on exhibit at the International Fair and Exposition in Barcelona, Spain.

* * *

COSGROVE REELECTED RMA PRESIDENT

R. C. Cosgrove has been reelected president of the Radio Manufacturers Association. In other elections Henry C. Bonfig succeeded E. A. Nicholas as vice president and chairman of

(*Continued on page* 42)

NEWS BRIEFS

(*Continued from page 41*)

the set division; Fred R. Lack succeeded George Lewis as vice president, and Allen Shoup succeeded Thomas A. White as a vice president. M. F. Balcom was reelected vice president and chairman of the tube division. Leslie Muter was reelected RMA treasurer for the eighth time.

Elected to the RMA board of directors were: W. J. Barkley, Henry C. Bonfig, Lloyd C. Coffin, George R. Haase, Lloyd A. Hammarlund, Larry F. Hardy, W. P. Hilliard, Harold C. Mattes, A. D. Plamondon, Allen Shoup, Ross D. Siragusa, C. M. Srebroff and J. Hall Stackpole.

* * *

DI-ACRO BULLETIN

A 40-page booklet, No. 4 6-10, describing dieless duplicating has been published by the O'Neil-Irwin Manufacturing Company, Minneapolis 15, Minn. Benders, shears and brakes are discussed and illustrated.

* * *

TURNER NAMES WEBSTER CHIEF ENGINEER

Glenn E. Webster, formerly in charge of speech equipment for Collins Radio Company, has been appointed chief engineer of The Turner Company, Cedar Rapids, Iowa.

* * *

DR. BOWN NOW BELL LAB RESEARCH DIRECTOR

Dr. Ralph Bown, assistant director of research at Bell Telephone Laboratories since 1944, has been named director of research.

He succeeds Dr. M. J. Kelly who has been serving both as director of research and executive vice president of the Laboratories and who will continue in the latter capacity.

* * *

MONACK OPENS ENG. OFFICE

A. J. Monack has resigned as engineering vice president and a member of the board of directors of the Mycalex Corporation of America to engage in consulting services on glass, glass-metal seals, and electronic insulation.

Offices will be at Rutherford, N. J.

* * *

CY READ JOINS MONTGOMERY WARD

Cyrus T. Read has resigned his post at Hallicrafters to become supervising buyer of electronic equipment for Montgomery Ward & Co., Chicago.

* * *

MILLEN CATALOGS

A 24-page components catalog and a 12-page special products catalog have been released by James Millen Manufacturing Company, Inc., 150 Exchange Street, Malden, Mass. In the components catalog appear data on transmitting and receiving capacitors, dials, drives, scales, knobs, sockets, standoffs, bushings, r-f chokes, antenna devices, safety terminals, beads, couplings, flexible couplings, coils and coil forms, i-f transformers, etc. The special products catalog contains descriptions of a secondary frequency standard, frequency determination unit, u-h-f calibrator, synchroscope, delay lines, etc.

* * *

BURLINGTON INSTRUMENT DATA

A 20-page catalog covering panel milliammeters, ammeters, microammeters and voltmeters for a-c and d-c, and external shunts, etc., has been prepared by the Burlington Instrument Company, Burlington, Iowa.

* * *

FEDERAL BULLETINS

A series of bulletins describing square-loops for f-m; selenium rectifiers; 10-, 20- and 50-kw f-m transmitters; and selenium rectifier equipments, have been released by the Federal Telephone and Radio Corporation, Newark, N. J.

The selenium rectifier, a sub-miniature item, 1¼"x1¼"x11/16", is discussed in two bulletins, which contain circuit diagrams and operation plots. Power supplies, battery chargers and commercial power systems using the larger type selenium rectifiers are described in a 12-page bulletin.

A coaxially fed square loop for f-m application is analyzed in two 16-page brochures. Offered are constructional and installation data, field test plots and engineering analyses.

Technical data on 88- to 108-mc f-m transmitters for 10, 20 and 50 kw appear in a 60-page booklet. Presented are complete circuit data, diagrams, station setups, and engineering highlights of the various transmitters.

* * *

SYLVANIA APPOINTS VIRGIL GRAHAM MANAGER OF TECHNICAL RELATIONS

Virgil M. Graham has been named manager of technical relations for Sylvania Electric Products, Inc. He was formerly manager of the Sylvania industrial apparatus plant at Williamsport, Pa.

* * *

RAYTHEON ACQUIRES SUBMARINE SIGNAL CO.

Submarine Signal Co. was merged with Raytheon Manufacturing Co. recently.

H. J. W. Fay, former president and member of executive committee of Submarine Signal, will serve on the Raytheon board.

* * *

DR. SALMON HONORED BY ACOUSTICAL SOCIETY

The Acoustical Society of America recently presented its Biennial Award to Dr. Vincent Salmon of the Jensen Radio Manufacturing Company.

The award specifically recognized his contribution to horn theory, both by theoretical work and by practical application to horn loudspeakers.

Dr. Salmon is physicist in charge of research and development.

* * *

TECHNOLOGY INSTRUMENT NAMES GLOVER CHICAGO REP

Ralph P. Glover, consulting engineer, 1024 Superior Street, Oak Park, Illinois, has been retained as technical representative in the Chicago area by Technology Instrument Corporation, Waltham, Massachusetts.

THE INDUSTRY OFFERS . . .

ALTEC LANSING DIACONE SPEAKER

An 18-watt multicell Diacone-type speaker, model 603, using a metal high-frequency diaphragm and a low-frequency cone coupled together by a mechanical dividing network and driven by a single 3" voice coil of edgewise wound aluminum ribbon, has been announced by Altec Lansing Corporation, 1161 North Vine St., Hollywood, Calif. The metal high-frequency diaphragm operates into a multicellular horn.

Speaker using Alnico V is 15" in diameter, with a horizontal distribution angle of 60° and a vertical distribution angle of 40°. Voice coil impedance is 15 ohms.

* * *

SELECT-O-GRAPH CODE WRITER

An electric code typewriter that provides spaced tones for any type of code has been developed by the Select-o-Graph Manufacturing Co., 502 W. Colorado Ave., Colorado Springs, Colorado.

The machine consists, basically, of a cam arrangement driven by a variable speed motor and friction drive mechanism, connected to an electronic audio oscillator. Has a volume control and switch, 3-position tone control, calibrated speed control from 2 to 60 words per minute and three indicator lights. Also has an interlocking key mechanism which makes it impossible to strike another key while a cam is already in motion.

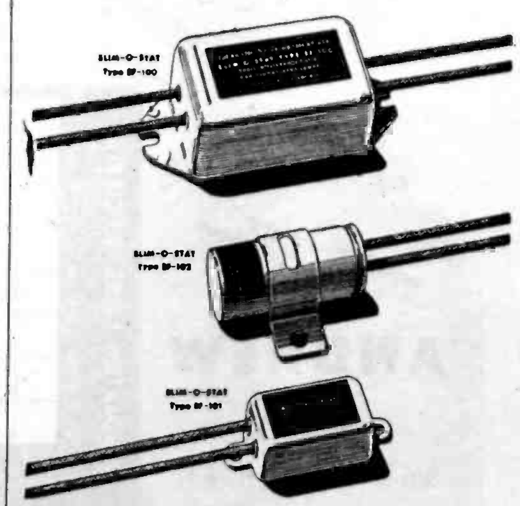
* * *

SOLAR FLUORESCENT LAMP NOISE FILTERS

Three fluorescent lamp noise filters, elim-o-stat type, have been announced by Solar Manufacturing Corporation, 285 Madison Avenue, New York 17, N. Y.

Filters are of two basic electrical types, a balanced twin-pi filter for maximum attenuation and a delta capacitor filter for normal usage; the latter available as types EF-101 and EF-102 in bathtub and cylindrical metal housings, the former as type EF-100.

Filters are described in Solar bulletin SFF-100; a comprehensive technical discussion of their development appears in the July-August issue of *The Solar System*.



* * *

PYRAMID CAPACITORS

A series of dry electrolytics in sealed metal tubes and screw-base aluminum cans, and dry electrolytics in wax-filled impregnated cardboard tubes, in single and dual types, has been announced by Pyramid Electric Company, 415-421 Tonnele Avenue, Jersey City 6, N. J.

Capacity ranges are from 4 to 80 mfd in the singles and from 4+4 to 80+40 mfd in duals.

Capacitive-inductive noise suppressors are also being made by Pyramid.

* * *

NATIONAL R-F CHOKES

Two chokes, 2½ mh (R-100S) and 1 mh (R-300S), have been announced by the National Company, Inc., Malden, Mass.

The R-100S has a continuous universal winding in four sections wound on an isolantite form for 6-32 screw mounting in any position. Overall dimensions are 2"x11/16"; current rating is 125 ma, d-c resistance is 50 ohms.

R-300S is wound on isolantite in a continuous universal winding in three sections. Has a d-c resistance of 10 ohms, a current rating of 300 ma, and a distributed capacity of 1 mmfd. Over-all dimensions are 2"x11/16.".

* * *

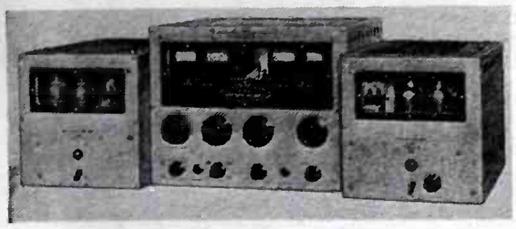
TWT TRANSMITTERS

A 1,000-watt 5-band transmitter, model 900A, has been announced by Taylor Western Transmitters, 6127 S. Western Ave., Los Angeles, Calif.

Five-band change operation on 10, 15, 20, 40, and 75 meters. Provides 100% modulation of the phone carrier power on all bands.

Tubes in the r-f chain include 6V6 oscillator, 6V6 doubler, 3D23 as second doubler or buffer amplifier, and an Eimac 4-250A as power amplifier output tube. Power supply tubes include one 5Z3 bias rectifier, two 866A low voltage rectifiers and two 866As as high voltage rectifiers.

Audio channel consists of a 6V6 first speech, 807 second speech and a second Eimac 4-250A as a positive modulator. This positive modulator is biased to approximately three to four times class C and at carrier operation draws practically no plate current, the approximate 700 watts of carrier power being supplied by the first Eimac 4-250A to the load or antenna.

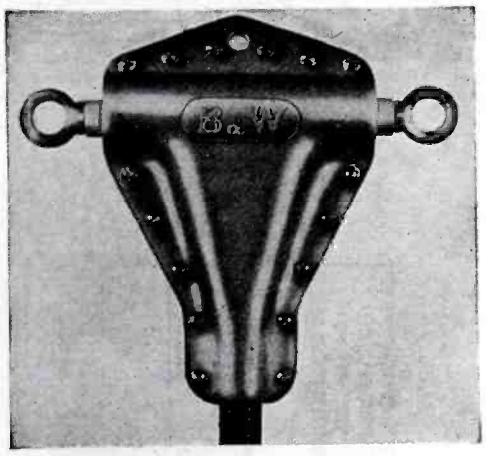


* * *

B & W COAXIAL CABLE CONNECTOR

A coaxial cable connector, CC-50, has been announced by Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa. Provides water-tight coaxial cable connections, and also serves as center insulator for a half wave doublet.

Made of aluminum with steatite insulation. A bottle of weatherproof cement and a piece of ⅝" outside diameter rubber tubing, plus the necessary assembly screws are supplied with each connector.

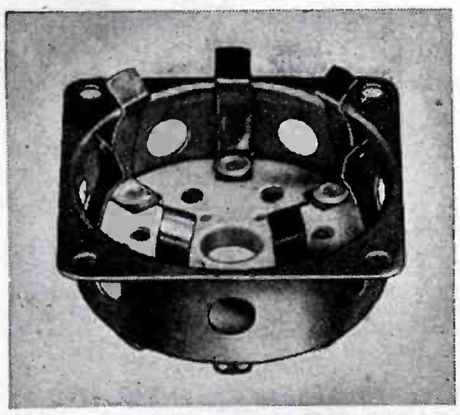


* * *

JOHNSON SOCKETS

Ceramic sockets for 826, 829 and 832 transmitting tubes, 122-101, have been developed by the E. F. Johnson Company, Waseca, Minnesota. Socket has an aluminum base shield, and is designed so that button mica bypass capacitors may be mounted directly on the tube socket base.

Other features include grid terminals designed so that the connecting wires may be isolated from other circuits.



* * *

ELECTRIC MACHINERY CO. CONSTANT-VOLTAGE GENERATOR

An a-c generator, model regulectric, for use in engine generator sets to provide power at constant voltage, has been developed by Electric Machinery Mfg. Co., Minneapolis 13, Minn. Uses a built-in voltage regulating circuit employing the principle of series-resonance.

* * *

RCA VIBROTRON TUBE

A sub-miniature metal triode weighing 1/15 of an ounce, which converts mechanical motion directly into a variable electron flow, the vibrotron, has been developed by RCA.

Tube is about 1" in length and about ¼" in diameter. Leads for supplying voltages to the tube are brought out through a glass seal at one end. At the other end a flexible metal

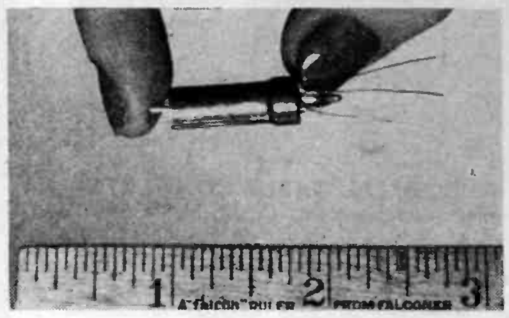
(*Continued on page* 46)

THE INDUSTRY OFFERS . . . —

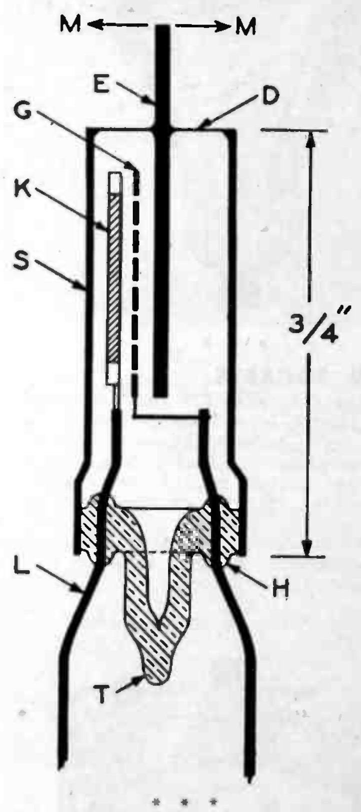
(*Continued from page 45*)

diaphragm permits transferring external motion to a movable electrode within the tube.

Can be used as a phonograph pickup. Said to provide for a system having low acoustic noise and needle chatter. Tube operates as an integral part of the pickup head and amplifier, without the need of a preamplifier or coupling transformer.



Below, schematic of vibrotron. Motion of movable electrode (E) in direction MM is transferred through a thin metal diaphragm (D) to affect the electron flow of triode consisting of electrodes (K) cathode, (G) grid, and (E) movable anode. Motion of the movable anode in direction MM produces a proporitionate change in the electron flow. The triode is contained within a metal envelope (S) and has its leads (L) brought out through a vacuum-tight glass header (H) with exhaust tip (T).



* * *

AIRADIO VARIABLE CAPACITORS

Two- and three-gang variable capacitors are now being manufactured by Airadio, Incorporated, Stamford, Conn. Capacitors have an oscillator section providing a maximum of 162 mmfd and one or two sections with a maximum of 452 mmfd.

* * *

ASSOCIATED RESEARCH INSULATION RESISTANCE METER

A portable insulation resistance meter, model 261 vibrotest, testing to 50,000 megohms (center scale 1,200 megohms) has been announced by Associated Research, Inc., 231 So. Green St., Chicago 7, Illinois.

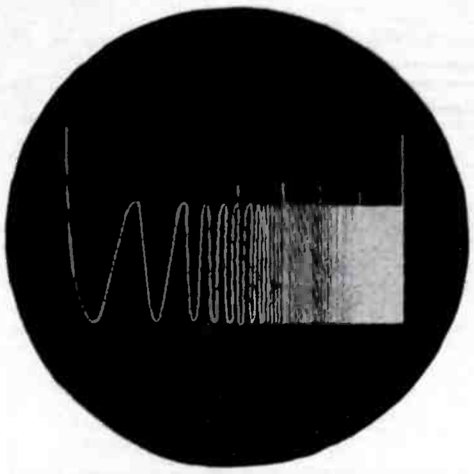
* * *

CLARKSTAN SWEEP FREQUENCY TRANSCRIPTIONS

A 100-10,000 cps sweep-frequency transcription to provide instantaneous a-f response checks, has been announced by Clarkstan Corp., 11927 W. Pico Blvd., Los Angeles 34, California.

The transcription, developed by Wayne R. Johnson, has a repetitive rate of 20 cps at constant amplitude below 500 cps and constant velocity above 500 cps. The sweep is logarithmic. There is a synchronizing pulse of 200 microseconds duration at start of sweep to lock the oscilloscope. Frequency markers are provided at alternate thousand cycles. Frequency response variations are said to be held within

±1 db. Recordings are made on 10" vinylite at 78 rpm and on 16" at 33⅓ rpm, the latter recorded with NAB curve.



Oscillographic recording of transcription reproduction.

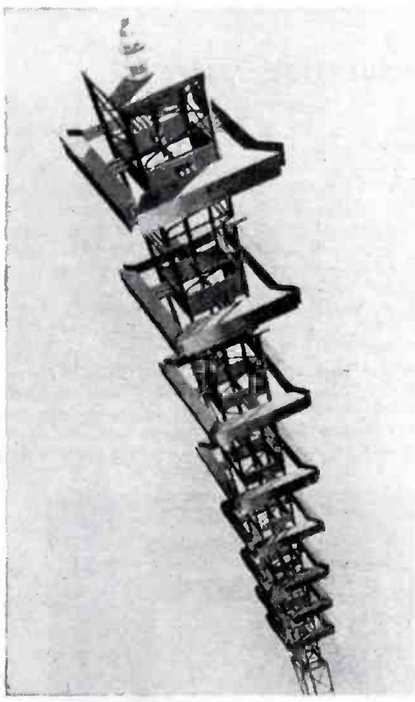
* * *

FTR 8-BAY F-M ANTENNA

A square-loop antenna for f-m broadcasting has been developed by Federal Telephone and Radio Corporation, Newark, New Jersey. This antenna, when 8 bays are used, is said to provide a power gain of nine.

Additional bays can be stacked.

Antenna features omnidirectivity in the horizontal plane, a minimum of resonant circuits, horizontal polarization and no field tuning. Coaxial lines of the 51.5-ohm (3⅛" or 1⅝") can be used to feed the array.



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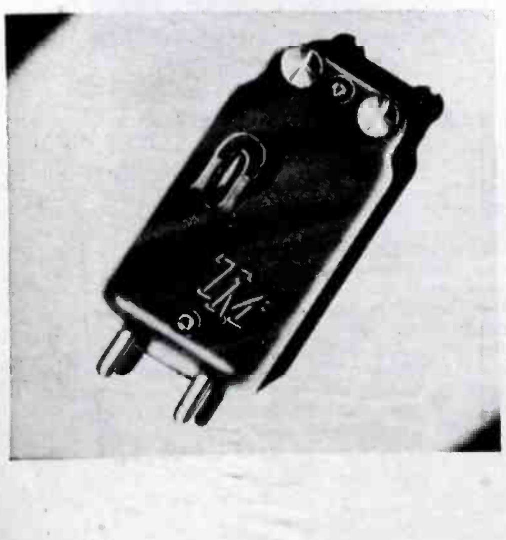
MAGNETOSTRICTION PHONO PICKUP

A phonograph pickup, type TM, using the torsional magnetostriction principle, has been developed by Magnetostriction Devices Com-

(*Continued on page* 48)



THE INDUSTRY OFFERS . . .

(*Continued from page 47*)

pany, 739 Boylston Street, Boston, Massachusetts.

Operating at a needle-point pressure of 20 grams.

Hum pickup is said to be minimized by use of extremely small diameter coils wound integrally upon the torsional member and connected in series opposition with respect to external fields.

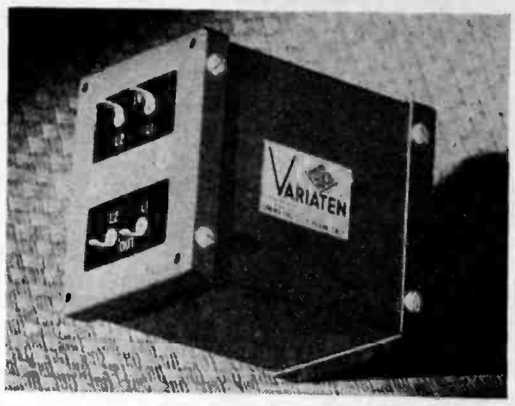
* * *

CINEMA ORTHOCOUSTIC EQUALIZERS

Orthocoustic equalizers, type 4137, are now being produced by the Cinema Engineering Co., 1510 W. Verdugo Ave., Burbank, California.

Available for 500- and 600-ohm circuits. Insertion loss is approximately 16 db. Fitted with two input and two output terminals, and shielded against pickup of extraneous inductances.

Measures 2¾"x3¼"x2½" overall.

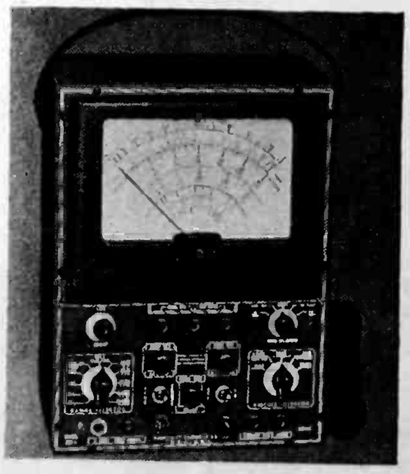


* * *

RCP INSULATION TESTER

An insulation tester, 665A, with an insulation resistance range up to 10 billion ohms, has been announced by Radio City Products Co., Inc., 127 W. 26th St., New York City, N. Y. In addition, the instrument includes a vacuum-tube voltmeter, ohmmeter and capacitymeter.

Insulation testing range: 1 to 10,000 megohms at 500 volts. Vacuum-tube ohmmeter offers direct reading; seven ranges from 0.1 ohm to 1,000 megohms. Capacitymeter covers from 0.0000025 to 2,000 mfd in eight ranges. A-c vacuum-tube voltmeter also is direct reading, input capacity 0.00005 mfd at terminals of instrument. Input resistance, 160 and 16 megohms; seven ranges to 6,000 volts. D-c vacuum-tube voltmeter (direct reading) has a sensitivity of 160 megohms on high ranges and 16 megohms on low ranges; six ranges to 6,000 volts.



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G. R. 5-AMPERE VARIACS

A series of Variac autotransformers, type V-5, to replace the 200-C models, has been announced by General Radio Company, 275 Massachusetts Avenue, Cambridge 39, Massachusetts.

Uses grain-oriented strip cores, both iron and copper, and aluminum structural parts instead of steel and zinc.

Unit brush is used, which can be changed without tools. Brush pressure is assured by an accurate coil spring; brush extension is limited to prevent short-circuit damage through contact of the brush holder with the winding.

Rated output current for 115-volt models is 5 amperes; maximum current is 7.[illegible] amperes. Voltage output can be varied from 0 to 17%

above line voltage. Volt-ampere rating is 0.862 kva. 230-volt models will handle 0.575 kva with current ratings of 2 amperes, rated, and 2.5 amperes maximum.

• • •

ELECTRO-VOICE CRYSTAL MICROPHONE AND STAND

A combination crystal microphone and desk stand, model 902, has been announced by Electro-Voice, Inc., 1239 South Bend Ave., South Bend 24, Indiana.

Molded in one piece of high impact, butyrate plastic.

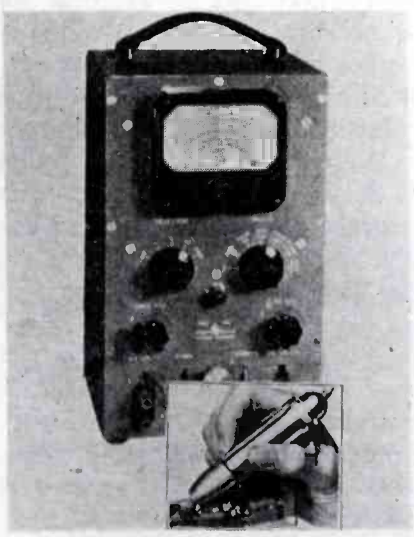
High capacity crystal. Frequency response is substantially flat from 70 to 7,000 cps. Output level is 48 db below 1 volt/dyne/cm², open circuit; voltage developed by normal speech (10 dynes/cm²) is .0394 volt.

• • •

HEWLETT-PACKARD H-F VACUUM-TUBE VOLTMETER

A h-f vacuum-tube voltmeter that measures a-c voltage from 20 cps to 700 mc, d-c voltage at 100 megohms input impedance, and resistance from 0.2 ohm to 500 megohms, has been developed by Hewlett-Packard Co., Palo Alto, Calif.

Input capacity is 1.3 mmfd; input resistance is 6 megohms below 10 mc, less at higher frequencies due to dielectric losses.



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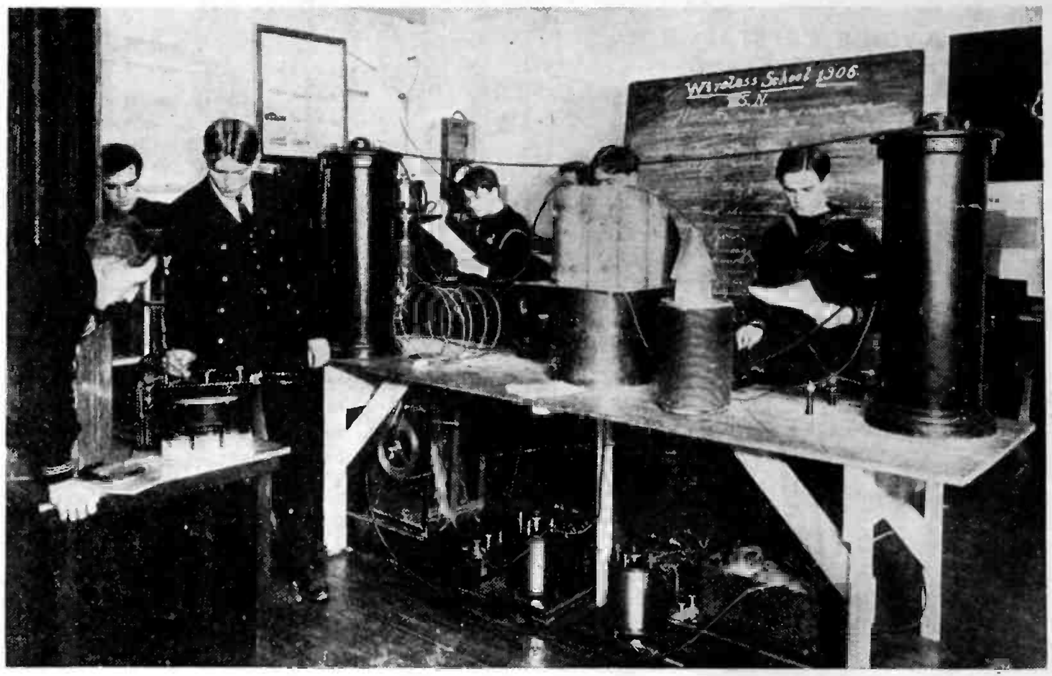
ALPHA METAL OFFERS TRI-CORE SOLDER SAMPLES

A test quantity of tri-core solder wire is being offered to manufacturers by Alpha Metals, Inc., Tri-Core division, 369 Hudson Avenue, Brooklyn 1, N. Y.

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

W. J. McGONIGLE, President   RCA BUILDING, 30 Rockefeller Plaza, New York, N. Y.   GEORGE H. CLARK, Secretary

George P. Shandy, chief inspector of the maintenance, repair and installation department of the Radiomarine Corporation of America, resides in Brooklyn. . . . Jim Maresca, first secretary of VWOA, has been in radio over thirty years and served at Camp Evans Signal Labs at Belmar, N. J., during World War II. Jim worked there in 1919, with Weagant for the Marconi Company. . . . Happy to learn of the recovery of Forrest Vosler from a delicate eye operation. Vosler, holder of the Congressional Medal of Honor, received the VWOA Marconi Memorial Medal of Valor at our annual dinner cruise. He is at present a control-room operator at WSYR, Syracuse, N. Y., and a student at Syracuse University. . . . E. M. Stetson has become a VWOA member. He has been a shipboard operator since 1935, serving with Bull and Standard Oil. He is now with Tropical Radio. . . . Rodney D. Chipp, another newcomer to the VWOA ranks, hails from Bloomfield, N. J. He has served as a shipboard operator with TRT and RMCA. He has also been a code instructor for RCAI and a station engineer at KLNH. For eight years he was with NBC and during the war was appointed a Lieutenant Commander in the U. S. Navy. . . . Major Leroy Thomson, now on active duty as a U. S. Signal Corps officer, has become a VWOA member. . . . A Canadian has joined our ranks, George Wells of Montreal. He has been pounding brass since 1919, serving on the ships of the Prince Line. He has operated many of the Canadian coastal stations for the government. . . . R. C. Reinhart, president of Atlas Sound Corporation, who recently joined VWOA, was a pounder in 1926, serving as an operator with the Standard Oil, and shore stations and several private yachts. . . . E. W. Kreis, who began his operating career in Milwaukee in 1915, has received his VWOA card. He operated ships of the Great Lakes, and also served with the U. S. Shipping Board. . . . B. J. Borsody, now a VWOA member, is a veteran since the days of 1918. He was an operator with the AEF of the U. S. Regular Army Field Artillery.



Wireless schoolroom in the early days of the U. S. Navy communications program.
(Courtesy George Clark)

He has been with the New York City Fire Department as chief operator of WNYF. During the war he was a U. S. Navy Lieutenant Commander and commanding officer at Guam and the Mariana Islands. He holds a *Speed Key Certificate,* valid on Pacific Fleet circuit, and issued by the U. S. Navy after a test in 1945. . . . Walter Jablon of Hammarlund, is now living at W. Englewood, N. J. . . . A. C. Krones, a new VWOA member, began his key pounding in 1925 as a shipboard operator. He is now with the Milwaukee police department. . . . It is a genuine pleasure to welcome 25-year veteran wirelessman R. P. Herzig, Radioman First Class, U.S.N. . . . Ben Tjtow, RCA business office manager, was at the recent fall meeting. Ben was a very active member in New York before his assignment to other states and cities for the commercial department of RCAC. Welcome back, Ben, let's see you often. . . . We were delighted to receive acknowledgment of the receipt of honorary membership certificate from Admiral Luke McNamee, president of Mackay Radio. We are proud to include him among our illustrious honorary members. . . . We understand that the honorary membership certificate recently tendered Robert V. Howley, president of Tropical Radio, now occupies a position of honor in his office in Boston. . . . Ye prexy and Bill Simon recently had a very pleasant luncheon with H. H. Parker of the Westchester Lighting Company, who did such great work as secretary for several years a few years back. . . . We've received some additional highlights on veteran Commander Samuel Freedman. Now at the Radio Repair Shop, U. S. Submarine Base, New London, Conn., he started with Postal in 1918 as a Morse operator. He then went to the Marconi Company in 1919, and then with various RCA subsidiaries. Later he was engaged in police radio engineering. Since 1941 he has been with the United States Navy in radio and electronics materiel. A. B. Deane received his commercial license in 1932, taught code, and then went to sea for over five years.

PREVENTIVE MAINTENANCE

(*Continued from page* 28)

can quickly be damaged if they are used carelessly.

Large wrenches. Two types are available; adjustable end wrenches and monkey wrenches to remove or hold bolts, studs, and nuts of various sizes, and especially the large ones. Jaws should always be adjusted to fit snugly against the flat sides of the bolt or nut. Wrenches should be kept clean, slightly oily in order to prevent rust, and stored in the bottom of the tool box.

Screwdrivers. Screwdrivers of different sizes are used for maintenance work. In the selection of a screwdriver for a particular job, the bit should be approximately the same width as the head of the screw, and fit snugly in the slot; the handle should be large enough to give adequate leverage.

Soldering irons. Soldering irons are crucial pieces of maintenance equipment, and must be carefully handled. Tips must be kept clean and bright and properly tinned. The cords should be in good condition, and rolled around the irons when stored. Attachment plugs must be tightly fastened to the wire. A reasonable amount of care will keep the irons in good working condition, but it will be necessary occasionally to refile and re-tin the tips.

Whenever the tip becomes pitted and misshaped:

(*1*) The tip should be filed until it is free from pits, has desired shape, and is smooth.

(*2*) Iron should be connected to an a-c 115-volt outlet and allowed to heat, tip temperature being tested with a piece of rosin-core solder. When the solder melts, it should be rubbed all over the tip until the tip is completely coated with solder.

(*3*) The tip should be removed from the heating element occasionally, and the scale cleaned from the shank of the tip and from the threads. Cleaning can be done with sandpaper. All grains should be removed from the threads before the tip is again inserted into heating element.

Soldering hints. Before a joint is

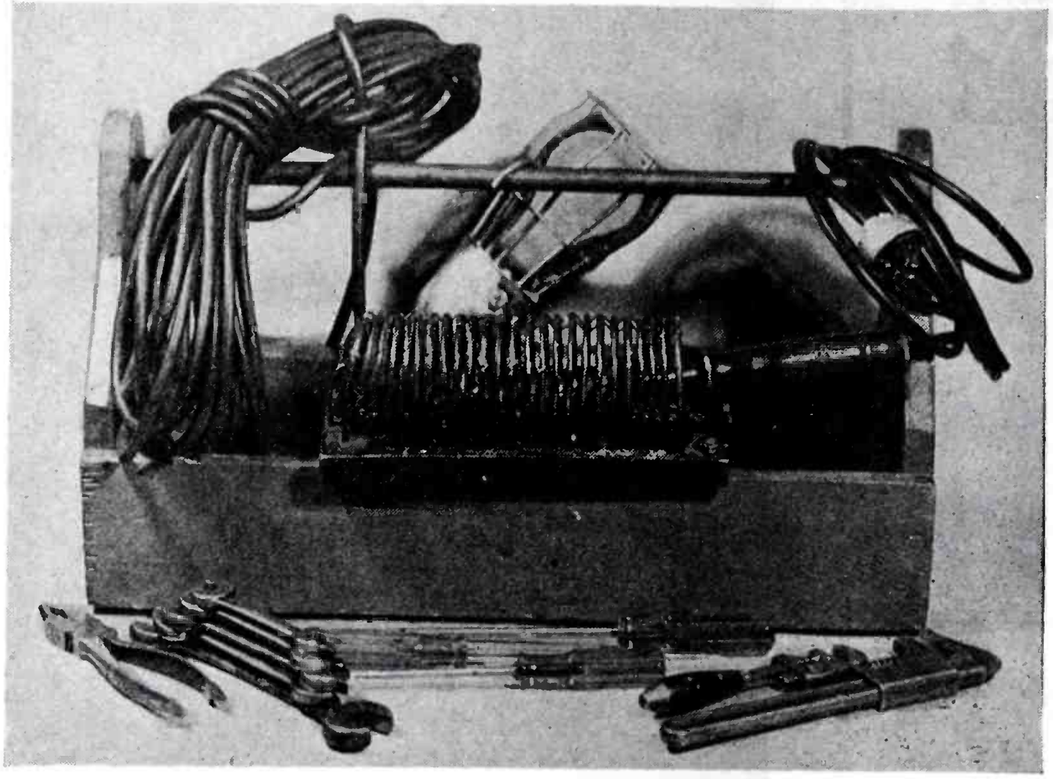


Figure 2
A typical maintenance tool kit.

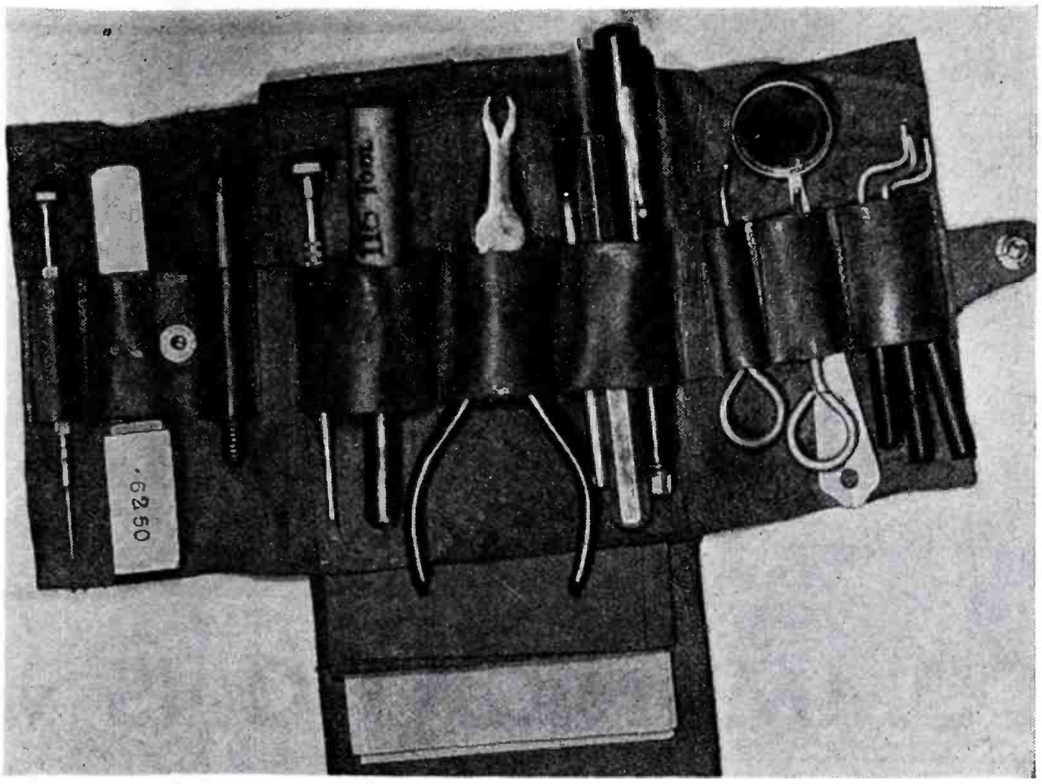


Figure 3
Tool kit used for maintenance of relays.

soldered, it should be prepared in the following manner:

(*1*) Joints should be cleaned carefully, using sandpaper to remove corrosion from the wire and lug.

(*2*) Joints should be mechanically tight.

(*3*) Clean, freshly tinned soldering iron should be held against the joint, heating it until the solder flows over the joint.

(*4*) Sufficient solder should be used to fill the joint completely and heat applied until the connection is smooth.

(*5*) A dirty iron should never be used. Joints must be clean too.

(*6*) Solder alone should not be expected to make a joint tight. Wire must be wrapped around the lug or connector until it is mechanically tight before the solder is applied.

(*7*) Joint should not be allowed to move before the melted solder sets or hardens.

Friction tape. Friction tape is cloth, coated with an adhesive compound. It is used on joints and wire which must be kept from touching bare surfaces. It is also used as a cover on rubber tape wrappings, since it has a more durable surface than rubber. When small joints are covered, it is advisable to split the tape down the center to form two ⅜″ strips. Friction tape should never be used alone on wires carrying high voltage. Rubber tape should be used first. Friction tape will not protect a joint from water. Where a joint must be waterproof, rubber tape with a covering of friction tape should be used.

Vises. The threads of the mounting bracket screw and of the jaw screw of

(*Continued on page* 55)

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(*Continued from page 53*)

the vise must be clean and somewhat oily. Dust filings and lint should not be permitted to cake in the threads.

Spintite wrenches. These wrenches are used to remove nuts of various sizes. Care should be exercised in choosing a particular wrench for a particular size of nut. Wrenches should fit snugly around the nut, otherwise the corners of the nut will be rounded off and removal will be difficult.

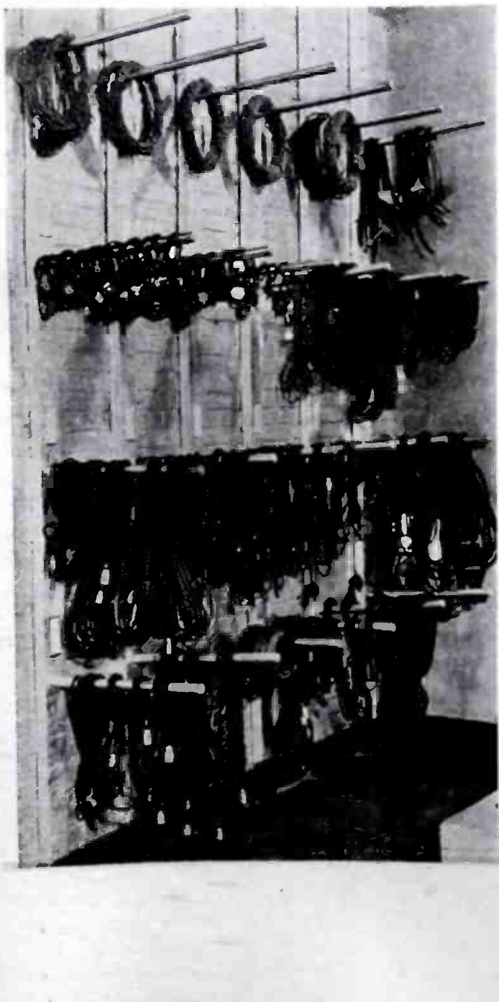
Safety shorting sticks. These handy items will have to be made.

To construct, a dry piece of wood or some other material which is a good electrical insulator, is necessary. It should be about 15″ long and about 1″ in diameter. The latter dimension is not very important. A piece of copper or brass rod or thin tubing should then be fastened to one end of the stick so that the rod extends a few inches beyond the end of the stick. The free end of the rod should be bent in the form of a small hook. Then a piece of heavy flexible hook-up wire, about 18″ long, should be fastened to the metal rod at the point where it is fastened to the stick, and a heavy clip attached to the free end of the wire.

When using the safety shorting stick to discharge capacitors, the clip should be fastened to the frame of the cabinet. To short circuit capacitors to ground, the rod should be placed against capacitor terminals.

[*To be continued*]

Figure 4
Wire, cable and extension cord rack at WOR.



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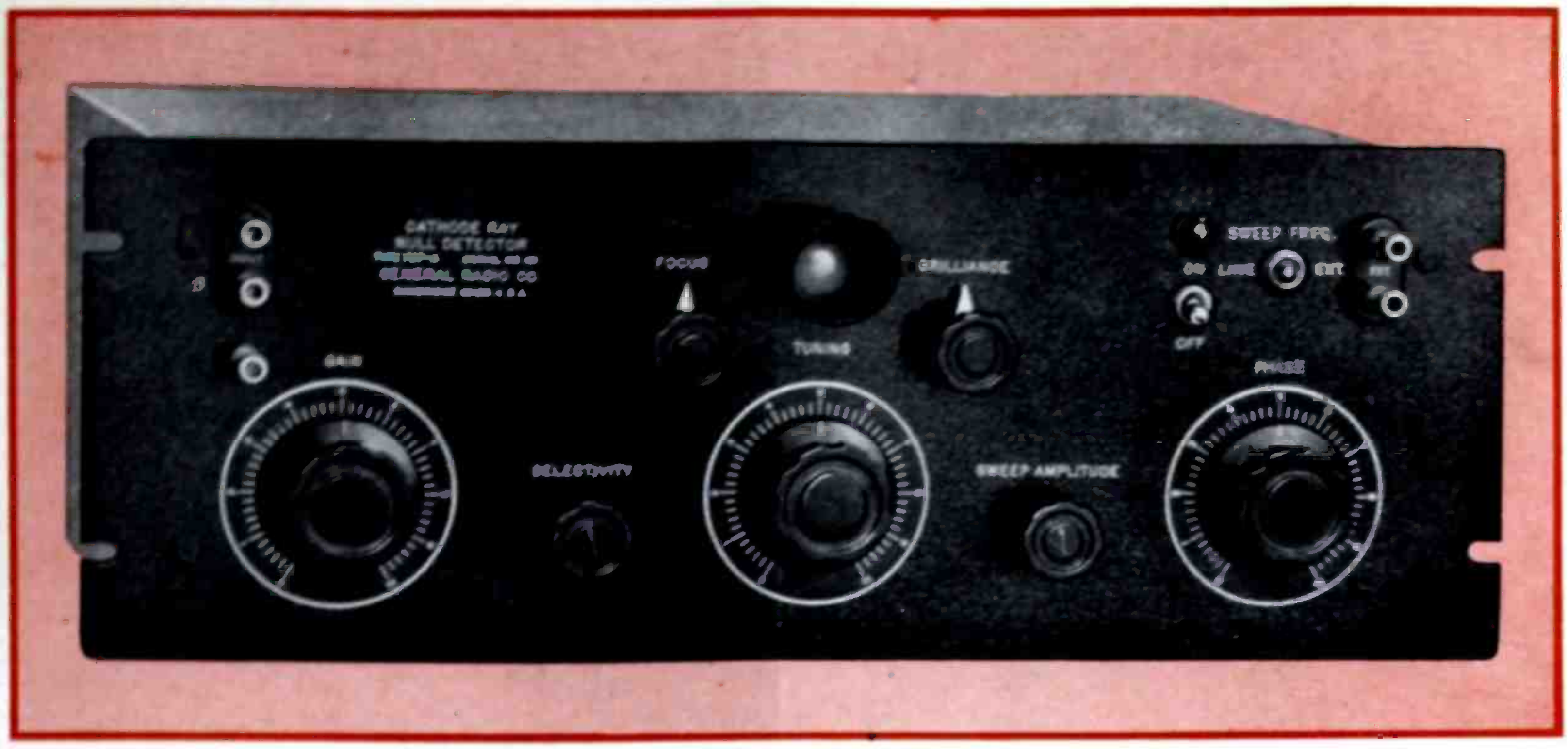

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5—Makes possible precise balancing of either component with only moderately close balance of the other

6—Precise measurement of the steady component can be made while the other varies erratically

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8—Provides positive indication of the direction of off-balance for either component, as selected

9—Can be calibrated to show the degree of unbalance

10—Can be used at all times at maximum sensitivity, even with the bridge far off-balance

11—Supplies instantaneous response

12—Will withstand any overload caused by marked off-balance and is instantaneous in recovery

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			Frequency in Megacycles					Frequency in Megacycles					Conductor Dia.	O.D. Over Jacket
			1.0	1.7	30	100	300	1.0	1.7	30	100	300	Solid Copper	
K12	52	29	.066	.086	.425	.83	1.70	39	30	8.50	3.0	1.5	.188"	.885"
K13	52	29	.058	.076	.320	.69	1.45	51	43.8	13.5	5.4	2.3	.250"	1.135"
K14	71	21	.070	.092	.460	.93	1.90	36.5	27.8	5.55	2.71	1.34	.114"	.885"
													Stranded Copper	
K45	52	29	.155	.202	.900	2.1	4.20	13	9.9	2.4	.96	.480	.086"	.415"
K49	75	20	.182	.237	1.03	2.1	3.80	9.1	6.9	2.1	.79	.435	.048"	.415"

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