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TV & RADIO ENGINEERING

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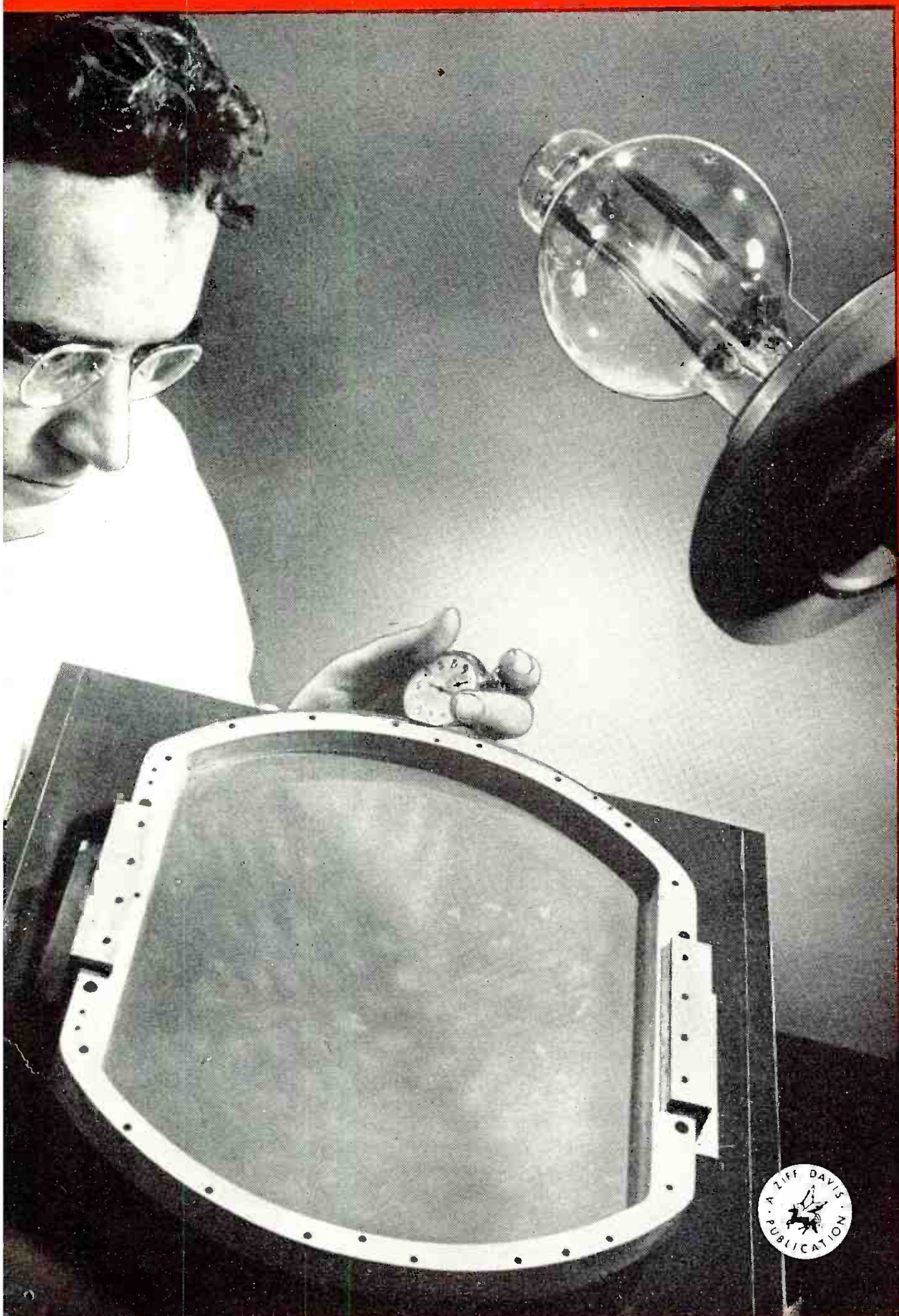

FEBRUARY, 1954

DEPARTMENTS

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Edited by H. S. RENNE
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Color TV picture tube screen being formed by a photographic process at *Sylvania* Research Laboratories. An aperture plate containing more than 200,000 precisely spaced small holes is used in this process.

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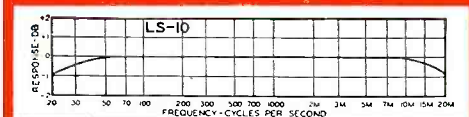

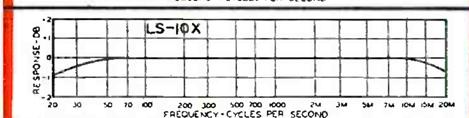

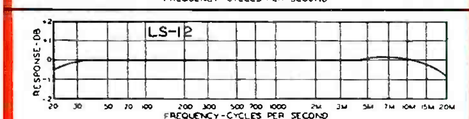

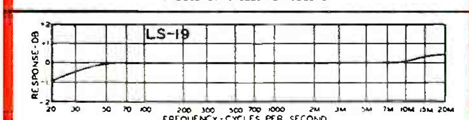

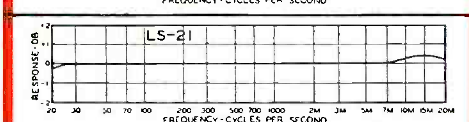

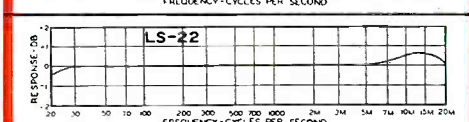

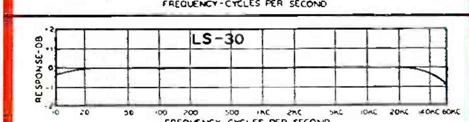

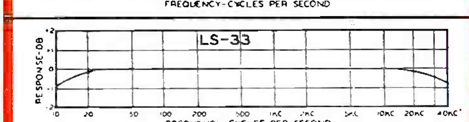

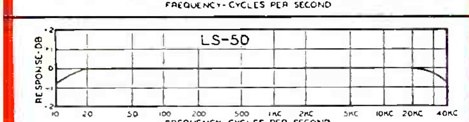

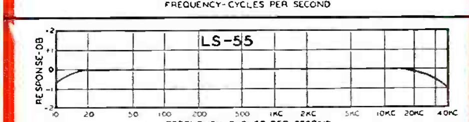

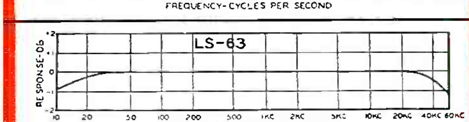

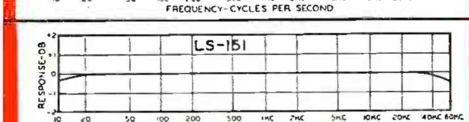

*UTC LINEAR STANDARD transformers are the ONLY audio units with a GUARANTEED uniform response ... ± 1 DP from 20 to 20,000 cycles.

INPUT TRANSFORMERS

Case Size	LS-1	LS-2
Length	3⅛"	4 7/16"
Width	2⅝"	3½"
Height	3¼"	4 3/16"

Type No.	Application	Primary Impedance	Secondary Impedance	± 1 db from	Max.† Level	Relative* hum	Unbal. DC in prim'y	Case No.	List Price
LS-10	Low impedance mike, pickup, or multiple line to grid	50, 125/150, 200, 250, 333, 500/600 ohms	60,000 ohms in two sections	20-20,000	+10 DB	−74 DB	.5 MA	LS-1	$25.00
LS-10X	As above	As above	50,000 ohms	20-20,000	+10 DB	−92 DB-Q	.5 MA	LS-1	35.00
LS-12	Low impedance mike, pickup, or multiple line to push pull grids	50, 125/150, 200, 250, 333, 500/600 ohms	120,000 ohms overall, in two sections	20-20,000	+10 DB	−74 DB	.5 MA	LS-1	28.00
LS-12X	As above	As above	80,000 ohms overall, split	20-20,000	+10 DB	−92 DB-Q	.5 MA	LS-1	35.00
LS-15X	Three isolated lines or pads to one or two grids	30, 50, 200, 250 ohms each primary	60,000 ohms overall, in two sections	20-20,000	+10 DB	−92 DB-Q	.5 MA	LS-1	37.00

INTERSTAGE AND MATCHING TRANSFORMERS

Type No.	Application	Primary Impedance	Secondary Impedance	Response	Max.† Level	Relative* hum	Unbal. DC in prim'y	Case No.	List Price
LS-19	Single plate to push pull grids like 2A3, 6L6, 300A. Split secondary	15,000 ohms	95,000 ohms; 1.25:1 each side	± 1 db 20-20,000	+12 DB	−50 DB	0 MA	LS-1	$26.00
LS-21	Single plate to push pull grids. Split pri. and sec.	15,000 ohms	135,000 ohms; 3:1 overall	± 1 db 20-20,000	+10 DB	−74 DB	0 MA	LS-1	26.00
LS-25	Push pull plates to push pull grids. Medium level. Split primary and sec.	30,000 ohms plate to plate	50,000 ohms; turn ratio 1.3:1 overall	± 1 db 20-20,000	+15 DB	−74 DB	1 MA	LS-1	32.00
LS-30	Mixing, low impedance mike, pickup, or multiple line to multiple line	50, 125/150, 200, 250, 333, 500/600 ohms	50, 125/150, 200, 250, 333, 500/600 ohms	± 1 db 20-20,000	+15 DB	−74 DB	.5 MA	LS-1	26.00
LS-33	High level line matching	1.2, 2.5, 5, 7.5, 10, 15, 20, 30, 50, 125, 200, 250, 333, 500/600	50, 125, 200, 250, 333, 500/600 ohms	± .2 db 20-20,000	15 watts			LS-2	30.00

OUTPUT TRANSFORMERS

Type No.	Application	Primary Impedance	Secondary Impedance	Response	Max.† Level	Relative* hum	Unbal. DC in prim'y	Case No.	List Price
LS-50	Single plate to multiple line	15,000 ohms	50, 125/150, 200, 250, 333, 500/600	± 1 db 20-20,000	+15 DB	−74 DB	0 MA	LS-1	$26.00
LS-52	Push pull 245, 250, 6V6 or 245 A prime	8,000 ohms	500, 333, 250, 200, 125, 50, 30, 20, 15, 10, 7.5, 5, 2.5, 1.2	± .2 db 25-20,000	15 watts			LS-2	35.00
LS-55	Push pull 2A3's, 6A5G's, 300A's, 275A's, 6A3's, 6L6's, 6AS7G	5,000 ohms plate to plate and 3,000 ohms plate to plate	500, 333, 250, 200, 125, 50, 30, 20, 15, 10, 7.5, 5, 2.5, 1.2	± .2 db 25-20,000	20 watts			LS-2	35.00
LS-63	Push pull 6F6, class B 46's, 6AS7G, 807-TR, 1614-TR	10,000 ohms plate to plate and 6,000 ohms plate to plate	30, 20, 15, 10, 7.5, 5, 2.5, 1.2	± .2 db 25-20,000	15 watts			LS-2	25.00
LS-151	Bridging from 50 to 500 ohm line to line	16,000 ohms, bridging	50, 125/150, 200, 250, 333, 500/600	± 1 db 15-30,000	+18 DB	−74 DB	1 MA	LS-1	27.00

The values of unbalanced DC shown will effect approximately 1.5 DB loss at 30 cycles.
* Comparison of hum balanced unit with shielding to normal uncased type. Q Multiple alloy magnetic shield.
† 6 MW as ODB reference.

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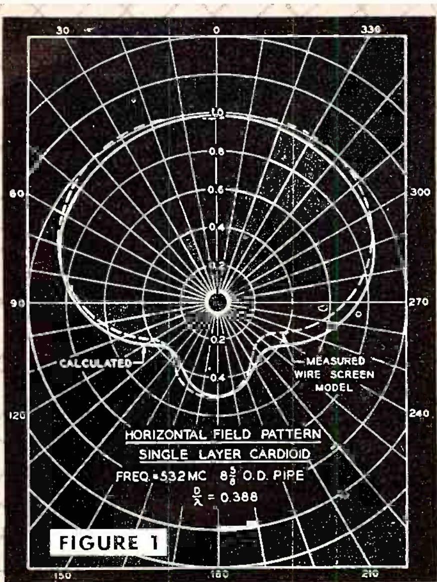

FIGURE 1

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Use an RCA "contour-engineered" UHF Pylon Antenna

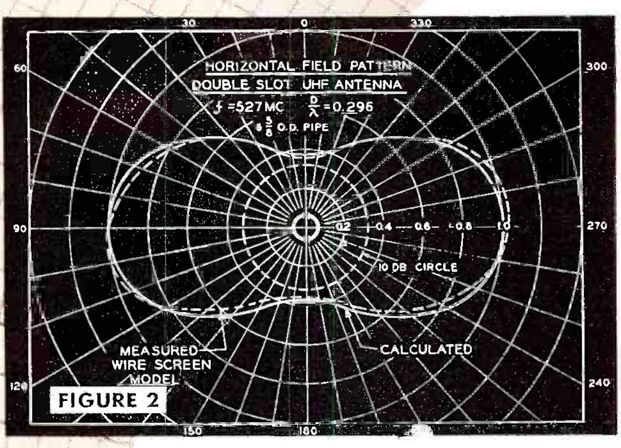


FIGURE 2

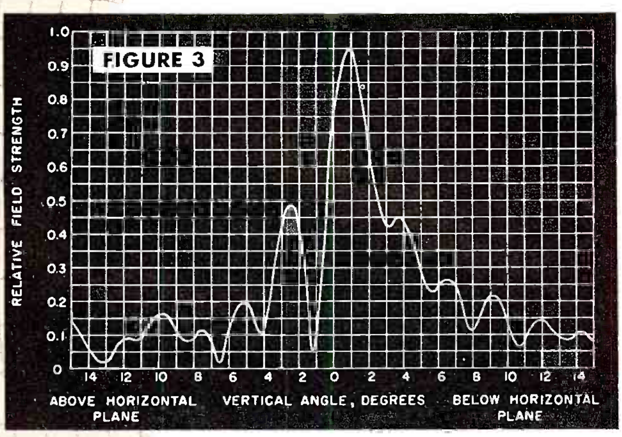


FIGURE 3

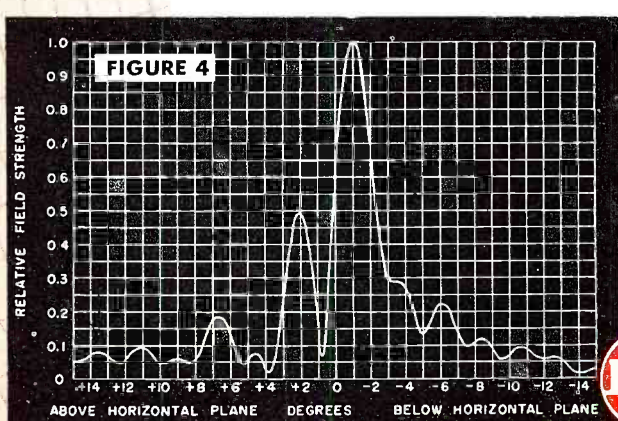
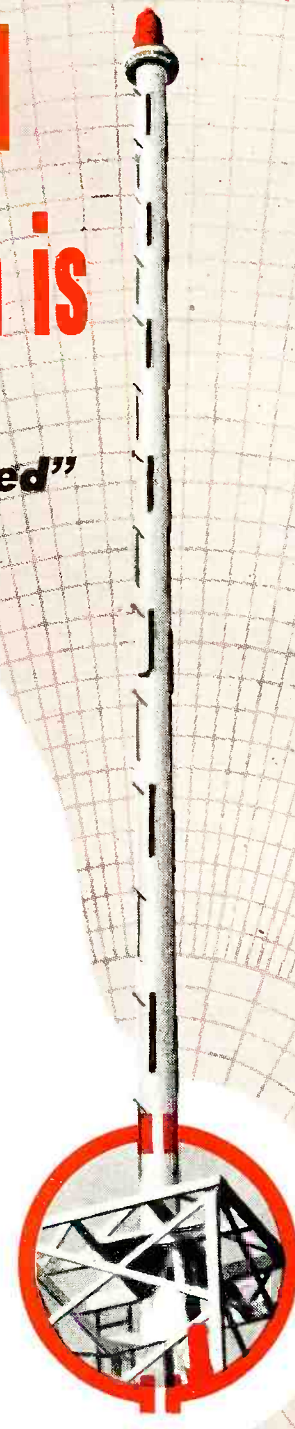


FIGURE 4

- **For "single-direction" coverage,** RCA has UHF Pylons that produce a horizontal field pattern shaped like a Cardioid (see Fig. 1).
- **For "elongated" coverage.** RCA has UHF Pylons that produce a horizontal field pattern shaped like a peanut (see Fig. 2).
- **For "circular" coverage.** RCA has a wide selection of UHF Pylons that produce equal signals in ALL directions.
- **For better overall coverage,** RCA UHF Pylons have built-in "Beam Tilt" that minimizes power loss in vertical radiation.
- **For better "close-in" coverage.** RCA UHF Pylons are equipped with a new, advanced type null fill-in system (used in conjunction with beam tilting). See Figs. 3 and 4.
- **The gain that's published is the gain you get.** RCA UHF Pylons include no tuning compromises that would result in loss of gain. RCA UHF Pylons can be furnished with gains in the order of 3, 6, 9, 12, 21, 24, and 27!
- **RCA has all UHF antenna accessories:** towers, mitered elbows, line transformers, spring hangers, dummy loads, wattmeters, frequency and modulator monitors, filterplexers, and transmission line (measured performance—VSWR—is better than 1.05 to 1.0). You can get everything from ONE responsible source—RCA!


RCA Adjustable Beam High-Gain UHF Pylon —installed

An antenna system can make or break a TV station. Make sure yours is right. Your RCA Broadcast Sales Representative can help you plan.

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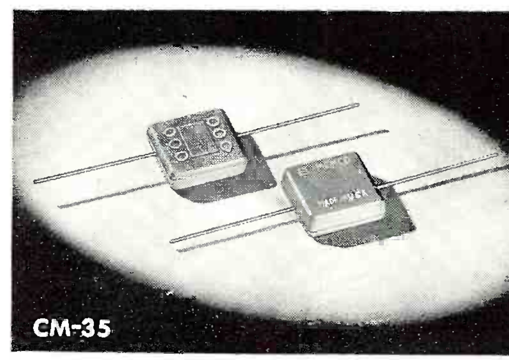

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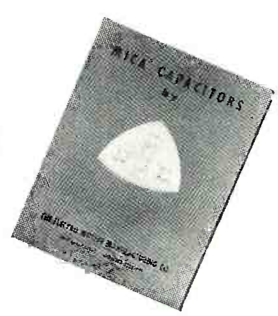

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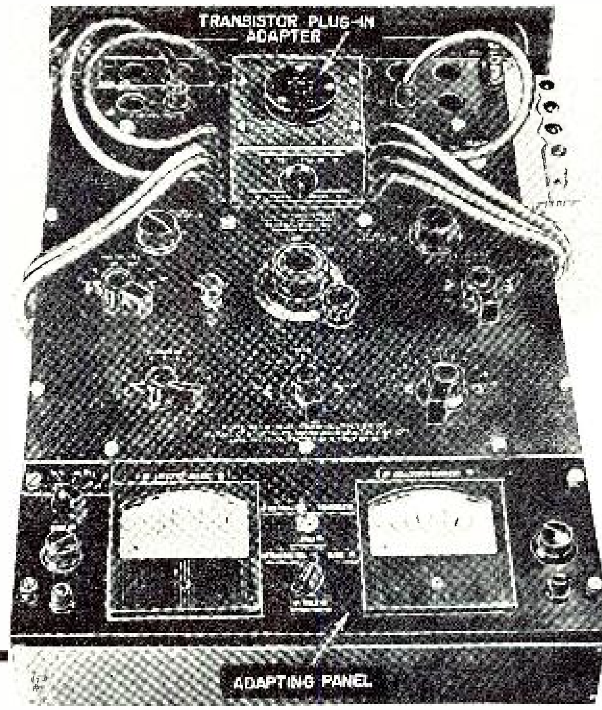
THE ELECTRO MOTIVE MFG. CO., INC. **WILLIMANTIC, CONNECTICUT**

A BRIDGE TRANSISTOR TESTER

By **DAVID DORMAN**

Research Laboratories
Sylvania Electric Products Inc.

Commercial vacuum tube bridge may be adapted to measure point-contact transistor parameters.



The *General Radio* vacuum tube bridge Type 561-D adapted for transistor measurements.

MANY TESTING procedures previously described in the literature utilize the short-circuit mode of operation to provide transistor characteristics in terms of conductances. These short-circuit conditions are well suited for the measurement of junction transistors; however, the same conditions result in very unstable point-contact transistor operation. An important advantage of the measurement technique described herein is that the open-circuit mode of operation which is most favorable for point-contact transistor measurement is utilized.

The *General Radio* Type 561-D vacuum tube bridge is well known as a measuring device for vacuum tubes. A study of this bridge has revealed that it is readily adaptable for accurate and simple measurement of point-contact transistor parameters R_{11}, R_{22}, R_{12}, R_{21}, and α. If the transistor is considered as an active four-terminal network, as shown in Fig. 1, these small a.c. signal parameters may be defined as follows:

R_{11}= input resistance with the output open-circuited (i_c=0)

R_{22}= output resistance with the input open-circuited (i_e=0)

R_{12}= feedback resistance with the input open-circuited (i_e=0)

R_{21}= forward resistance with the output open-circuited (i_c=0)

α = current gain with the output short-circuited (v_c=0)

Over a small region of the static characteristics, the linear relations between the incremental emitter and collector voltages and currents can be described by the linear equations:

$$v_e = R_{11}i_e + R_{12}i_c \quad . . . . . . (1)$$

$$v_c = R_{21}i_e + R_{22}i_c \quad . . . . . . (2)$$

and the slopes of the appropriate set of characteristic curves are expressed by:

$$R_{11} = \frac{\delta v_e}{\delta i_e}\bigg|_{i_c = 0} \quad . . . . . . (3)$$

$$R_{22} = \frac{\delta v_c}{\delta i_c}\bigg|_{i_e = 0} \quad . . . . . . (4)$$

$$R_{12} = \frac{\delta v_e}{\delta i_c}\bigg|_{i_e = 0} \quad . . . . . . (5)$$

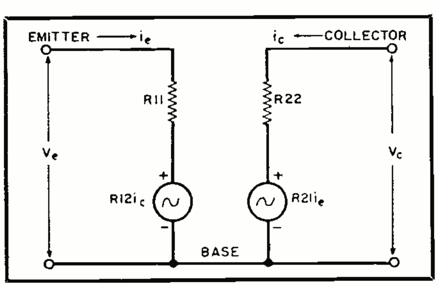
$$R_{21} = \frac{\delta v_c}{\delta i_e}\bigg|_{i_c = 0} \quad . . . . . . (6)$$

The expression for α is:

$$\alpha = \frac{\delta i_c}{\delta i_e}\bigg|_{v_c = 0} \quad . . . . . . (7)$$

Resistance parameters or coefficients, Eqts. (3)-(6), and α, Eqt. (7), may be closely correlated with the dynamic coefficients of vacuum tubes, R_p, G_m, and μ. The *General Radio* bridge measures these tube coefficients by means of null-balance arrangements of the various alternating increments [1,2]. It is possible to adapt these bridge null-balance arrangements to permit accurate and direct measurements of the point-contact transistor coefficients.

Fig. 1. Equivalent circuit of transistor shown as an active four-terminal network.



It is not intended at this time to describe the theory of operation of the bridge, which already has been very adequately done[2], but rather to present the circuitry in order to illustrate fully the direct measurement correlations between tubes and transistors which may be advantageously exploited.

Bridge modifications and all but one switch (the transistor switch which enables one to use the bridge for transistor measurements) are housed in a panel mount measuring approximately 15½" x 5½" x 5". Two power supplies wired into the bridge setup supply the emitter and collector bias requirements. The transistor is inserted into the bridge by means of a plug-in type octal adapter, and the transistor switch—which applies or removes the desired bridge terminals to the emitter, collector, and base—is mounted on the plug-in octal adapter.

The close analogy which exists between the dynamic coefficients of the vacuum tube and the transistor may be more easily observed by a study of the definitions of both groups of coefficients. Transistor coefficients are defined in Eqts. (3)-(7), and those for vacuum tubes in Eqts. (8)-(10).

$$R_p = \frac{\delta v_p}{\delta i_p}\bigg|_{v_g = 0} \quad . . . . . . (8)$$

$$G_m = \frac{\delta i_p}{\delta v_g}\bigg|_{v_p = 0} \quad . . . . . . (9)$$

$$\mu = \frac{\delta v_p}{\delta v_g}\bigg|_{i_p = 0} \quad . . . . . . (10)$$

Upon examining Eqt. (8), the expression for R_p, it becomes apparent

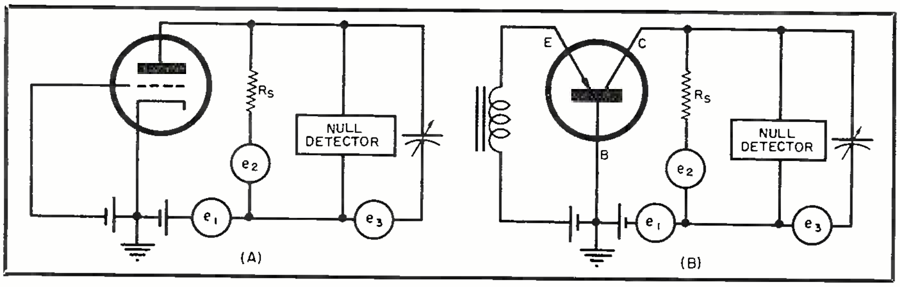


Fig. 2. (A) Simplified bridge circuit for measuring R_p. (B) Modified R_p bridge circuit designed to measure R_{22} of point-contact transistors.

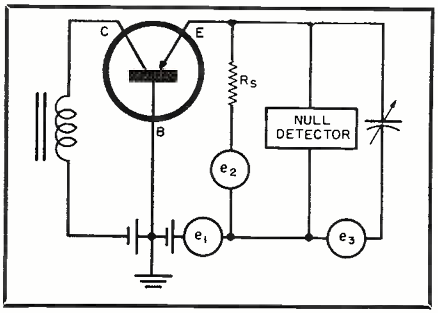


Fig. 3. Modified R_p bridge circuit designed to measure R_{11}.

that the increments of alternating voltage and current involved correspond to those for R_{22} of the transistor, i.e., v_c and i_c correspond to v_p and i_p, respectively, while the condition $i_e = 0$ may be considered the dual[3] of $v_g = 0$. It is very simple to satisfy the condition $i_e = 0$ with the insertion of a 600-henry audio choke in the emitter circuit; this essentially opens the circuit to the bridge test signal of 1000 cps. The simplified bridge circuit for measuring R_p and the associated circuit for measuring R_{22} are shown in Figs. 2A and 2B.

In the circuit for measuring R_p, as illustrated in Fig. 2A, it is desired to measure the alternating plate current flowing as a result of a small voltage change introduced into the plate circuit under the condition that there be no alternating voltage on the grid. The small voltage change introduced into the plate circuit is represented by the test voltage e_1. Test voltage e_2 is adjusted so that the resultant current flowing through R_s balances the plate current. When the two currents are equal, there is no voltage across the null detector. Since the sharpness of the null may be obscured by reactive current which arises from the interelectrode capacitances of the tube being tested, lead capacitances, etc., a reactive current generator, e_3, (capacitance balancing winding in series with a variable capacitance) is introduced—as shown—and may be adjusted to pass an equal and opposite reactive current.

Increments of R_{11} likewise are analogous to those of R_p. Since R_{11} is defined as the transistor input resistance, the bridge R_p measuring circuit must therefore be placed in the emitter circuit, as shown in Fig. 3. This is done simply by reversing the transistor emitter and collector leads. It is necessary to maintain the proper d.c. biasing when reversing the transistor, and this is insured in the switching procedure.

The test setup for measuring R_{11} provides an a.c. open collector circuit, and the bridge R_p circuit measures the alternating emitter current flowing as a result of a small voltage change introduced into the emitter circuit by e_1. The collector circuit is effectively open-circuited to a.c. by the audio choke. Test voltage e_2 is adjusted so that the resultant current flowing through R_s balances the emitter current. When the two currents are equal, a null will be exhibited by the detector and the bridge decade resistor balance will yield the value of R_{11}.

When measuring the transconductance of a tube with the bridge, it is necessary to determine the alternating plate current flowing as a result of a small signal voltage introduced into the grid circuit under the condition that there be no alternating voltage on the plate. A nearly parallel situation exists in the measurement of α. α has been defined to be a measure of the alternating collector current flowing as a result of small changes in emitter current under the condition that there be no alternating voltage on the collector. Figure 4A shows the bridge circuit for measuring G_m, and Fig. 4B shows the modified G_m circuit designed to measure α. The G_m position measures:

$$\left.\frac{\delta i_c}{\delta v_e}\right|_{v_c = 0} \quad \ldots\ldots\ldots \quad (11)$$

To measure α, a 100,000-ohm resistance—designated as R_E in Fig. 4B—is inserted in the emitter circuit. Since typical values of R_{11} are of the order of 500 ohms, the effective resistance of the emitter circuit is R_E. The partial derivative of v_e may then be replaced by $\delta i_e R_E$, and the quantity measured by the bridge becomes:

$$\frac{1}{R_E}\left.\frac{\delta i_c}{\delta i_e}\right|_{v_c = 0} = \frac{1}{R_E}\alpha. \quad \ldots \quad (12)$$

The bridge reading is in micromhos:

$\therefore$ Alpha (α) = 0.1X bridge reading (13)

Figures 4A & B show that necessary conditions are satisfied by placing the null detector directly between the collector and base, so that at null balance $v_c = 0$. It is very important in measuring α to throw the sign of coefficient switch to negative. Since signals transmitted through the vacuum tube undergo a phase reversal, while on the other hand signals are transmitted through the transistor without phase changes, reversing the sign of coefficient switch is necessary to supply accurate in-phase test voltages to the transistor under test.

The next tube coefficient to be considered is μ. The μ position of the bridge measures:

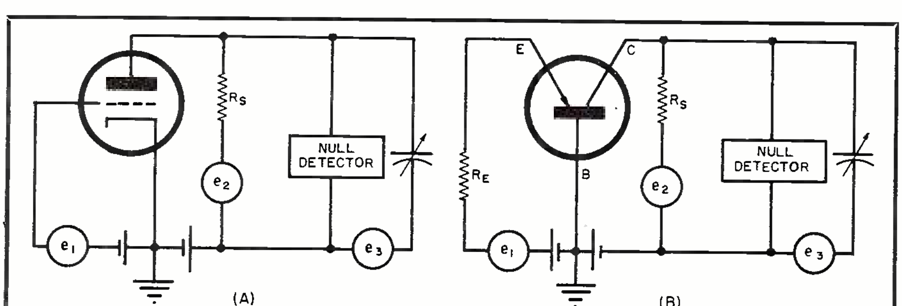
$$\left.\frac{\delta v_p}{\delta v_g}\right|_{i_p = 0} \quad \ldots\ldots\ldots \quad (14)$$

Here again, with some very simple adaptations, the exact requirements for measuring R_{21} are met. Figures 5A and 5B show the bridge circuit for measuring μ and the modified μ circuit designed to measure R_{21}.

To measure R_{21}, R_E (the 100,000-ohm resistor) is once more inserted into the emitter circuit, thus making the effective resistance of the emitter circuit equal to R_E. The partial derivative of v_e may then be replaced by $\delta i_e R_E$, and the quantity measured by the bridge becomes:

$$\frac{1}{R_E}\left.\frac{\delta v_c}{\delta i_e}\right|_{i_c = 0} = \frac{1}{R_E}R_{21} \quad \ldots \quad (15)$$

Fig. 4. (A) Simplified bridge circuit for measuring G_m. (B) Modified G_m bridge circuit designed to measure α of point-contact transistors.



$$\therefore R_{21} = \mu \text{ reading} \times 10^5 \text{ ohms.} \quad (16)$$

To measure R_{21}, it is necessary to throw the sign of coefficient switch to negative—as before—to supply accurate in-phase test voltages to the transistor under test. On examining Fig. 5B, it will be clear that the necessary conditions for measuring R_{21} are satisfied. At the point of null balance indicated by the null detector, i_c=0.

Alternating increments of R_{12} likewise correspond to those of μ with the exception that the transistor input circuit is to be measured. This problem is again overcome simply by reversing the transistor emitter and collector leads so that the bridge measuring circuit is placed in the emitter circuit. The test setup for R_{12} now provides an a.c. open circuit in the emitter when a null balance is obtained. Figure 6 shows the modified μ measuring circuit designed to measure R_{12}. The quantity measured by the bridge is:

$$\left.\frac{\delta v_e}{\delta v_c}\right|_{i_e = 0} \quad (17)$$

Since $\delta v_c = \delta i_c R_{22}$, this quantity becomes:

$$\left.\frac{\delta v_e}{\delta i_c R_{22}}\right|_{i_e = 0} = \frac{1}{R_{22}} (R_{12}). \quad (18)$$

$$\therefore R_{12} = \mu \text{ reading} \times R_{22} \text{ ohms} \quad (19)$$

The value of R_{22} previously measured by the bridge (Fig. 2B) is used with this measurement of μ to calculate R_{12}.

An external resistance of a value much larger than R_{22} was not used for this test, as the value of R_{22}—being of the order of 20,000 ohms—would require the use of an external resistance of the order of 2,000,000 ohms. Essentially constant-current bias is supplied to both the emitter and the collector of the transistor under test. A simple and convenient means of providing this bias has been through the use of two high-voltage power supplies with a large series resistance introduced in both the emitter and collector leads. Placing a 2,000,000-ohm resistance into the collector circuit would then require a power supply capable of providing more than 1000 volts, which is impractical.

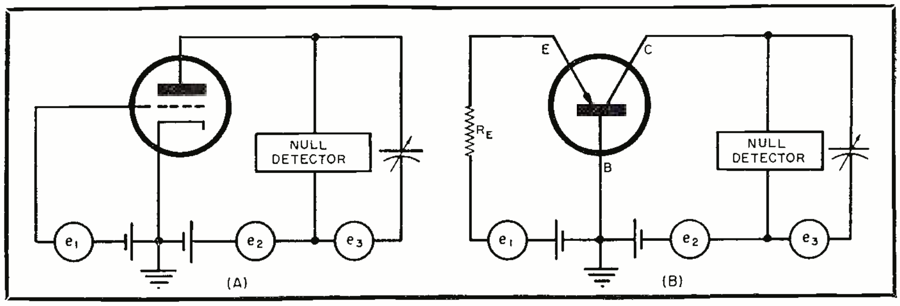


Fig. 5. (A) Simplified bridge circuit for measuring μ. (B) Modified μ bridge circuit designed to measure R_{21} of point-contact transistors.

In the test procedure outlined in Table 1, a bridge oscillator output of approximately 1000 cps at 25 volts results in a test signal level of 3.4 volts. This signal level appears in the test circuitry when the "multiply by" switch is set to 1. With the aid of an oscilloscope null detector, it is possible to observe whether or not the test signal overloads the transistor under test. Setting the "multiply by" switch to the position marked 10 results in a decrease of the test signal level by a factor of 10 to 0.34 v. The next larger "multiply by" switch positions result in proportionately lower test signal levels. Therefore, with the aid of the scope detector, an appropriate test signal can be chosen. Table 1 lists the "multiply by" switch positions found suitable for performing the various required tests on those transistors measured to date.

One of the difficulties sometimes encountered in the measurement of point-contact transistors by the bridge balance method is that balance may be obscured by transistor noise. The transistors that have been measured so far exhibited low enough noise levels so that bridge balances to three significant figures were possible. If other transistors exhibit higher noise levels, it should be fairly simple to minimize the effects of noise by increasing the input test signal (at the same time making sure that the increased signal level does not produce distortion). The possibility of signal analysis is one of the most important advantages of utilizing an oscilloscope for purposes of null detection.

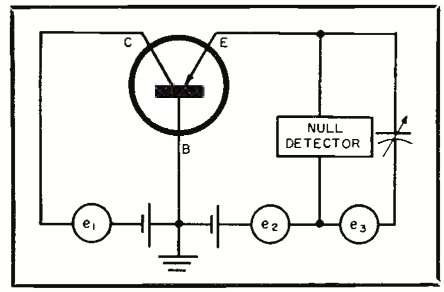


Fig. 6. Modified μ bridge circuit designed to measure R_{12}.

Another difficulty which may arise in measuring point-contact transistors is that oscillations may occur with short-circuit terminations of the transistor. This method of termination, although somewhat undesirable for point-contact transistor parameter measurements, is known to be used in other testing techniques which measure the conductance rather than resistance parameters[4]. Thus, a second important advantage of the modified bridge method can be pointed out, i.e., open-circuit a.c. terminations for all tests except that for α—which utilizes a 100,000-ohm resistor in the emitter circuit—make it very unlikely that a transistor will break into oscillations.

(*Continued on page –34–*)

Table 1. Procedure for measuring various transistor parameters by means of the modified vacuum tube bridge.

BRIDGE ADJUSTMENTS						ADAPTING PANEL ADJUSTMENTS				
Parameter to be Measured	Coefficient Selector Switch & Sign	"Multiply by" Switch	"Divide by" Switch	Decade Resistor Balance	Capacitor Multiplier Switch	Transistor Switch	Switch #1	Switch #2	Switch #3	Bridge Measurements
R_{11}	R_p (+)	1	10^2	adjust for balance	out	test	reverse	tran-sistor	R_{11}	R_p
R_{22}	R_p (+)	1	10	"	"	"	normal	"	R_{22}	R_p
R_{12}	μ (−)	10	10	"	"	"	reverse	"	R_{12}	μ x R_{22}
R_{21}	μ (−)	1	10	"	"	"	normal	"	R_{21}	μ x 10^5
α	G_m (−)	10	1	"	"	"	normal	"	α	G_m/10

ESTABLISHING A POWER

By
NICHOLAS ALCHUK

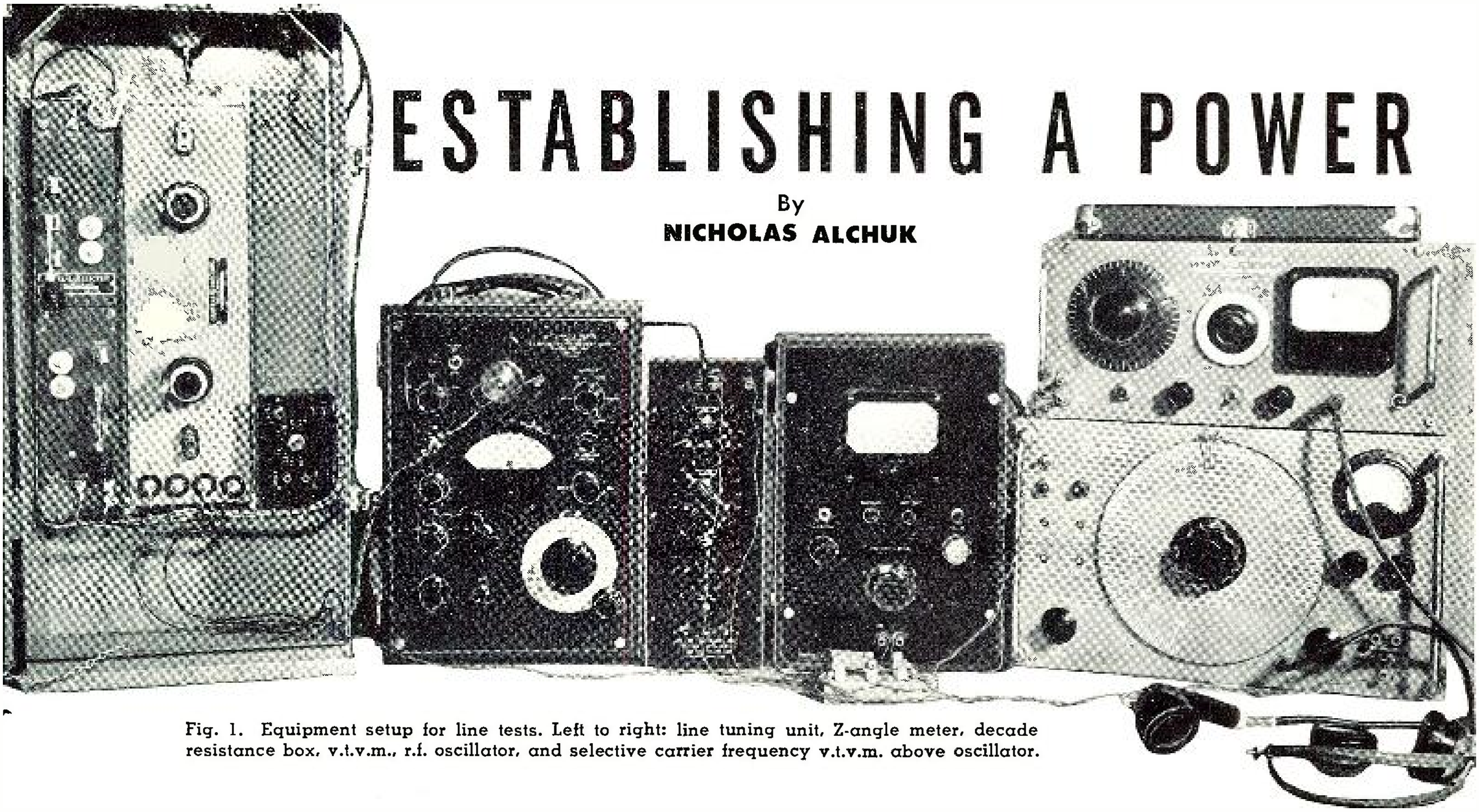


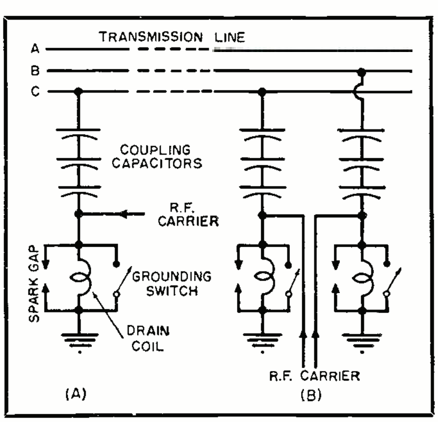
Fig. 1. Equipment setup for line tests. Left to right: line tuning unit, Z-angle meter, decade resistance box, v.t.v.m., r.f. oscillator, and selective carrier frequency v.t.v.m. above oscillator.

GENERATION and distribution of power require the use of much auxiliary equipment. In the past decade, the power industry has relied heavily upon power line carrier facilities. Their value for telemetering, load control, and other functions has been established.

Problems confronting a power line carrier engineer differ greatly from those met by the communication engineer. The power line carrier channel must be fitted into the existing transmission line network. In many instances, special devices must be used and measures taken to insure consistent operation of the equipment. Determination of the behavior of r.f. signals on transmission lines is more difficult than predicting their performance in free space.

The method of coupling an r.f. carrier to the transmission line depends greatly on line configuration. Attenuation, impedance, carrier frequency, and single- or double-circuit tower construction all have an effect on the transmission. Phase-to-ground and phase-to-phase coupling (shown schematically in Fig. 2) are the two methods most widely used.

Fig. 2. Methods of coupling r.f. carrier to transmission line: (A) phase-to-ground, and (B) phase-to-phase.



Coupling Capacitors

The vital link in injecting the carrier onto the transmission line is the coupling capacitor. It is usually made up of individual series-connected oil-impregnated paper capacitors, installed in a porcelain housing, and may be used on lines up to 230 kv. A typical 115-kv. assembly is shown in Fig. 4.

When determining the over-all attenuation of a carrier channel, it is essential to know the impedance of the capacitor. Not only is the information important from a transmission consideration, but it is a check on the capacitor itself. Once the capacitor has been mounted and connected to a line, it is not economically feasible to take the line out of service and perform measurements.

Measurements are made with and without protective equipment connected to the capacitor. In addition, the high side of the capacitor is grounded in order to place the low side at a high r.f. potential, thus simulating its actual operating condition. Generally, an unknown impedance can be measured by means of a *Q* meter or an r.f. bridge. The *Q*-meter method is more versatile, since certain liberties can be taken in the measurements owing to the low frequencies used (50 to 200 kilocycles).

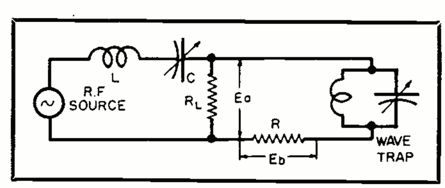
Wave Traps

To confine the carrier to a transmission line and reduce losses into the steel network or tap lines, wave traps are employed at both ends of a carrier channel. The traps are parallel-tuned devices, of either single or double frequency, wound with heavy bar or stranded wire. Since they are connected in series with a phase wire, they must carry the line currents which range from 100 to 400 amperes. The traps are rated at 800 amperes for 230 kv., and 400 amperes for 115 kv. Figure 6 shows a 230-kv. installation.

Successful operation of a carrier channel depends upon the received signal level. Equipment losses may be readily calculated; however, an untrapped transmission line contains so many variables that a usable figure of attenuation is difficult to compute. Wave traps, inserted at known high attenuation points, insure that the attenuation is kept to a minimum.

The impedance of wave traps is important. The higher the impedance, the more of the carrier signal is confined to the transmission line. Single frequency traps have impedances of ap-

Fig. 3. Typical circuit for measuring the impedance of a wave trap.



LINE CARRIER CHANNEL

Factors to be considered include coupling methods, power line characteristics, and impedances of traps and coupling capacitors.

proximately 10,000 ohms at the operating frequency. This value drops to about 3000 and 5000 ohms, respectively, for the low and high frequencies of double-frequency traps. Several methods are available for measuring impedance; and when the frequency, inductance, and Q are known, the method shown in Fig. 3 is normally used. The equation for determining the impedance Z in Fig. 3:

$$Z = \frac{E_a}{E_b} R$$

is accurate for normal operating conditions. The voltages E_a and E_b are measured by a v.t.v.m. This arrangement gives the total impedance but does not evaluate the resistive and reactive components.

Line Tuning Unit

For maximum transfer of power, the r.f. source must look into an essentially resistive component. Using the capacitor alone as a coupling source, the load is capacitive. The function of the line tuning unit is to resonate the capacitor at the frequency of operation. This unit consists of series inductance variable within the 50 to 200 kc. range. In addition, a coupling transformer is utilized to match the tuning unit to a coaxial cable. Single- and double-frequency units are manufactured, as well as phase-to-phase and phase-to-ground couplers. The tuning unit as a whole has a broadband characteristic, with an insertion loss of approximately 2 db. Figure 5 shows a double-frequency line tuning unit which may be operated either single or double frequency phase-to-phase, or single frequency phase-to-ground. The tuning unit is normally mounted at the base of the coupling capacitor, and a coaxial cable connects it to the carrier equipment.

In the early years of power line carrier installation, it was common practice to mount the terminal equipment near the coupling capacitor and line tuning unit. Connection to the line tuning unit was made by a high impedance insulated cable. This condition resulted in the lead and the terminal equipment operating at the line impedance. If the lead were not aerially supported, shunt conductance losses to ground became excessive in lead lengths of 100 feet or more. Development of coaxial cable made it possible to locate equipment 1000 feet or so away from the coupling units because of the reduced losses in such cable.

Line Tests

Although not often necessary, line tests are desirable to determine the impedance of the transmission line. In addition, the attenuation and optimum operating frequency can be determined. It is possible to calculate the performance of a transmission line; however, the many factors involved—such as transposition schemes, spacing of conductors, size of conductors, and type of insulators—make for a tedious and sometimes laborious task. The calculated values on many occasions are too high and contribute additional errors in the over-all transmission scheme. Line test results are useful for obtaining figures of the following items: (1) frequency coordination, (2) impedance and attenuation, (3) carrier frequency noise.

Frequency Coordination

Power line carrier frequencies have been allocated in the 50 to 200 kc. frequency band. Since many utilities operate in a loop system, with all generating plants feeding power into a hypothetical loop, care must be exercised in the choice of frequency for

(*Continued on page -36-*)

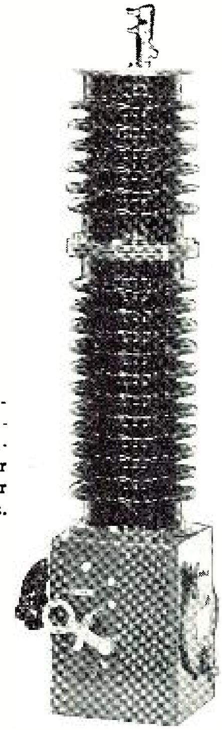


Fig. 4. A 115-kilovolt 0.002-microfarad coupling capacitor unit for power line applications.

Fig. 5. Typical line tuning unit used to resonate a coupling capacitor such as the one in Fig. 4.

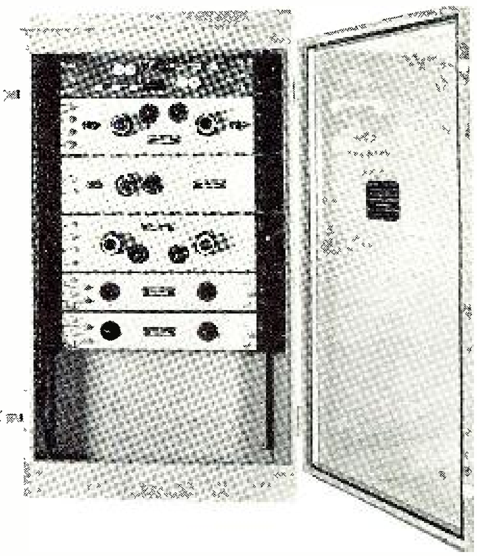
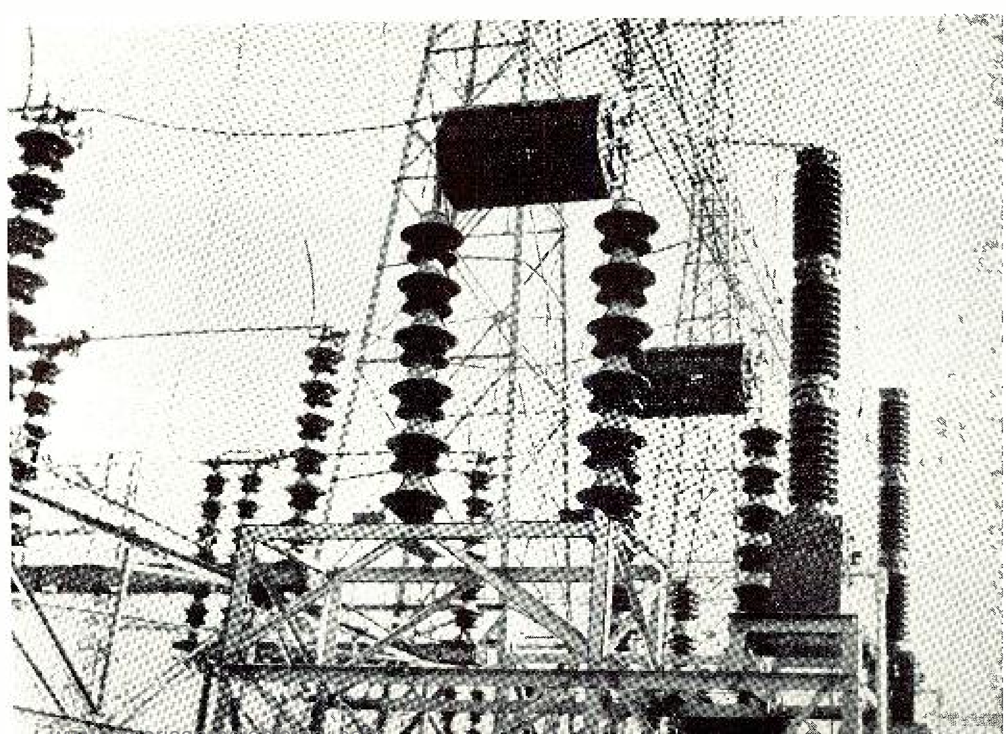


Fig. 6. A 230-kilovolt phase-to-phase coupling arrangement using principles outlined in Fig. 2B.



CAST

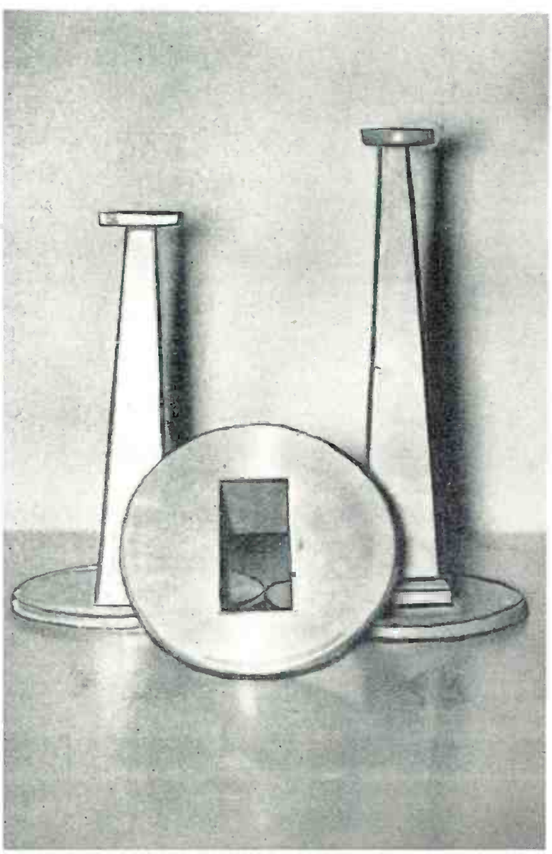
By

SAMUEL FREEDMAN

Sightmaster of California Company

Fig. 1. Forming the metal pattern for a 3000-9000 mc. cast wave guide adapter, complete with flanges.

Fig. 2. Finished wave guide adapters made by the Sightmastermold process: a 3000-9000 mc. transition (left), and a 3000-30,000 mc. transition (right).



BONDING fine sands with synthetic resins makes it possible to precision-mold wave guides complete with flanges to any dimension or configuration in a single casting operation. This is accomplished by the "Sightmastermold" process which has been developed by *Sightmaster of California Company*, of Santee, California. Use of this process, which incorporates a shell molding technique, improves the performance and very substantially reduces the cost of microwave wave guides, particularly with new designs and components made of aluminum.

Shell-molded wave guides may be of a quality and composition difficult to achieve by other known wave guide fabricating methods such as extruding, brazing, investment casting or electroforming. In the case of aluminum, it is difficult to extrude the stronger alloys to JAN dimensional tolerances and to braze them without heat deformation. Also, it is impossible to electroform aluminum and some other metals as plated depositions on "lost materials" which are subsequently removed. The Sightmastermold process facilitates the use of aluminum with its general advantages of light weight, low cost, plentiful domestic supply and attractive appearance, and is suitable for use with all known metals having melting points from as low as 500° F or less up to over 2000°F.

A problem that has always existed in producing wave guides has been the lack of satisfactory flanging or joining techniques. Flanges have usually been secured from sources other than those which furnish the extruded wave guide tubing, thereby necessitating the soldering, brazing or welding of such flanges and the use of corrosive fluxes at every flange or junction. Every time flanges are brazed to wave guide tubing (normally extruded pipe), particularly in the case of aluminum, the heat causes deformation of the metal which results in misalignment and rejection of material or parts. In order for any flange to fit into brazing position on a wave guide, there must be some dimensional clearances—which result in misalignment and reduction in efficiency.

No wave guide performance can be better than its flanges and flange clearance/alignment permit. In some cases, wave guides must be held to a dimensional tolerance of two-thousandths of an inch and should have a smooth surface of less than 25 micro-inches. Misalignment, nonuniformity of dimension and discontinuity cause a mismatch which is manifested in the form of an increased voltage standing wave ratio. A mismatch causing a VSWR of 1.22 was reported to be sufficient to make a leading military radar inoperative because the magnetron tube would break down and arcing could be detected.

VSWR must be kept as low as possible in pulsed systems where peak powers are of a magnitude so much in excess of average power that adequate component safety factors are difficult and costly to provide. In aircraft or airborne pulsed radar equipment, high safety factors would result in excessive weight and space needs. In high powered megawatt ground radar installations, high safety factors would involve components larger than are normally available as standard. The best way of obtaining minimum

WAVE GUIDES

Wave guides and adapters can be cast complete with flanges by the Sightmastermold process.

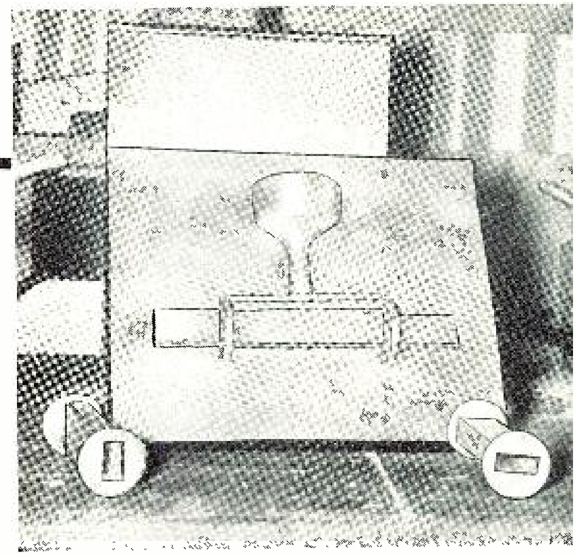


Fig. 3. Metal pattern used to fabricate the X-band (9375-mc.) wave guides shown on the table.

VSWR's is to eliminate completely any soldering, brazing or welding in wave guide fabrication and flanging.

A common sight in wave guide plants is the "Lady with the File," or her male counterpart, whose sole task is to file down wave guide and flange extremities so that parts will pass electrical test inspection. Sometimes, the deformation or discontinuity is too great to be overcome by this elementary method, and the part has to be scrapped. At other times, in desperation or because of lack of proper components, two defective or high VSWR parts have been known to be joined together in reverse in an attempt to balance out the defects. In extreme cases, rather than start all over again, there have been situations where "dent tuning" has been resorted to in order to secure satisfactory operation.

In fabricating tapered wave guide adapters, it is very difficult to overcome electrical discontinuities and mismatch. For a transition from one size to another, 14 distinct brazed surfaces must be joined, counting the four-sided rectangular flange as one operation. Such wave guide adapters have many uses in the microwave art.

When *Sightmaster of California Company* expanded its microwave calorimeter program after the Korean outbreak, the need for more and better adapters increased. As a result of the poor availability of adapters as well as the high number of physical/electrical discontinuities present in conventional adapters of heavy brass, a program of research and development was started. The approach was from the standpoints of better availability, lower cost, lighter weight and improved performance. It became desirable to abandon old methods and concepts of making wave guides. After considerable research and investigation, a decision was made to cast wave guides, not using ordinary casting techniques, but by means of a modified and improved version of a shell molding process originally invented in Germany during World War II and delayed in adoption pending the availability of more suitable resins. Since wave guides are normally hollow, thin-walled and sharp-cornered instead of solid or thick-walled, the word "Sightmastermold" is used to differentiate from "shell mold."

A metal pattern is used as the starting point in this process. Illustrated in Fig. 3 is a simple pattern for a straight wave guide section. Figure 1 shows a pattern maker forming the first half of the metal pattern complete with flanges for a wave guide adapter; it is held to close dimensions with proper allowance for metal shrinkage and time cycle dimensional changes during the production process to take care of metals such as aluminum that can shrink 3/16" per foot in every plane. Another type of pattern is a core box (Fig. 4) which makes the core and decides the wall thickness as well as the internal surface smoothness of a wave guide.

When heated and immersed in a special sand-resin mix, the heat from the metal pattern penetrates the mix, thereby causing the resin to become plastic and bond the sand to form an accurate impression or mold of the pattern configuration. The pattern is formed in two halves, with alignment provisions, to make up a complete shell mold ready to go into position for pouring. When the metal has solidified after pouring, the shells are destroyed in order to remove the finished pieces. Being made of plentiful and inexpensive sands and resins, an unlimited number of shells can be formed rapidly from a single metal pattern and they are therefore expendable. The concept is to save the metal casting and destroy the shell mold. The casting is worth dollars while the shell mold is worth only pennies in relative terms of value and cost.

Figure 2 shows finished wave guide adapters made by the Sightmastermold process, complete including flanges. They are surface-smoothened and drilled as required. VSWR's in tapered wave guide adapters made by this process are very low. In a typical example, a tapered adapter was used to join a small wave guide to a larger wave guide containing a water load, and the VSWR for the whole combination was only 1.03.

One metal pattern can be used to make thousands of shells. Each pair of shells comprises a mold. Each mold makes a complete wave guide part, including flanges or appendages. The pattern can be stowed away and brought out whenever needed. Although the mold is made in two parts, thereby creating a visible seam when the component is first removed from the mold, this seam is external only. No internal seam or discontinuity is present since metal flows around an internal core properly spaced to yield required wall thickness. The external seam can be completely eradicated by surface buffing of the part, as can the pouring path or gating

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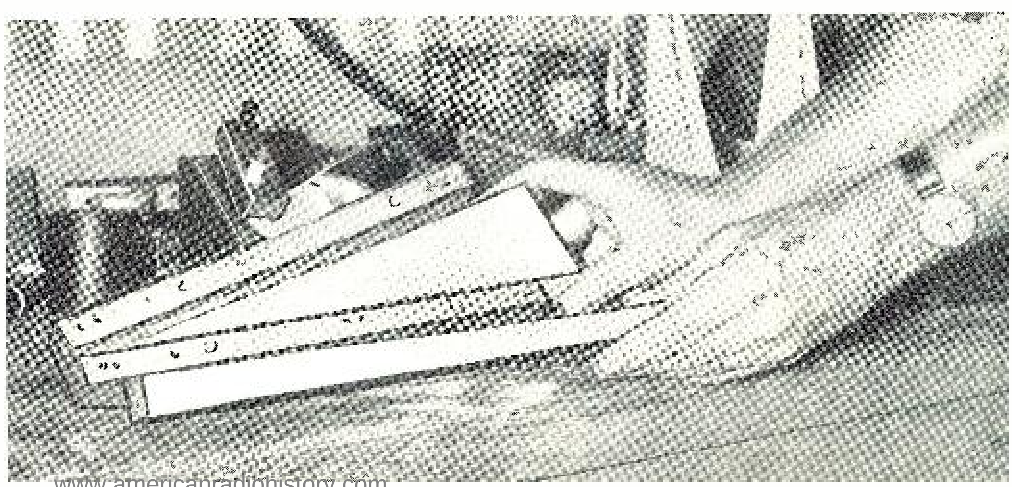
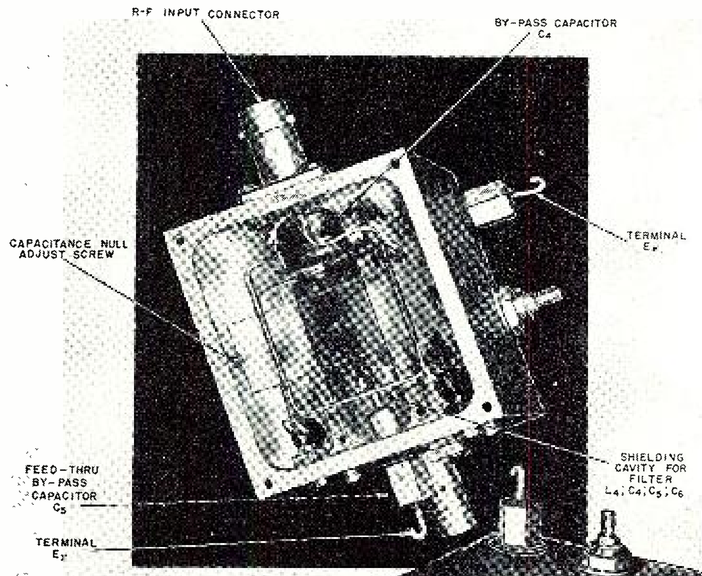
Fig. 4. Sand-resin core form being removed from core box.

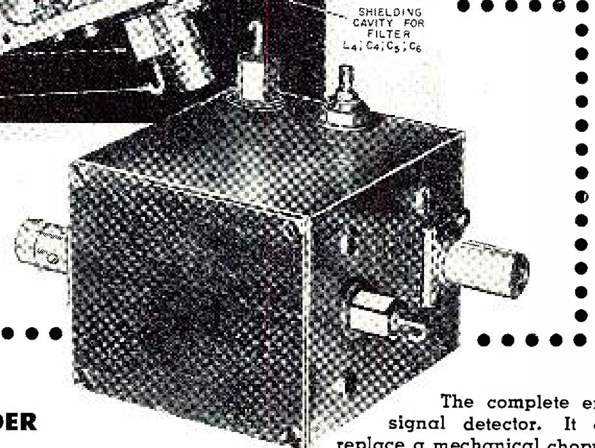


ERROR VOLTAGE DETECTOR

High resolution and stability are attained using crystal diodes in a bridge circuit.



Interior construction of error voltage detector. Body is milled from a solid block of aluminum.



The complete error signal detector. It can replace a mechanical chopper.

By

M. L. KUDER

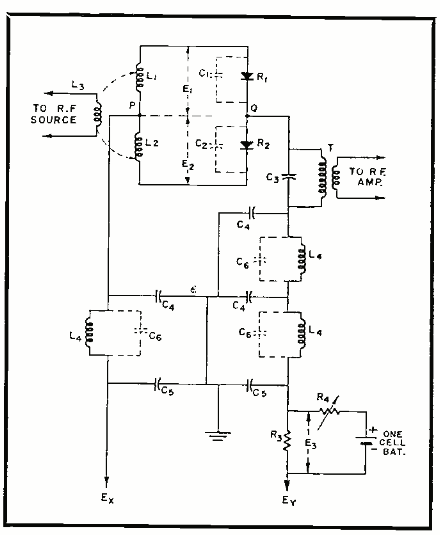
National Bureau of Standards

SOME OF the most important and rapid technological advances of the past decade have been in the automatic control of machines and processes, and substantial extension of this trend toward automatization in industrial and military technology seems highly probable. Many significant applications of automatic control are based on servo feedback systems. These systems may be thought of as arrangements in which any deviation of a controlled device or process gives rise to an error signal—usually an electrical voltage. The servo system then initiates a corrective action which continues until the error signal is brought very nearly to zero, i.e., until the desired condition is reached.

A crucial element of any servo system is the method or device used for sensing the error signal, which usually means detecting the difference between two voltages. Ideally, a signal detector should be able to measure the error signal immediately when the controlled process deviates from the desired condition by even the smallest amount, and to initiate remedial action in the shortest possible time. The need for greater response speeds in some servo applications brought about a search for a detector which would make a more rapid sampling of the output than a mechanical vibrator or chopper with its limited frequency. Inertia characteristics of a mechanical device place a definite limitation on the over-all response speed. The chopper principle, however, must be retained in order that the error detector may respond to d.c. signals as well as a.c. signals up to video frequencies—a fundamental requirement of many servo applications.

In order to achieve a more rapid sampling rate, it was found necessary to eliminate the mechanical parts altogether and to use electronic circuit elements. Some sensitivity is sacrificed, but the speed of response of the system is tremendously increased, and resolution to 1 millivolt with a bandwidth of 1 mc. can be achieved. The best stability in an electronic circuit is usually obtained when only passive components are used in the critical parts of the system. At present, a germanium diode appears to be the best passive chopper element. When it is designed into a device that is self-compensating for temperature coefficients of the crystals, zero-drift stability to 1 millivolt is readily attainable.

Circuit of the error voltage detector.



Essentially, the NBS error voltage detector is a bridge modulator with an r.f. carrier as its source and the modulating signal as a dynamic controller of resistive balance. High sensitivity for signals near zero in amplitude is the primary aim, and nonlinear reduction in sensitivity for signals departing from zero is both convenient and desirable. Two of the arms of the bridge are germanium diodes whose forward resistances are compared, and the other two arms are inductors which serve as r.f. voltage sources for excitation of the diodes. The usual difficulty with contact potentials in germanium diodes is minimized by having the crystals operate at a carrier voltage high compared to the contact potential.

During one half of the carrier cycle, neither diode conducts, and the output is zero. During the other half-cycle, the output is still zero when the two diodes have the same forward resistance. But an error voltage applies a differential bias, unbalances these resistances, and causes a portion of the r.f. carrier to appear at the output. Thus, the error voltage causes partial half-wave rectification of the r.f. source, and the output voltage itself contains a component at the r.f. frequency which is amplified and serves as the indication of the error-signal voltage.

Mechanical details are important in the design and construction of the detector. Excellent shielding between in-

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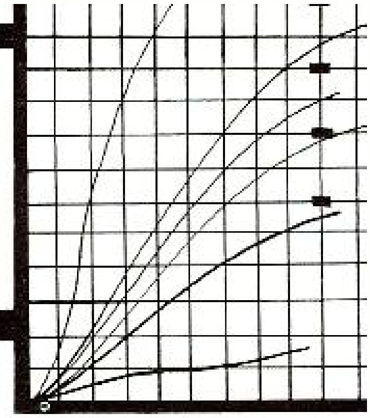


TRANSISTOR CONTROL OF MAGNETIC AMPLIFIERS*

By

G. F. PITTMAN, JR.

Westinghouse Electric Corporation

Possible applications of transistors as control elements in self-saturating magnetic amplifiers.

IT IS the purpose of this article to present some results of an investigation of possible applications for transistors in magnetic amplifier circuitry. Although the transistors which are available commercially at present leave much to be desired—especially in terms of temperature sensitivity—transistor technology is advancing at a rapid pace, and it is felt that an awareness of possible applications in the magnetic amplifier field may prove valuable in permitting utilization of improved transistor characteristics as they become available. The applications discussed involve the use of transistors as control elements of self-saturating magnetic amplifiers.

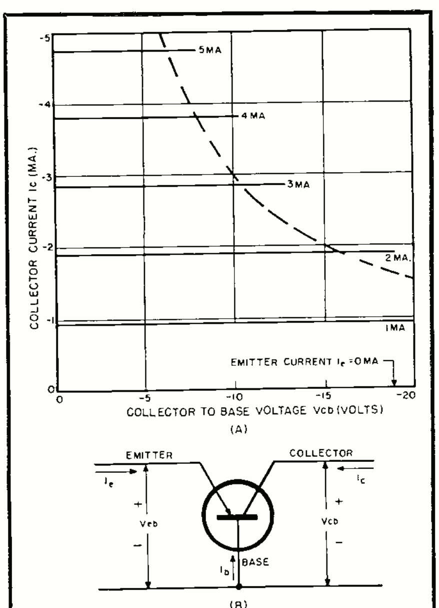
General Concepts

Although the operation of self-saturating magnetic amplifiers has been treated numerous times in the literature[1], several general concepts which are directly related to the subject of this article bear mentioning.

Control of self-saturating magnetic amplifier output is exercised directly by controlling the flux level to which a core is reset during the half-cycle preceding its firing[2,3,4]. In order to accomplish resetting of the core, power (both current and voltage) must be supplied to a control winding on the core. In particular types of circuits, however, it is more convenient to consider either the control current or the control voltage as the independent control variable; both concepts will be used in discussing the operation of the circuits to be considered—the choice being one of convenience of explanation.

The response time characterizing the response of a self-saturating magnetic amplifier output to a step change in the control variable depends upon the manner in which resetting is accomplished. If the resetting of a core of a two-core, self-saturating magnetic amplifier is dependent only upon the value of the control variable during that half-cycle in which the core is reset, then the output on a given half-cycle will depend only upon the value of the control variable during the preceding half-cycle. The minimum possible response time, one cycle of the a.c. source frequency, is obtained under these conditions. Assuming that there is no interaction between the two cores of a self-saturating magnetic amplifier through the output circuit, the conditions are fulfilled if resetting is carried out independent of the voltage induced in the control winding of the core proceeding toward firing. Circuits in which this is the case, and which yield one-cycle response, have been described in the literature[3]. In practice, it is found that the assumption of no interaction between the resetting and firing cores through the output circuit is valid for full-wave bridge and center-tap d.c. self-saturating output circuits, but that some interaction takes place in the doubler output circuit. This results in the minimum or residual response time of the doubler circuit being somewhat longer than the one-cycle minimum response time of the other circuits.

Fig. 1. (A) Idealized nonlinear characteristics of a junction transistor. (B) Common base transistor connection.



On the other hand, in the case of conventional self-saturating circuits with low control circuit impedance, a major portion of the resetting is produced by the voltage induced in the control winding of the core proceeding toward firing. Thus, a change in the control voltage produces—in the half cycle following its occurrence—only a relatively small percentage of the ultimate change in reset flux level, and response times far in excess of one cycle of the a.c. source frequency result.

The transistors referred to in this article are of the *p-n-p* junction type; however, the results apply equally well to the *n-p-n* junction type with due regard for polarities, and basically to point-contact transistors as well.

In general, the transistor is considered as a circuit element exhibiting nonlinear characteristics of the type shown idealized in Fig. 1A. Referring to the common base connection of Fig. 1B, the plot gives collector current I_c as a function of collector-to-base voltage V_{cb}, with emitter current I_e as a parameter. These characteristics indicate that if a load is placed in the collector circuit the transistor will function essentially as a controllable constant-current source controlled by the current supplied to the emitter, provided the collector-to-base voltage is maintained between zero and some negative value dictated by the power dissipation capabilities of the transistor (as shown by the dashed line in Fig. 1A). Approximately a one-to-one correspondence is seen to exist between output (collector) and input (emitter) currents; however, the impedance level

*This article is based on a paper presented at the 1953 National Electronics Conference, held in Chicago, Ill., Sept. 28-30.

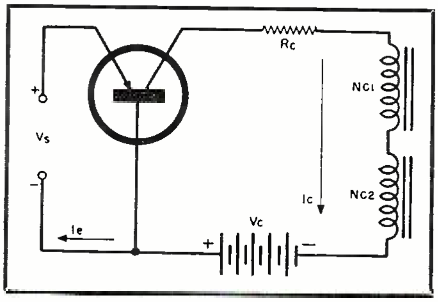


Fig. 2. Transistor preamplifier for magnetic amplifier control windings.

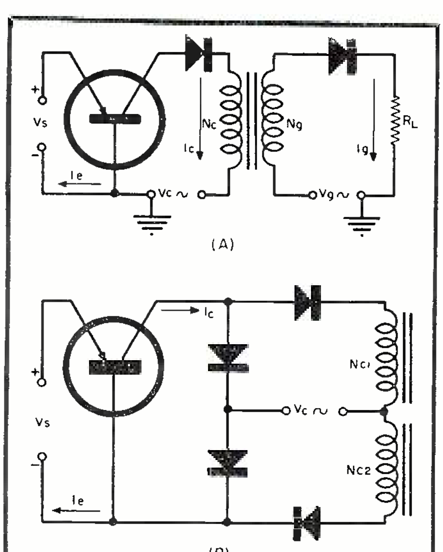
of the emitter circuit is considerably lower than that of the collector circuit, resulting in a net power amplification.

Although the common base transistor connection shown in Fig. 1B is used as the basis for the applications discussed in this report, other connections are possible, and at times are advantageous. For instance, the common emitter connection—in which the signal current is supplied to the base terminal—provides output circuit characteristics quite similar to the common base connection, and is applicable to any of the uses to be described. Input current and power requirements of the common emitter connection are considerably lower than those of the common base connection; however, changes in characteristics with temperature are much more severe.

Methods of Control

An application which is immediately suggested by the power amplification capabilities of the transistor is the use of the transistor as a preamplifier feeding the control windings of a magnetic amplifier as its load, shown in Fig. 2; (only the control windings, N_{c1} and N_{c2}, of the magnetic amplifier are shown since the output circuit may incorporate any of the conventional self-saturating connections). Because of the interdependence of magnetic amplifier input power and response time, the power gain obtained through the transistor preamplifier may be used to achieve any of several desirable effects, depending upon the design of the magnetic amplifier and its control windings:

Fig. 3. (A) Circuit which permits control of magnetic amplifier output by a variable impedance control element. (B) Full-wave version of (A).



1. Input power to the magnetic amplifier for a given signal power may be increased, resulting in a shorter magnetic amplifier response time.
2. Signal power required to obtain a given magnetic amplifier output may be reduced by the amount of the transistor power gain without a corresponding increase in magnetic amplifier response time.
3. A combination of the above two effects may be achieved, i.e., both response time and signal power requirements may be reduced to some degree.

In any case, an increase in over-all figure of merit (power gain/response time) is effected by the insertion of the transistor preamplifier.

The constant-current source or high differential resistance characteristic of the transistor collector circuit has an important effect upon the magnetic amplifier being controlled. Assuming that the transistor operates at all times within the region of its characteristics, as shown in Fig. 1A (the collector-to-base voltage being maintained at less than zero at all times), the control circuit current will have a constant value as determined by the emitter current supplied to the transistor. The flow of induced harmonic currents in the control circuit under this condition is prevented by the high differential resistance of the transistor collector circuit. In the absence of induced current flow, no coupling exists between the two cores of the magnetic amplifier through the control circuit, and the resetting of one core is in no way affected by the induced voltage in the control winding of the other core in its firing half-cycle. Thus, the response time of the magnetic amplifier is the minimum or residual value corresponding to the self-saturating output circuit in use (one cycle of the a.c. source frequency for full-wave bridge and center-tap d.c.-output circuits and somewhat longer for the doubler circuit).

Blocking of induced current flow by the transistor implies that voltages induced in the magnetic amplifier control windings will appear in full across the transistor collector and base terminals superimposed upon the d.c. voltages existing in the circuit. The condition is therefore imposed that induced control-winding voltages, acting in conjunction with the d.c. voltages present, must be of a sufficiently low magnitude that transistor voltage and power dissipation ratings are not exceeded and that the collector-to-base voltage does not go positive. This condition must be given careful consideration in the design of control windings to be fed by the transistor preamplifier.

Use of the transistor preamplifier with the self-saturating magnetic amplifier circuit thus results in a transistor-magnetic amplifier with a response time equal to the residual or minimum response time of the magnetic amplifier but with lower signal power requirements than those of the magnetic amplifier under residual response time conditions. The over-all figure of merit is therefore significantly higher than that of the magnetic amplifier alone.

The transistor control scheme just discussed is a straightforward cascading of two power amplification units with due allowance being made for the active nature of the magnetic amplifier input circuit. A number of less conventional methods of control may be developed if the transistor is considered, not as an amplifier, but rather as a circuit element which may be integrated into the magnetic amplifier circuitry. Two examples will be given of such a utilization of transistors as variable circuit elements for the control of magnetic amplifier output.

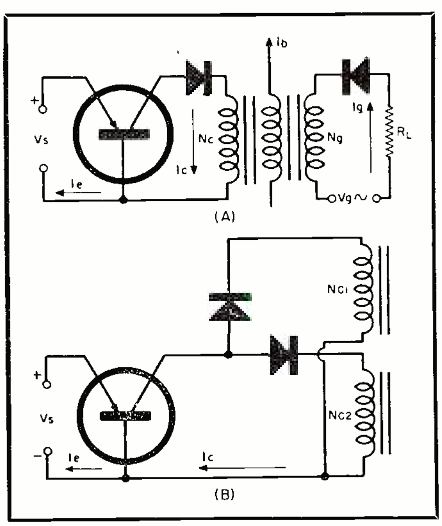
Figure 3A shows, in half-wave form, a circuit which permits control of magnetic amplifier output by a variable impedance control element[5]. The control circuit contains an a.c. voltage source, V_c, of such magnitude and polarity that—with the control element exhibiting its minimum impedance—the core is reset just the amount necessary to prevent firing on the subsequent half-cycle. The rectifier in series with the control circuit serves to prevent the flow of current in this circuit during the firing half-cycle. During the resetting half-cycle of the a.c. source voltage, the voltage drop across this element due to the flow of control-circuit current subtracts from the effectiveness of the control-circuit a.c. voltage source in resetting the core. Thus, by varying the impedance of the control element, the amount of resetting and—hence—the output on the subsequent half-cycle may be controlled. The transistor is admirably suited to this application since the impedance seen between its collector and base terminals is variable between essentially zero and infinity, permitting full control of magnetic amplifier output from cutoff (with zero impedance) to full saturation output (with infinite impedance).

A full-wave circuit using a transistor in this manner is shown in Fig. 3B; as in Fig. 2, only the control windings of the magnetic amplifier are shown. In this circuit, the a.c. voltage source in series with the transistor appears across the control windings of the two cores on alternate half-cycles, the control circuit of the other core being blocked by the rectifier in series with it. The rectifier arrangement is such that the current flow through the transistor is always in the same direction. Control of resetting is exercised, just as in the half-wave circuit above, by the impedance seen between the transistor collector and base terminals varying in accordance with the signal current supplied to the transistor emitter circuit.

As in the case of the transistor preamplifier, the resetting in this circuit proceeds independently of the action of the firing core; the response time is again the minimum or residual value for the output circuit used. The transistor provides a power amplification in this circuit also, since the power controlled by the transistor is greater than that required by the emitter circuit to control it. Consideration of the operation of this circuit and of the transistor preamplifier circuit shows that overall power gains and response times of the two circuits will be very nearly the same for a given magnetic amplifier and transistor.

A different method of utilization of the transistor as a variable impedance element to control magnetic amplifier output is shown in Fig. 4A, again in half-wave form. The core is biased to cutoff by the bias current which is supplied from a stiff current source in order to prevent the flow of induced currents in the bias winding. Polarities are such that—during the firing half cycle of the a.c. source voltage—the voltage induced in the control winding is blocked by the control-circuit rectifier. On the other hand, during the resetting half-cycle, the induced voltage appears across the transistor collector and base terminals. Depending upon the signal current supplied to the emitter, the transistor permits more or less induced current to flow in the control winding during the resetting half-cycle. This current acts as an additional controlling magnetomotive force on the core in a direction opposing the resetting action of the bias magnetomotive force.

Fig. 4. (A) Another method for controlling a magnetic amplifier output by a variable impedance control element. (B) Full-wave version of (A).



In the extreme case of zero emitter current, the transistor exhibits a very high impedance between its base and collector terminals. Thus, the flow of induced current is essentially prevented, and the core resets fully under the action of the bias current. Minimum output results with zero signal.

At the other extreme, if an emitter current is supplied which corresponds to a transistor collector current equal to or slightly greater than the bias current reduced to the control winding turns base, the transistor appears as a very low impedance across the control winding, and induced current flows freely. Under this condition, the core acts as a current transformer during the resetting half-cycle, and a current flows in the control winding approximately equal to and opposite the bias current on a common turns base. The net controlling magnetomotive force is approximately zero, and the core does not reset at all; full output is obtained.

For intermediate values of emitter current, proportional induced currents are permitted to flow; control of resetting—and thus of output—is achieved.

A full-wave control circuit using this method of control is shown in Fig. 4B. Here again, the cores are controlled on alternate half-cycles while the control circuit of the other core is blocked by the rectifier in series with its control winding. As with the methods previously discussed, the over-all response time is the minimum value corresponding to the output circuit used. The power controlled by the transistor and the signal power requirements are approximately the same as in the previous method for a given magnetic amplifier, so that the performance of this method of control is comparable to the first two in all respects.

Experimentation

Figure 5 shows experimental transfer characteristics obtained for the three methods of transistor control applied to a full-wave bridge self-saturating magnetic amplifier with the speci-

Cores: 1" I.D. x 1½" O.D. x ½" tape wound of 2-mil "HIPERNIK V" material
Windings:
gate winding turns—1240
control winding turns—480
bias winding turns—20
Rectifiers:
self-saturating—two 1½"-sq. selenium cells per leg
load—one 1½"-sq. selenium cell per leg
control circuit—1N63 germanium diodes
Load Resistance: 25 ohms
A.C. Supply: 30 volts (r.m.s.), 60 cps

Table 1. Specifications used in obtaining the characteristics of Fig. 5.

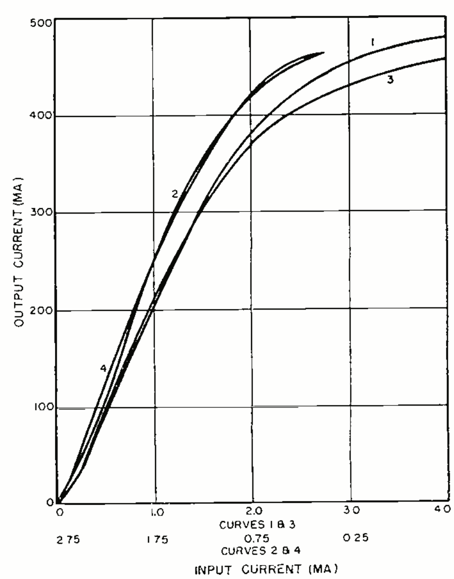
fications given in Table I. The transistor used is a CK-722 *p-n-p* junction type with common base connection.

Curve 1 shows magnetic amplifier output current plotted against transistor emitter input current for the transistor d.c. preamplifier shown in Fig. 2. In this case, the collector d.c. source voltage was 16.5 volts and the total control circuit resistance 4100 ohms. A d.c. bias current of 70 ma. was applied to yield magnetic amplifier cutoff at zero emitter current.

Curve 2 shows similar data for the transistor control scheme of Fig. 3B. For this curve, the emitter input cur-

(Continued on page –30–)

Fig. 5. Experimental transfer characteristics. (1) Magnetic amplifier output vs. emitter input current for Fig. 2. (2) Similar curve for Fig. 3B. (3) Transfer characteristic for Fig. 4B using a 70-ma. bias current. (4) Transfer characteristic of magnetic amplifier with high control circuit impedance.



INTERNATIONAL TELECOMMUNICATIONS VIA V.H.F. RELAYS

By

VICTOR J. NEXON and **WILLIAM S. HALSTEAD**

Microwave Services, Inc. Unitel, Inc.

Part 1. A review of recent findings with respect to propagation of radio waves beyond the horizon at frequencies above 30 mc.

SERIOUS congestion on the limited number of international radio channels at frequencies below 30 mc., the need for speedier and more reliable radiotelephone service between continental areas, and the unstable propagation characteristics of the present high-frequency radio circuits have led to consideration of means by which expansion and improvements in international radio facilities may be attained.

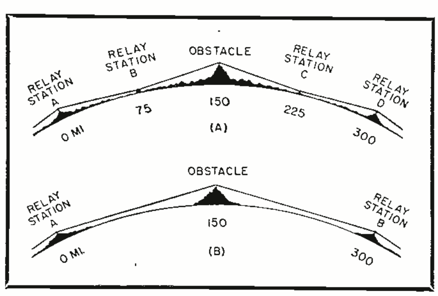
In addition to these important factors, continuing progress in the development of international television and radio broadcasting, superspeed facsimile, and multiplex telephony has presented a basic technical requirement for transmission bandwidths far greater than those available in the existing radio channels at frequencies below 30 mc. Because these advanced communication techniques can become powerful new tools in unifying, strengthening and informing the free world, engineers dealing with international telecommunications are seeking enough radio spectrum space to accommodate these wide-band services.

In the opinion of the authors of this article, the utilization of carrier frequencies above 30 mc. and employment of relay techniques in which concentrated energy is directed along narrow paths in the earth's atmosphere present an effective means with which to meet the expanding requirements of international radiocommunications. With these higher frequencies—ranging upwards from 30 mc. through the v.h.f., u.h.f. and s.h.f. bands—and employment of radio beam propagation methods, a high order of efficiency of radio spectrum utilization is obtained which enables the same frequency allocations to be used in many geographic areas without risk of interference. Moreover, the greater channel widths that are practicable in the v.h.f., u.h.f. and s.h.f. bands permit full utilization of wide-band modulation and multiplex methods of relatively great efficiency and traffic-handling ability.

As an example, a single wide-band v.h.f. channel of modest proportions, having a modulation base-band of 500 kc. and employing a relatively small number of multiplex telephone channels, can carry the equivalent of all of the radiotelephone, telegraph and facsimile traffic now transmitted across the Atlantic by the many short-wave radio stations and cables utilized in overseas services.

Such a system, utilizing a transmission path within the earth's atmosphere, would be relatively free of the interference and distortion now commonly experienced on long-distance radio circuits that utilize ionosphere reflection paths. By employing modulation bandwidths of several megacycles or increasing the number of radio carriers at relay stations, it is possible to provide hundreds of duplex telephone channels and circuits for tone-teletype, facsimile, and international broadcast services—including television on important occasions of international interest.

Fig. 1. Profile of path between v.h.f. relay stations separated by a mountain, illustrating "obstacle-gain" principle.



Basic relay methods which permit wide-band transmission through a large number of stations in a chain extending over continental distances have already demonstrated their practicability and high degree of performance in the *AT&T* microwave relay system between the Atlantic and Pacific coasts. It is logical, in view of the successful operation of the American transcontinental system, to give consideration to the use of similar radio relay principles in the s.h.f., u.h.f., or v.h.f. bands in traversing long distances in areas outside of the United States, where—in many instances—telecommunication facilities are inadequate to meet basic needs of countries with respect to domestic as well as international services.

In this larger world area, where improved telecommunications can do much to expand trade and assist in unifying the free world, a radio relay system can span territory between the principal cities of countries in which wire lines cannot meet present requirements or effectively be maintained or protected. The radio relay systems can, if desired, be integrated with v.h.f. communication facilities—at elevated points strategically located in different regional areas of a country through which the relay chain extends—to serve many important domestic needs while simultaneously serving to carry international traffic between the nation's borders.

In this manner, by combining in a single coordinated system the radio transmission facilities for a number of services, such as domestic and international telephone, telegraph, radio and television broadcasting, mobile and airway communications, and radar, the system becomes economically feasible for countries in which the cost would otherwise remove from consideration the use of radio relay methods.

Location of Relay Link	Airline Distance *(miles)*	Elevation of Stations Above Sea Level *(ft.)*	Frequency *(mc.)*	Antenna (1) Input (2) Gain	Character of Path	Service Facilities
Grasse, France to Calenzana, Corsica	127	1902 1049	97 107	(1) 100 w. (2) 10 db (1) 100 w. (2) 10 db	over water	multichannel telephone (24 carrier channels)
Mt. Cavo, Italy to Mt. Serpeddi, Sardinia	242	3200 3200	40-50 40-50	(1) 500 w. (2) 20 db (1) 1 kw. (2) 20 db	over water	multichannel telephone (48 carrier channels)

Table 1. Characteristics of two v.h.f. relay links using transmission paths beyond the radio horizon.

While the potential of wide-band radio relay at frequencies above 30 mc. and especially above 1000 mc. has been realized in many domestic services in the United States and abroad, the limitations of transmission range of many of these systems within quasi-optical distances have presented many technical and economic problems that have restricted the general application of wide-band relay methods in the international field. The high cost of a wide-band microwave relay system in which average interstation distances of the order of 30 miles are involved, as in typical radio relay systems in the United States, may make it impracticable to consider the utilization of these short-range relay techniques in many areas of the world where communication facilities are inadequate to meet basic needs and where wide-band relay services could be of great value. For this reason, consideration has been given to the use of high power transmitting systems at frequencies in the v.h.f. and u.h.f. bands to span distances of the order of 150 miles or more between relay stations in areas where this would be desirable.

To date, there has been accumulated a considerable amount of measured data that indicates the practicability of v.h.f.-u.h.f. relay systems in which separations between stations of 150-300 miles may be attained by utilization of high transmitter power, high antenna gains, and sensitive receivers. Work conducted by manufacturers, laboratories and users, including reports of the Central Radio Propagation Laboratory[1] and Federal Communications Commission[2], leaves little doubt that useful signals in the v.h.f. and u.h.f. bands can be transmitted over these distances.

As a review of some of the work and the results experienced over "beyond horizon" distances, information will be given on several reports and their conclusions. In addition, data on commercial operating systems will be presented.

Reference is made to a report by Irvin H. Gerks[3], published in the Proceedings of the I.R.E. for November, 1951. Utilizing a 30-kw. transmitter at a carrier frequency of 412 mc., with antenna gains of 28 db at the transmitter and 20 db at the receiver, results were obtained that led to the following partial conclusion at the time: "For communication grade of service, it appears entirely feasible to operate a 100-mile link with low, directional antennas and about 10 kw. of transmitter power with a probability of satisfactory field strength more than 90% of the time. In fact, quite effective use of the scattered wave can be made to a distance of 200 miles."

A further reference is made to a paper by Kenneth Bullington[4] in the Proceedings of the I.R.E. for January, 1953. Various tests were made at 460 mc., 535 mc. and 3710 mc., utilizing high transmitting power and large antennas. The data presented in this paper indicated that median signals received at 300 miles were approximately 65 db to 90 db below free space, depending on the test area and the frequency. A comparison of this data with long-term data accumulated by the FCC—as presented in the Bullington paper—shows similar variations of median received signals with distance, and indicates a received median signal level of approximately 78 db below free space for frequencies from 40 to 300 mc. at 300 miles.

A conclusion is quoted from this report: "Although the signal levels are much higher than was commonly expected, high transmitter power and large antennas are needed to obtain

Table 2. Reports on long-range transmission of television signals over distances up to 330 miles.

Location of Television Transmitting and Receiving Points	Airline Distance *(miles)*	Elevation of Antennas Above (1) Average Terrain (2) Sea Level *(ft.)*	Frequency of Video Carrier *(mc.)*	Power *(ERP, kw.)*	Character of Path	Remarks
KEYL-TV, San Antonio, Texas to XELD-TV, Matamoros, Mexico	254	(1) 450 (2) 1187 (1) 335 (2) 400	77.25 (Ch. 5)	35.2	over land; flat terrain	Programs from KEYL-TV received directly by XELD-TV and retransmitted on schedule*.
KGUL-TV, Galveston, Texas to Brownsville, Texas	300	(1) 550 (2) 608 (1) (2) (approx. 50-100)	199.25 (Ch. 11)	235	over water	Consistent reception of KGUL-TV in Brownsville for 11 days in March, 1953. No multipath distortion noted*.
WBZ-TV, Boston, Mass. to Mt. Washington, N. H. (*Unitel* field studies)	140	(1) 530 (2) 669 (1) 3817 (2) 6346	67.25 (Ch. 4)	100	over land; hilly to mountainous	Excellent TV reception at summit of Mt. Washington. No observable multipath effect or fading. Measured field in excess of 1 mv/m.
WNAC-TV, Boston, Mass. to Mt. Washington, N. H. (*Unitel* field studies)	135	(1) 480 (2) 600 (1) 3817 (2) 6346	175.25 (Ch. 7)	200	over land; hilly to mountainous	Excellent TV reception. No multipath effect noted. Measured field in excess of 1 mv/m.
XEW-TV, Cortez Pass, Mexico City to Aircraft employed in field measurements of *Unitel, Inc.*	330	(1) 5800 (2) 12800 (1) 5900 (2) 6000	187.25 (Ch. 9)	25	over land; mountainous to flat	Television image received at 130 miles. No multipath effect observed. Estimated field strength of 10-20 μv/m.

**Data from Albert Metcalf, Director of XELD-TV, Matamoros, Mexico* reliable voice channels over distances of 200 miles or more. The high-gain antennas needed at both the transmitter and receiver indicate that the most likely application of long-path transmission will be for point-to-point service over difficult terrain."

By utilization of the Bullington data in which a loss of 78 db below the free-space value for a path length of 300 miles at a frequency of 250 mc. is indicated, and assuming a free-space propagation loss of approximately 135 db, it is calculated that the total propagation loss between two isotropic antennas at this distance is 213 db. To offset this loss, a 50-kw. transmitter providing a power level of + 47 dbw, and two paraboloid antennas having diameters of approximately 50 feet giving a combined gain of 58 db, may be utilized to provide a total power level of + 105 dbw. This will provide a resulting input level at the receivers of − 108 dbw, excluding line losses, which is considered to be within the useful range of a typical v.h.f. receiver for satisfactory operation with bandwidths of several megacycles.

If the transmitting station is located at maximum practicable elevation to increase the distance to the region beyond the horizon where the largest propagation losses occur, it is probable that these power requirements may be reduced—as is borne out in practice at many v.h.f. stations where high elevations are commonly employed.

Antennas having the necessary high-gain characteristics in v.h.f. and u.h.f. bands can be constructed, as evidenced by the fact that one company—*RCA*—is now developing a paraboloid antenna of large dimensions which will provide the very substantial amount of effective radiated power required in superoptical transmission paths in the v.h.f. or u.h.f. bands. This antenna is 40 feet in diameter and is designed for use with frequencies from 230 to 500 mc. Its gain is from 26 to 32 db over this range.

Presently available tubes and other components for use in commercial television transmitting equipment have power output ratings up to 50 kw. in the v.h.f. television band and to at least 12 kw. in the u.h.f. television band. Thus, the tools now exist which—when used in combination with high gain antennas—provide megawatts of effective radiated power within the v.h.f. and u.h.f. regions of the radio spectrum below 1000 mc. As an illustration, a wide-band u.h.f. transmitter having a modulation bandwidth of several megacycles, and capable of providing 10 kw. at the input of a paraboloid antenna which has a power gain of 30 db at a carrier frequency of 500 mc., will develop an effective radiated power of 10 megawatts.

In the upper portion of the v.h.f. television band, where transmitters of higher output ratings are practicable at this time, it is possible to provide on a wide-band basis an antenna input power of 50 kw., which—with a paraboloid antenna having a power gain of 30 db—will give an effective radiated power of 50 megawatts.

With this order of effective radiated power, when viewed in the light of available data on u.h.f. and v.h.f. propagation beyond the horizon, reliable operation of relay systems having interstation distances of 200-300 miles on overland or over-water routes appears to be feasible.

When it is realized that a distance of approximately 290 miles represents the greatest over-water hop on projected international relay routes along the island chains that extend between the continents of the world, the ability to accomplish reliable wide-band v.h.f. or

(*Continued on page -37-*)

"OBSTACLE-GAIN" TRANSMISSION

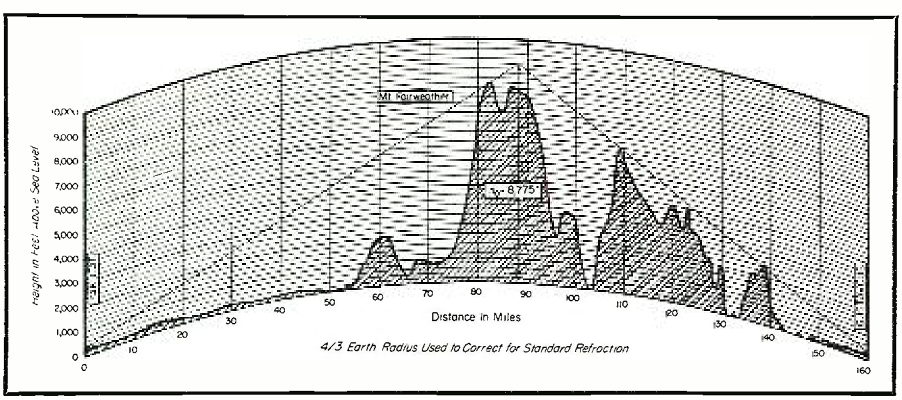
RECENT experiments with long-range v.h.f. transmission in mountainous regions have demonstrated the possibility of utilizing knife-edge obstacles as a means for increasing the received signal energy of television, FM, and military communications. These experiments have verified the "obstacle-gain" theory which predicts the possibility of tremendous power gains for v.h.f. propagation over mountain obstacles. Analyses of the experimental data and interviews with scientists and engineers in the field were conducted jointly by the U. S. Army Signal Corps, the National Bureau of Standards, and *Radio Corporation of America*. Indications are that the disadvantages previously attributed to the transmission of very high frequencies (30 to 100 mc.) among high mountain ridges can actually become powerful aids for reducing both transmission loss and tropospheric fading. The results of these obstacle-gain experiments may have a deciding influence on the future choice of sites for transmitting and booster station installations.

The obstacle-gain theory states that the transmission of very high frequencies over a knife-edge type obstacle should be considered as a four-ray combination of reflection, diffraction, and atmospheric refraction. Thus, if a transmitter and receiver are separated by a mountain, the radio waves would be received by means of the following mechanisms: (1) diffraction at the top of the obstacle; (2) reflection from the ground between the transmitter and the obstacle and then diffraction over the obstacle; (3) diffraction over the obstacle and reflection from the ground between the obstacle and the receiver; and (4) a combination of the two ground reflections with diffraction over the obstacle.

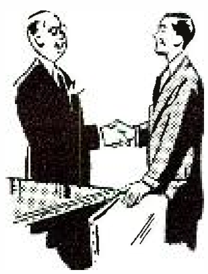
A requirement for the use of the obstacle-gain method for increasing signal strength is that the height of the obstruction must be greater than the elevation of the common horizon. For example, transmission losses will be considerably reduced at 100 mc. if a knife-edge type of obstacle for a 150-mile circuit is at the mid-point of the path and about 1300 feet above the surrounding terrain. Theoretically, these conditions should result in a 30-db decrease in transmission loss over that which would be calculated if the obstacle were not there. The amount of reduction in transmission loss can be varied by different combinations of antenna heights, obstacle heights, and frequency.

One of the obstacle-gain experimental paths examined in detail was a 38-mc., 160-mile communication circuit between Yakutat and Gustavous, Alaska, operated by the Civil Aeronautics Administration. The radio wave transmissions, which originated from and terminated at low-level installations (approximately 200 feet above sea level), passed over a 9000-foot ridge of Mt. Fairweather. On the basis of the existing smooth-earth diffraction theory for an unobstructed path, the calculated transmission loss for the circuit was 207 db. However, on the basis of the four-ray theory and the assumption that Mt. Fairweather acted as a single 8775-foot knife edge, the expected transmission loss was only 127 db. Experimental results showed that the actual transmission loss was approximately 134 db, within 7 db of the value predicted by the knife-edge calculations. The net obstacle gain was 73 db.

Profile of v.h.f. path from Yakutat to Gustavous, Alaska (160 miles).



What means most to an Engineer?



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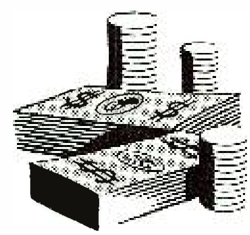

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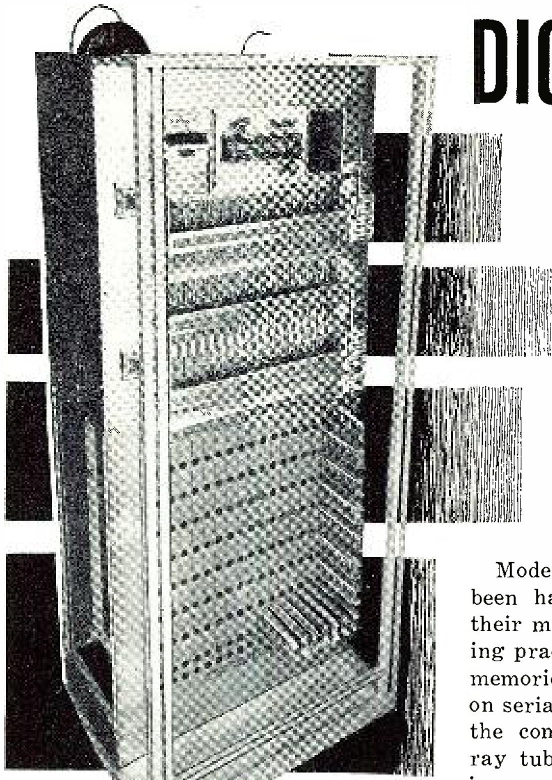


Memory packages are in the lower half of this experimental unit.

DIODE-CAPACITOR MEMORY FOR COMPUTERS

By

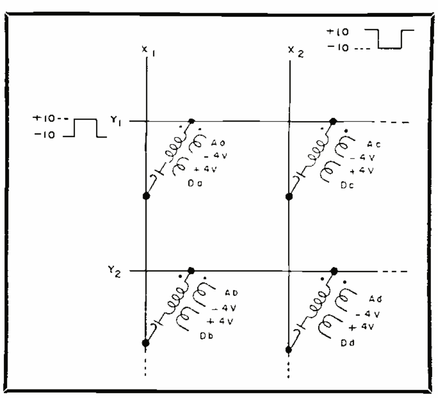
ARTHUR W. HOLT

National Bureau of Standards

This simple, reliable memory provides very short access times for high speed computers.

CONTINUED research on rapid-access memories for high speed electronic computers has resulted in the development of an information storage device utilizing diodes and capacitors as the basic storage units. A recently completed prototype memory based on this idea appears to be faster than any other system; it more than matches the speed of the arithmetic unit used presently in SEAC (National Bureau of Standards Eastern Automatic Computer) and should at the same time, because of its simplicity, be more reliable than other memories now in use. The most difficult part of the basic problem of high speed access was overcome by the development of a selector matrix switch using diodes and transformers.

Fig. 1. Portion of the word selector matrix used in the high speed memory system.



Modern electronic computers have been handicapped by the inability of their memories to attain speeds matching practical arithmetic units. Acoustic memories are slow because they depend on serial presentation of information to the computer. The Williams cathode-ray tube storage system is a distinct improvement because information can be supplied in parallel, but access time is still not small enough to balance the capabilities of possible arithmetic units. The diode-capacitor memory, however, which can be designed to present in excess of 100,000 randomly located 50-digit words per second to the computer, attains a speed corresponding to that of the arithmetic unit—with a resulting decrease in machine computation time for mathematical problems. In contrast, SEAC's acoustic memory has a random access of 6000 words per second while the Williams memory has an access rate of up to 60,000 words per second.

The system developed by NBS uses ordinary linear capacitors as discrete storage elements in a matrix arrangement. These capacitors provide memory by storing one of two voltage states; the charge which gradually leaks away through the associated circuitry is periodically restored. The memory circuit employs two diodes and a capacitor for each digit stored. If properly constructed, this type of memory promises very high reliability, because the minimum signal is of the order of one or two volts and need only be recognized as positive or negative in order to read the information. In the mercury memory and Williams memory schemes, the value of the low-level signal output is critical.

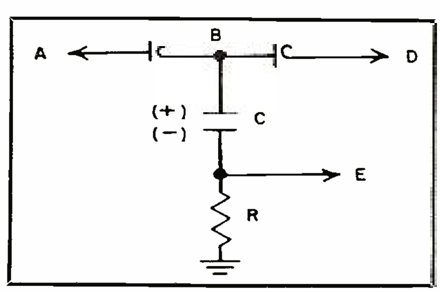
The basic circuit for the storage element is shown in Fig. 2. Point E is used for both reading and writing, while the two diodes are used as a "squeezer" to connect the capacitor to the read-write circuits. During holding, both diodes are biased in their back direction. For example, the anode of one diode might be held at −4 volts while the cathode of the other is held at +4 volts. Then, if the capacitor has a charge of, say, 2 volts, both diodes will be biased in their back direction, and only small currents will flow into or out of the capacitor.

When the ends of the diodes are both forced to ground potential ("squeezed"), one diode or the other will conduct, and a voltage will appear across the resistor. If the capacitor has been charged with 2 volts of such polarity as to make its lower terminal more negative than its upper terminal, there will appear at the output E a pulse of −2 volts, which dies out with the time constant RC. This negative pulse is recognized by the reading circuits at the output as the binary digit "zero." If the polarity on the capacitor had been in the opposite direction, the squeeze would have produced a positive pulse which would be recognized as the binary digit "one." Thus, the content of the storage element has been read; but in the process it has been at least partially discharged, and the information has been lost from the storage element. The information must be rewritten to continue the storage beyond the reading operation.

In order to write (or rewrite) information, it is only necessary to force the point E to the desired state and hold it there until the squeeze is over.

(*Continued on page* -32-)

Fig. 2. Basic circuit of storage element.




PRECISION
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BANTAM BX
CRYSTAL UNIT
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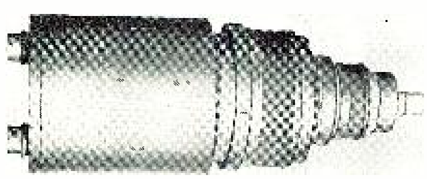
ACTUAL SIZE
BLILEY BANTAM BX
FREQ: 15mc-100mc
The new BANTAM BX has wire leads for mounting in a miniature selector switch or can be soldered to a printed circuit terminal board.
The new BANTAM BX does not sacrifice precision or dependability. It meets same performance and tolerance requirements as larger crystal units such as MIL types CR-23 or CR-32.
The new BANTAM BX is fully described in Bulletin 46. Now available for prototypes or in production quantities.
Bliley CRYSTALS
BLILEY ELECTRIC COMPANY
UNION STATION BLDG., ERIE, PA.

NEW TUBES

TV TETRODE

Gain in excess of 10 and a power output of 25 kw. are features of the GL-6251, a v.h.f. TV tetrode being produced at the Schenectady, N. Y., plant of *General Electric Company's* Tube Department. It is said to be the most powerful transmitting tube able to operate in all v.h.f. channels. Maximum ratings apply up to 220 mc., and only 5 kw. is needed to drive a pair of these tubes.



When used as a class B grounded-grid broadband TV amplifier, the GL-6251 has a useful synchronizing peak-power output of 30 kw. at 220 mc. In narrow-band class C service, the output is 25 kw. of continuous power when the tube is used as an amplifier or oscillator. Because of its ratings, the GL-6251 is also well adapted to dielectric heating equipment.

MINIATURE TWIN TETRODE

Having an over-all length of only $3\frac{1}{16}$" and a $\frac{7}{8}$" diameter, Type 6360 is the newest addition to the *Amperex* line of twin tetrode tubes. It is particularly suitable for low-drain mobile transmitters and multiplier chains, where its ability to increase the power level quickly and to deliver a balanced output makes it ideal for driving higher power and higher frequency push-pull stages.

The *Amperex* 6360 is designed for use as a class C amplifier and oscillator, frequency multiplier and modulator for frequencies up to 200 mc. at maximum ratings, and is capable of delivering 16 watts at 200 mc. under ICAS conditions. For further information, write to *Amperex Electronic Corporation*, 230 Duffy Ave., Hicksville, L. I., N. Y.

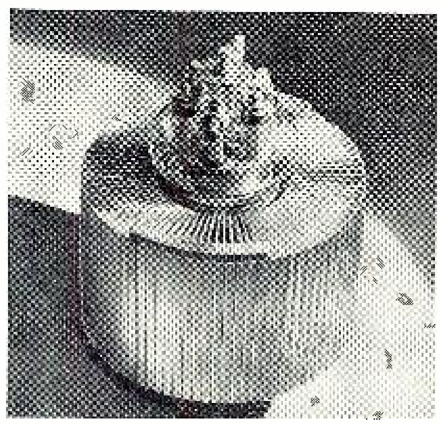
HIGH VACUUM RECTIFIER

Design rating charts and curves which define the performance of *CBS-Hytron's* 5AW4 high vacuum rectifier under a wide variety of operating conditions have been incorporated in a new data sheet on this tube. The data sheet, known as Bulletin #E-205A, is available from the Commercial Engineering Department of *CBS-Hytron*, Danvers, Mass.

A CTS-Rated tube, the 5AW4 was designed to replace the 5U4G; it has electrical characteristics similar to those of the older tube but includes many of the features of transmitting tubes that make for greater reliability and much longer life.

HEAVY-DUTY TRIODE

Machlett Laboratories, Inc., Springdale, Conn., has announced the ML-5531 —a forced-air-cooled heavy-duty triode for industrial and broadcast use. Operating at frequencies up to 30 mc., the ML-5531 meets the need for a single-tube oscillator in 15-kw. output electronic heater service and a single-tube final-stage amplifier in 10-kw. AM broadcast service.



Incorporating a heavy-wall anode, stress-free and self-supporting thoriated tungsten filament, sturdy electrode mountings and kovar seals, the ML-5531 is designed to provide long low-cost operation under rigorous conditions. Maximum ratings include 30-kw. plate input and 10-kw. plate dissipation. The filament operates at 6.3 volts, 92 amperes.

COLOR TV TUBE PRODUCTION

Color TV picture tubes will be available to set manufacturers "in limited quantities" from the *General Electric Company* during the first quarter of 1954. Pilot production of the 15", round, all-glass type, which gives an approximately 12" picture, was scheduled to begin in January.

Using three electron guns and a planar shadow mask for color selection, these tubes are being made at the *G-E* tube plant at Electronics Park, Syracuse, N. Y., and will cost a set manufacturer "about ten times" the price of comparable black-and-white tubes.

RCA TUBES

A half-wave vacuum rectifier, a 21" rectangular glass kinescope, and two "pencil-type" u.h.f. triodes with external plate radiators have been announced by the Tube Department of *Radio Corporation of America*, Harrison, N. J.

Vacuum Rectifier

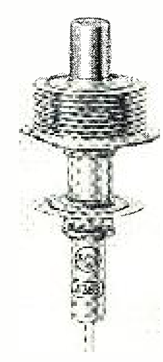
Intended for service as a damper diode in TV receivers, the glass-octal type 6AU4-GT (shown at left) is particularly suited for receivers which utilize picture tubes having 90° deflection. It is rated to withstand a maximum peak inverse plate voltage of 4500 volts, and can supply a maximum peak plate current of 1050 ma.

Kinescope

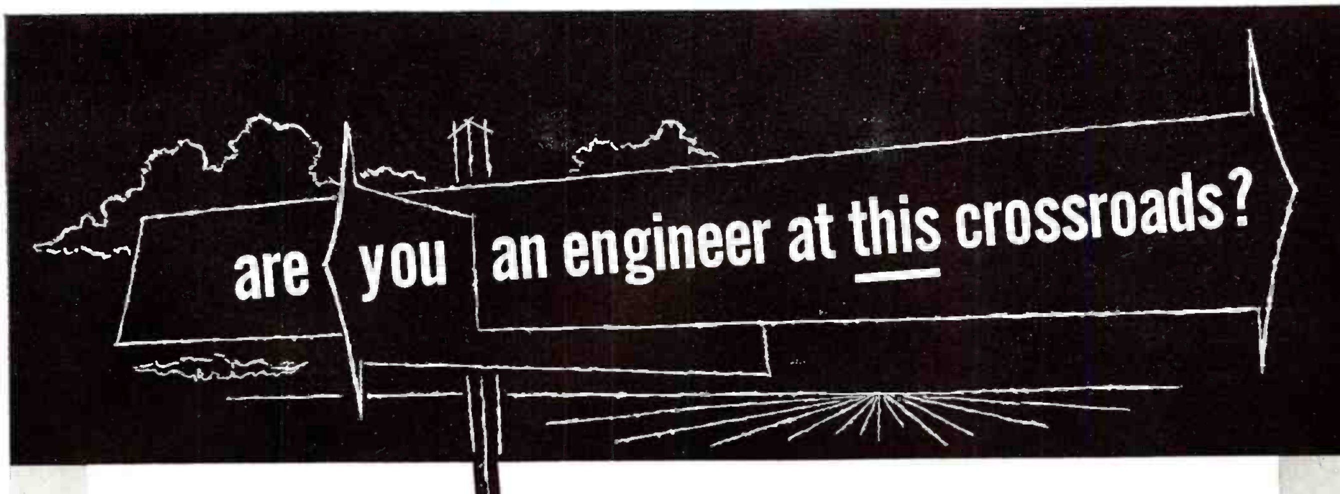
The 21ZP4-A is a rectangular glass picture tube utilizing magnetic focus and magnetic deflection. It has a screen size of $19\frac{1}{8}$" x $14\frac{3}{16}$" with slightly curved sides and rounded corners, spherical Filterglass faceplate, and a diagonal deflection angle of 70°. Other features include an external conductive bulb coating and an ion-trap gun.

"Pencil-Type" Triodes

Designated as the 6263 and 6264, these two u.h.f. tubes are designed for use in low-power mobile transmitters and in aircraft transmitters at altitudes up to 60,000 feet without pressurized chambers. They have a maximum plate dissipation rating of 13 watts (ICAS), and can be operated with full ratings at frequencies up to 500 mc. and with reduced ratings at frequencies as high as 1700 mc.



The 6263 (shown at right) has a μ of 27 and is intended for service as an r.f. power amplifier and c.w. oscillator, while the 6264—with a μ of 40—is primarily a frequency multiplier but may also be used as an r.f. power amplifier and c.w. oscillator.



Never in the history of the electronics industry has it been more important for engineers to choose the right path for their careers to follow.

Everyone has done a lot of military work . . . but now the industry must find new markets in the industrial field!

As a leader in the production of industrial electronic equipment, Westinghouse has the necessary sales, distribution and field engineers organized to enter these new markets. We need research, design and development men to turn out the products. Now is the time to get into our organization, so that you'll be in on the ground floor as the industrial field expands!

Investigate the real future! Salaries at Westinghouse are open, commensurate with experience and ability. In addition to the usual employee benefits, we offer a stimulating patent-award plan and excellent opportunities for advanced study and degrees. Write for information today!

NUCLEAR REACTOR CONTROL ENGINEERS

Duties: Design, development, and application of electronic circuitry including vacuum tubes and magnetic amplifiers as applied to the control of nuclear reactors.

Requirements: Three or more years experience and a B.S. degree in Electrical Engineering or in Physics.

SENIOR RADAR ENGINEERS

Duties: Applied research, development, and design of advanced radar, fire control and missile guidance equipment. Openings exist in the fields of local oscillators and associated circuitry, indicators, feed-back problems (closed-loop electronic circuits), pulsed circuits, video, simulators, i.f. strips, and in analysis of complex radar.

Requirements: Three or more years experience and a B. S. degree in Electrical Engineering or in Physics.

SENIOR COMMUNICATIONS ENGINEERS

Duties: Applied research, development, and design of advanced communications equipment and systems. Openings exist in the fields of automatic transmitters and communications circuitry.

Requirements: Three or more years experience and a B. S. degree in Electrical Engineering or in Physics.

TRANSFORMER DESIGN ENGINEER

Duties: The applied research, development and design of audio transformers, modulation transformers and reactors, electric-wave filters, iron-core radio frequency transformers, radio frequency chokes, etc.

Requirements: Three or more years experience and a B. S. degree in Electrical Engineering or in Physics.

OR if you have experience in the fields of antennas, rf plumbing, magnetic amplifiers, technical writing, or in high frequency heating design and application, please apply.

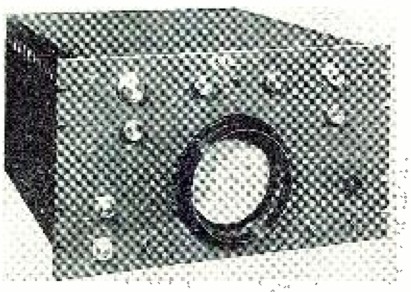
To apply send resume of education and experience to
R. M. Swisher, Jr.
Employment Supervisor, Dept. F—1
Westinghouse Electric Corporation
109 West Lombard Street
Baltimore 1, Maryland

Westinghouse
ELECTRONICS DIVISION
BALTIMORE, MARYLAND

NEW PRODUCTS

CATHODE-RAY INDICATOR

Total writing speeds in excess of 500 cm./μsec. can be obtained with the *SKL* Model 600 cathode-ray indicator when it is used in conjunction with



an *SKL* Model 610 high speed sweep generator. It was designed to utilize the high writing speed capabilities of the type 5XP cathode-ray tube in advanced or special applications.

Single transients having very high writing speeds, such as are found in high tension studies of insulation breakdown, lightning, and extremely short pulses, may be easily displayed. The Model 600 can also be used with high speed cameras to record the waveform and characteristics of transient voltages. For further information, write *Spencer-Kennedy Laboratories, Inc.*, 186 Massachusetts Ave., Cambridge 39, Mass.

POWER OSCILLATOR

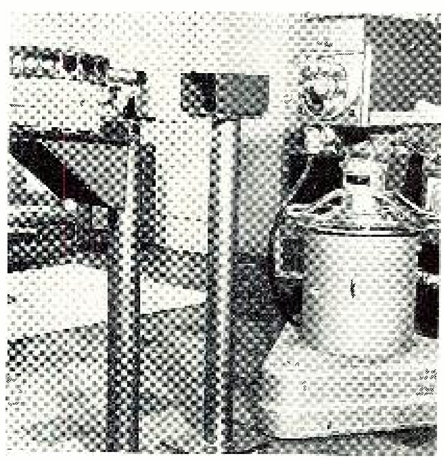
At the flick of a switch, the Model 1040 power oscillator will provide a frequency of either 400 or 1000 cps. Three watts of undistorted power (less

than 1%) are supplied at various output impedance levels by this instrument, which has been introduced by the *Industrial Test Equipment Co.*, 55 East 11th St., New York 3, N. Y.

Frequencies are factory-set to 0.25% and are maintained with high stability even with line voltage variations; a control on the front panel allows for a continuously variable output from 0 to 120 volts. While the Model 1040 is especially useful as a power source for all types of bridges and test setups, an isolated output transformer permits its use in modulation applications.

TV "IMAGE BOX"

Should regular film camera equipment fail, TV stations can televise films and slides on an emergency basis by

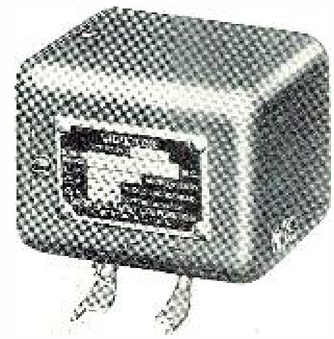


means of a low-cost device announced by *General Electric Company*, Electronics Park, Syracuse, N. Y. Called an "image box," this new device consists of an enclosed, specially ground glass plate developed for *G-E* by the *Bausch and Lomb Optical Company*. Images from films or slides projected upon one side of the glass plate can be picked up from the reverse side by a regular studio camera and relayed to the station's transmitter.

Q-CIRCUIT INDUCTORS

Boonton Radio Corporation, Boonton, N. J., has announced a new line of inductors, Type 590-A, designed for use in the *Q* circuits of this company's *Q* meters Type 170-A and Type 190-A. Available in six types, these inductors are useful for measuring the r.f. characteristics of condensers, resistors, and insulating materials over a frequency range of 20 to 230 mc. They may also be used as reference coils.

Each inductor consists of a high *Q* coil mounted in a shield, and is provided with spade lugs for connection to the coil terminals of the *Q* meters. The shield is connected to the lugs which connect to the low coil terminal

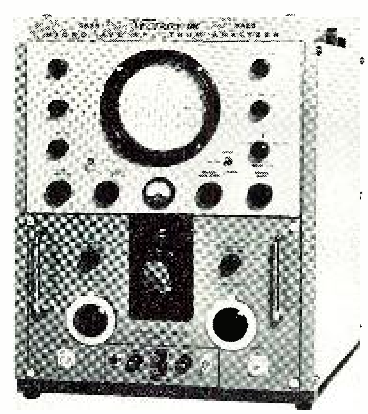


in order to minimize any changes in characteristics caused by stray coupling to elements or to ground.

MICROWAVE SPECTRUM ANALYZER

Vectron, Inc., has announced a new microwave spectrum analyzer with interchangeable r.f. heads—the Model SA25. A "low-noise" 20-kc. bandwidth i.f. strip (50 kc. available) incorporates the latest circuit techniques for higher usable gain and lower noise, and 12 interchangeable microwave r.f. heads are available to provide coverage in specific areas of the microwave band.

The Model SA25 has a double-range sweep, covering 2 to 20 cps (or 6 to 60 cps) in two overlapping ranges, for improved operation with long or short



pulses at low or high repetition rates. Full information and specifications are contained in Bulletin SA25, which may be secured on request from *Vectron, Inc.*, 406 Main St., Waltham 54, Mass.

BROADBAND AMPLIFIER

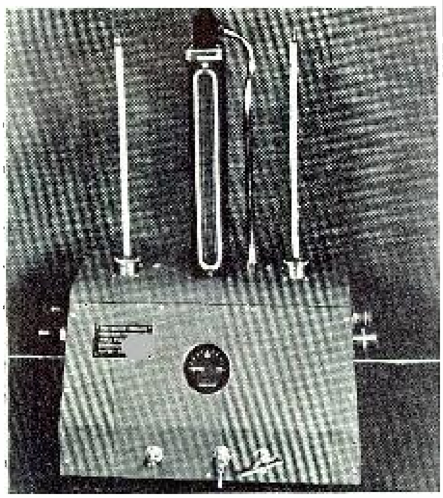
High gain over the 2000 to 4000 mc. frequency range is provided by the

Westlabs Model 24 broadband r.f. amplifier which utilizes a traveling-wave tube. The small-signal gain averages 35 db, and the saturation output power 30 mw. Maximum noise figure is 20 db.

Recently announced by *Westlabs Incorporated*, P. O. Box 1111, Palo Alto, Calif., the Model 24 is completely self-contained, including regulated power supplies and traveling-wave tube focusing structure. It is housed in a case of JAN aircraft equipment dimensions, and is directly usable as either a laboratory tool or a system component.

MICROWAVE CALORIMETER

Sightmaster of California Company, Santee, Calif., has announced an improved microwave calorimeter and dummy load for the measurement and absorption of microwave power of any



magnitude between 500 and 90,000 mc. In addition to outperforming other known calorimeters in accuracy and power/frequency coverage, the new water tap design permits a selling price approximately a quarter that of previous basic units.

Responding to energy levels from a fractional watt to over 50,000 watts average power, this instrument is capable of measuring or absorbing the power of any radar, u.h.f. TV transmitter, microwave relay or communication device, microwave tube, or energy source. As now designed, it weighs only 20 pounds.

CLOSED CIRCUIT TV CAMERA

Measuring 4¼" wide by 6⅛" high, with an over-all length of 9⅛", the Model 50-A is a new and smaller TV closed circuit camera for use in industry, commerce and education. Just announced by the *Dage Electronics Corporation*, this camera weighs only 7½ pounds.

A total of but seven tubes are required for the Model 50-A, and the con-

(*Continued on page* -39-)

NEW LITERATURE

WAVE GUIDE ENGINEERING DATA

Wave guide engineering data and curves are available in a new 20-page booklet which has been published by *Airtron, Inc.* Entitled "Microwave Nomograms and Charts," this booklet represents practical techniques and approaches developed over the years by *Airtron's* engineering staff in designing and using wave guide components such as mixers, duplexers, flexible and rigid wave guides, directional couplers, and allied accessories. It is intended to simplify the day-to-day handling of microwave problems.

Copies may be obtained free of charge by writing directly to *Airtron, Inc.*, Dept. H, Linden, N. J.

MAGNETIC IMPULSE COUNTER

Operating principles and characteristics of the *Kellogg* magnetic impulse counter and typical basic circuits are given in a four-page bulletin issued by the *Kellogg Switchboard and Supply Company*, 79 West Monroe St., Chicago 3, Ill.

The *Kellogg* magnetic impulse counter is a selector switch used to solve many switching or control problems where the intelligence to be registered, stored, and released is supplied in the form of electrical pulses. It has a wide application in the fields of industrial control, computer design, telephone, v.h.f. radio, microwave selective signaling and telemetering.

TUBE CHART

Amperex Electronic Corporation has prepared a chart that shows the rating in power output vs. frequency for *Amperex* power tubes in typical operation. It includes the FCC frequency allocations and associated applications correlated with tube performance.

Coded in color, this comprehensive chart is planned for quick use and easy readability; at a glance, it is possible to find the tube or tubes that will meet the general requirements for practically any r.f. or audio operation. A copy may be obtained free by writing to *Amperex Electronic Corporation*, Hicksville, L. I., N. Y.

ELECTRONIC COMPONENTS

The 1954 edition of the *Alden* Handbook, "Ideas—Techniques—Designs," is packed with new standard components for unitizing electronic equipment. It provides new data and planning sheets on plug-in packages and basic chassis, and describes the latest components for indicating and monitoring the operation of electronic equipment. New models of connectors and interconnecting systems that allow dynamic color-coding for easy circuit tracing have been added.

This booklet is available to manufacturers and designers writing on their respective letterheads to Department HB, *Alden Products Co.*, Brockton, Mass.

CUSTOM-BUILT TV EQUIPMENT

Since no two television stations have the same operating requirements, the equipment needs differ for each installation. Catalog B.30 pictures typical examples of *RCA* custom-built equipment for television, as used by various stations, demonstrating many unique features that may serve as a guide in solving a number of switching and control problems.

A list of basic equipment considerations is also included in this catalog, which is available on request from the Engineering Products Department, *RCA Victor Division*, Camden 2, N. J. Specify Form B.30.

AUDIO AMPLIFIER

Bulletin DB 85-950 describes the new *Westinghouse* Type FG 5 or 10 kw. variable frequency audio amplifier which will amplify 30 to 10,000 cycle signals as much as a million times. Applications are suggested; operation is discussed; design and construction features and complete electrical characteristics are given. For a copy of Bulletin DB 85-950, write to *Westinghouse Electric Corporation*, Box 2099, Pittsburgh 30, Pa.

HYPERBOLIC PROTRACTOR

How to use a hyperbolic protractor is the subject of a 44-page book published by the *International Telephone and Telegraph Corporation*, 67 Broad St., New York 4, N. Y. It is entitled "A Hyperbolic Protractor for Microwave Impedance Measurements and Other Purposes," by G. A. Deschamps, of the *Federal Telecommunication Laboratories*, and includes an actual protractor in its price of $2.50 a copy.

This protractor is used in connection with a projective chart to solve various problems on transmission lines, wave guide junctions, and polarization. The latter part of the book consists of a paper originally given by Mr. Deschamps at the IRE Professional Group Symposium on Microwave Circuitry in 1952 which presents some of the basic properties of this projective chart. The protractor can also be used for the same purpose with the more familiar reflection charts of the Smith or Carter types or with the rectangular impedance plot.

GAGE PRESSURE POTENTIOMETER

Brochure No. 3553, announced by *Bourns Laboratories*, describes the Model 304 miniature gage pressure potentiometer—a sensitive pressure pickup actuated by a miniature Bourdon tube. Photographs illustrate the method of accurately transmitting the movement of the tube to the sliding contact of the wire-wound potentiometer; and diagrams, curves, and charts provide additional technical information.

Write to Dept. NL, *Bourns Laboratories*, 6135 Magnolia Ave., Riverside, Calif., for a copy of this four-page brochure.

ELECTRONIC TEST EQUIPMENT

"Electronic Test Equipment" is the title of a 12-page bulletin just released by *Cal-Tronics Corporation*. In addition to a description of the company, its services and facilities, this bulletin contains eight pages of illustrations and descriptions of various types of test equipment built by *Cal-Tronics*. Equipment covered includes a synchonizer test unit, an electronic control amplifier test unit, a computer systems test unit, and a signal data converter test unit.

Copies of "Electronic Test Equipment" may be had by writing to *Cal-Tronics Corporation*, 11305 Hindry Ave., Los Angeles 45, Calif.

COMMUNITY ANTENNA SYSTEM

Advantages of the *Jerrold* W + K five-channel community antenna system are outlined in a four-page folder issued by the *Jerrold Electronics Corporation*, 26th and Dickinson Sts., Philadelphia 46, Pa. This community system is the first to deliver successfully more than three channels of clear consistent television in an economically practical fashion; the new Model K equipment, which has been added to the original *Jerrold* W system to distribute the two extra channels, is described in detail in the folder.

AUDIO GUIDE

Of special interest to technicians, engineers, designers and servicemen working with audio equipment is the 1954 edition of *Terminal's* "Audio Guide," available from *Terminal Radio Corporation*, 85 Cortlandt St., New York 7, N.Y.

The most complete catalog of its kind, this buying guide contains 130 pages of ready reference to high fidelity audio, communications, and public address sound equipment . . . radio and TV tuners, record changers, recorders and recording equipment, amplifiers, speakers, parts, accessories and cabinets.

ANALOG COMPUTERS

George A. Philbrick Researches, Inc., 230 Congress St., Boston 10, Mass., has reprinted a paper entitled "An Introduction to Analog Computers" in the form of a 24-page illustrated booklet; this paper was presented at the Eighth National Instrumentation Conference in Chicago, Ill., last September by Jerry Roedel, Head of the Computer and Electronics Section of the *Pullman-Standard Car Manufacturing Company*.

The history, classification, and precision of computing devices are discussed, with particular emphasis on analog computers, and consideration is given to the basic elements in the operational amplifier type of analog computer. Photographs of typical installations of this type of computer are included in the booklet.

MAGNETIC TAPE SPLICING

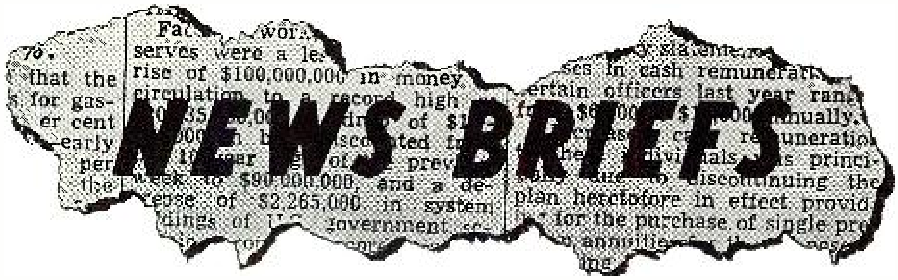
General considerations in magnetic tape splicing are discussed in a three-page bulletin now available on request from *Minnesota Mining and Manufacturing Company*, 900 Fauquier St., St. Paul 6, Minn. Included are solutions to such problems as splice weakness, loss of recorded signal due to poor head contact, and adhesive transfer causing sticky layers.

"Sound Talk" Bulletin No. 26, entitled "Splicing Techniques for Magnetic Tape," also contains detailed instructions for properly splicing magnetic tape for audio recording, as well as information on splicing critical recordings used in computer work and instrumentation.

TWO-WAY RADIO

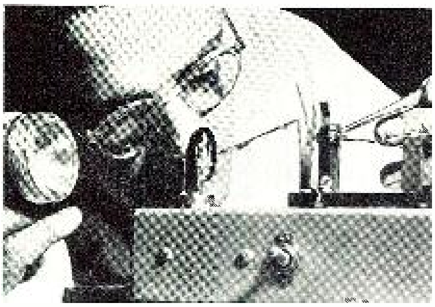
"How to Modernize Your Materials Handling Operations" is the title of a six-page illustrated booklet published by the *General Electric Company* on the use of two-way radio. The booklet relates the ways in which two-way radio can cut costs, improve efficiency, and increase production, and it describes *G-E* equipment now available for a wide variety of applications.

Copies are free on request from the Advertising Inquiry Section, *General Electric Company*, Electronics Park, Syracuse, N. Y.



GERMANIUM PHOTOCELL

Slightly thicker than a pencil lead, and only ⅜" long, the tiny germanium photocell announced by the *General Electric Company*, Schenectady, N. Y., is more sensitive to light than vacuum photo units a hundred times larger. Still in the developmental stage, this cell is so versatile that it can regulate domestic or industrial heating devices



or detect industrial targets for guided missiles. It is shown being tested by Dr. W. C. Dunlap, Jr., the *G-E* Research Laboratory scientist who developed it.

Called a "*p-n* junction photocell," the unit is simple in design: it consists of a metal cartridge housing a glass lens and a germanium wafer in contact with a metallic button of indium, and a whisker links the wafer to an outside lead. Comparatively large power output makes this photocell suitable for operating relays directly to control many production processes, whereas power developed by selenium and vacuum cells has to be amplified before such cells can operate most relays used in industrial controls.

NEWS FROM NARTB

Robert D. Swezey, WDSU-TV, New Orleans, La., has been elected chairman of the NARTB Television Circulation Study Committee. This committee, along with management and research executives of the four TV networks, is conducting a study with regard to a method of measuring the circulation of TV broadcasting in the United States.

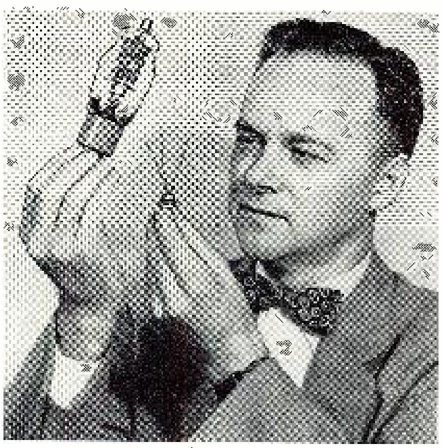
The AM Committee of NARTB has expanded its membership to include representatives of radio networks. NBC will be represented by William H. Fineshriber, Jr., and MBS by Earl M. Johnson. Chairman of the AM Committee is G. Richard Shafto, Station WIS, Columbia, S. C.

For the first time, NARTB will be represented on the Accrediting Committee of the American Council on Education for Journalism. Hugh B. Terry, president and general manager of Stations KLZ and KLZ-TV, Denver, Colo., has been appointed by NARTB to serve on the ACEJ Committee.

POWER-TYPE TRANSISTOR

Held in the left hand of Dr. Finn J. Larsen, research director of the *Minneapolis-Honeywell Regulator Company*, Minneapolis, Minn., is a thimble-size transistor which is 100 times more powerful than present commercially available models. It has the same output as the large vacuum tube shown—20 watts, or enough to operate motors, valves, relays and other equipment previously impossible to operate with transistors.

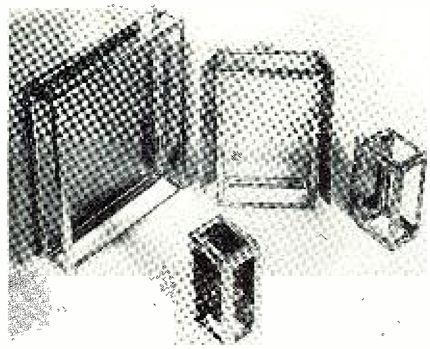
The key to *Minneapolis-Honeywell's* development of this power-type unit was the discovery of an effective means of removing heat from the germanium-alloy junction, the lack of which has hitherto been responsible for the inability of transistors to handle sizable amounts of current. Although the new transistor is not yet in commercial pro-



duction, it has already been incorporated in a prototype aircraft electronic fuel gauge, and may greatly expand the range of transistor uses.

ADAPTABLE ELECTRONIC CHASSIS

In response to the need for a components chassis that would lend itself to varied and changing electronic designs, the National Bureau of Standards has developed a widely adaptable chassis that is both economical and convenient. Its design includes a rectangular frame made of ⅜" x 1/16" steel



angle and sets of flat plates that are fitted to the frame with screws.

Several sizes of the NBS chassis are shown in the photograph. The 3" x 4" x 4" chassis in the foreground illustrates the freedom of accessibility to components in even the smallest model. Other circuits may easily be added by mounting the components on a plate of the proper size and screwing the plate to the frame. For special requirements, plates of a nonconducting material may be used.

ENGINEERS AT IIT

Two additions have been made to the staff of the Armour Research Foundation of Illinois Institute of Technology: Hillard M. Wachowski and Henry F. Schunk have both been appointed as full electrical engineers.

Mr. Wachowski, formerly assistant professor of electrical engineering at Northwestern University, is a specialist in microwaves, field theory, antennas, and electronics. He will work in the communications and radio-frequency applications section of the Foundation's Electrical Engineering Department.

Mr. Schunk, who held the rank of technical engineer at *International Business Machines Corporation*, Poughkeepsie, N. Y., is a specialist in input and output devices for digital computers, and will serve on the Computing Center staff.

SRI EXPANSION

Stanford Research Institute, Palo Alto, Calif., has acquired the facilities of the *Microwave Engineering Co.*, Los Angeles, located at the top of Mount Lee in the Hollywood district. The latter company will henceforth be part of the Engineering Division's Radio Systems Laboratory, and the location will be known as the Mount Lee Laboratory of Stanford Research Institute. Robert Krausz, former vice president and chief engineer for *Microwave Engineering*, has been appointed to head the new SRI operation.

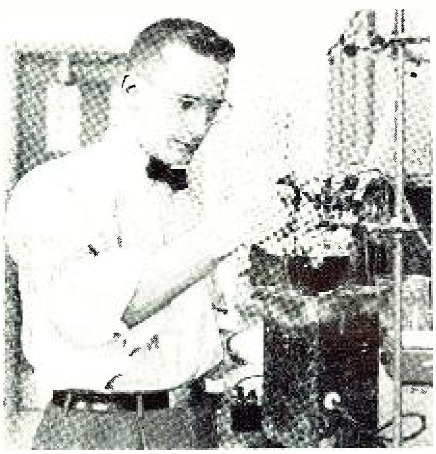
APPOINTMENTS AT G-E

Key appointments in the broadcast equipment unit of the newly formed Commercial Equipment Department in the Electronics Division of *General Electric Company*, Syracuse, N. Y., include those of C. Graydon Lloyd as manager of engineering, Frank P. Barnes as manager of marketing, and Glenn R. Lord as manager of manufacturing.

Mr. Lloyd joined the *Canadian General Electric Company* in 1935, and in 1952 was transferred to the *G-E* Electronics Division where he has been manager of engineering for broadcast equipment. Mr. Barnes, who joined *G-E* at Schenectady in 1937, became sales manager for broadcast equipment in 1950. Mr. Lord has been with *G-E* at Syracuse since 1951, serving in several supervisory manufacturing positions before becoming manager of manufacturing facilities for commercial products.

BATTERY RESEARCH

Dr. Joseph Varimbi has joined the expanding chemical research group of the *Edison Laboratory* of *Thomas A.*



Edison Inc., West Orange, N. J. His major project will be research in the battery field, in which *Edison* has held leadership from the time the laboratory's founder invented batteries as a source of electrical energy.

Dr. Varimbi received his Ph.D in chemistry from the University of Pennsylvania last June on the basis of his thesis on solutions of alkali metals in methylamine.

DU MONT ENGINEERS

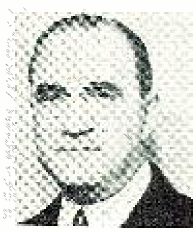
Increased programing and other expanding network activities have resulted in the creation of four additional technical administrative posi-

(*Continued on page -34-*)

Personals

JAMES T. CAMPBELL has been appointed district sales engineer manager for Washington, D. C., by the *Standard Electronics Corporation*, Newark, N. J. In addition to his duties with the FCC and consultants in Washington, he will serve this company's customers in Delaware, Maryland, Virginia and West Virginia. Mr. Campbell comes to his new assignment after 14 years with *Trans World Airlines* in radio communications engineering and sales.

DR. P. S. CHRISTALDI is the new manager of the Instrument Division of *Allen B. Du Mont Laboratories, Inc.*, Clifton, N. J. Associated with *Du Mont* since 1938, Dr. Christaldi was made chief engineer of the company in 1941, engineering manager of the Instrument Division in 1947 and assistant manager of this division in 1952. He holds a Ph.D. degree in physics from Rensselaer Polytechnic Institute, and is a Fellow of the Institute of Radio Engineers.



DR. ALFRED N. GOLDSMITH will be presented the Founders Award by the Institute of Radio Engineers in March "for outstanding contributions to the radio engineering profession through wise and courageous leadership in the planning and administration of technical developments which have greatly increased the impact of electronics on the public welfare." Co-founder of the IRE in 1912, Dr. Goldsmith has served as its editor since that time.

JAMES E. KEISTER, with *General Electric Company* since 1935, has just been appointed manager of engineering of the germanium products unit, Commercial Equipment Department of *G-E's* Electronics Division, Syracuse, N. Y. Mr. Keister served in a number of electronics engineering posts at both Schenectady and Syracuse, principally involving radar and TV transmitting equipment; he has been manager of semiconductor engineering since 1952.

FRANK KREMPEL, formerly assistant chief engineer of *Stewart-Warner Electric*, division of *Stewart-Warner Corporation*, Chicago, Ill., is now engineering head of government development and production contracts in the electronics field. He will direct operations of the Engineering Department in design or development work for Armed Forces contracts and in the modification of current military items to meet changing requirements.

DR. JAMES L. THOMAS has been appointed chief of the newly organized Resistance and Reactance Section of the Electricity Division of the National Bureau of Standards, Washington, D. C. With NBS since 1927, Dr. Thomas has made many contributions to the field of electrical measurements; he developed the special type of precision standard used by most standardizing laboratories for maintaining the unit of electrical resistance.

Transistor Control

(*Continued from page -15-*)

rent is plotted positive to the left and the curve shifted to cause the cutoff point to coincide with that of Curve 1, facilitating comparison of the curves. The control circuit a.c. source voltage used was 12.7 volts (r.m.s.), 60 cps.

Curve 3 is the transfer characteristic for the transistor control scheme of Fig. 4B using a 70-ma. d.c. bias current supplied through 3000 ohms.

Curve 4 shows the transfer characteristics of the magnetic amplifier alone under conditions of very high control circuit impedance, plotted to the same abscissa scale as Curve 2.

Comparison of Curves 1, 2, and 3 shows the similarity of performance between the three schemes. Measurements of emitter input power yield an over-all incremental power gain of approximately 22,000 in all cases. Since the response time is one cycle, the over-all figure of merit is about 22,000. Curve 4 indicates the similarity of these characteristics to the high control circuit impedance transfer characteristic of the magnetic amplifier alone.

Performancewise, there is little difference between the three transistor control schemes presented. In terms of apparatus, the d.c. preamplifier in general requires whatever transformers and rectifiers are necessary to provide the proper collector d.c. voltage supply. The second scheme generally requires a transformer to provide the proper control circuit a.c. voltage and the four control circuit rectifiers; since in this scheme maximum output is obtained with zero signal, some sort of signal biasing means may be necessary. The last method requires only the two control circuit rectifiers; to be sure, a bias current is also needed, but this is usually necessary in any case and no special impedance level is dictated. On the basis of equipment, the latter scheme seems to possess some advantage. In the final analysis, however, each method has features which may make it more applicable to the situation at hand.

Conclusion

Three examples of methods of utilizing the unique characteristics of transistors in the control of magnetic amplifiers have been presented which are intended to illustrate several possible types of applications and their salient features and to point out factors to be considered in these applications. No attempt has been made to provide an exhaustive treatment of possible uses of transistors in magnetic amplifier circuitry, nor should it be implied that the examples given represent optimum methods.

In many cases, because of temperature sensitivity and limitations and because of lack of consistency in characteristics of available transistors, the examples given—as well as numerous other possible applications—may be impractical at present. However, with the advent of improved transistors and more thorough investigation of their operation in magnetic amplifier applications, it is expected that the transistor will become an extremely useful magnetic amplifier circuit component.

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Cast Wave Guides

(*Continued from page -11-*)

used to get the molten metal into the mold.

The production cycle for Sightmastermolds is governed by three primary factors: (1) temperature used to heat the pattern, (2) pattern temperature, and (3) "dwell time," or the time that the hot pattern is immersed in the sand-resin mix before it is removed. The pattern temperature varies with the time that the pattern remains in and out of a heating oven. If oven temperature is 600° F, loading and unloading time is 30 seconds and oven curing time is two minutes, a constant pattern temperature of about 375° F may result. Thickness of the shell is determined by the "dwell time," which varies in practice between 5 and 30 seconds, depending on the mix used, the desired thickness of the shell, degree of pattern heat, etc. Shell molds are cured in an oven one-half to three minutes before being stored for immediate or eventual use. They may be stockpiled until ready for use.

Optimum formulas and techniques to improve wave guides constructed by this process are being developed with the cooperation of tooling, resin and silica firms. The selection of special clay-free washed sands, the use of correct mesh sand coarse enough to permit each grain to be bonded by plastic resin while fine enough to yield a smooth metal surface, shrinkage tables for conditions of operating practice, metal gating and breathing during solidification to eliminate casting voids, parting agents, core removal procedures, etc., are but some of the improvements which have been made.

Diode-Capacitor Memory

(*Continued from page -20-*)

While the ends of the diodes are at zero voltage, assume that E is forced to +2 volts and held there until the diodes are returned to their normal voltages of −4 and +4 volts. Then the capacitor is left with a charge of 2 volts and upon the next squeeze will produce a positive pulse at E, i.e., a "one" will be written. The opposite is equally possible: forcing E negative until the end of the squeeze will write a "zero." Once the diodes have been returned to their normal voltages, the charge on the capacitor will be undisturbed by later changes at E, provided that the magnitude of the voltage at E never exceeds 2 volts. Thus, E can have other pulses on it—either positive or negative—and the charge stored on the capacitor will remain unaffected because both diodes still have backward bias. This is important for organizing many basic storage elements into an efficient memory assembly and is the reason for charging the capacitor to only ±2 volts while biasing the diodes twice as much.

In this description, the diodes have been assumed to be ideal, having practically infinite forward conductance and practically zero backward conductance. The effect of finite forward conductance will reduce somewhat the output pulse amplitude, and it will determine how long a writing pulse must last to charge the capacitor adequately. The effect of finite backward resistance, however, is critical. Relatively long times will elapse during the holding operation, and even minute currents through the diodes would disturb the capacitor charge. The unit would gradually leak toward a condition of no charge on the capacitor or even a condition in which the sign of the charge on the capacitor is reversed. Thus, the permissible duration of the holding operation is determined by the rate at which the capacitor leaks charge through the back currents of the diodes. Arbitrarily long periods of storage of information are achieved by regeneration; before the capacitor charge can change to a point where there is danger of losing the information, the memory control circuits read the content of each cell and rewrite it.

An amplifier is accordingly needed at point E to sense the polarity of E during the early part of the squeeze period, together with a gate structure which will force E to the desired polarity during the latter part of the squeeze period. For reading or regeneration, E is forced to the same polarity that was read; for writing new information, the polarity to which E is forced is independent of what was read, but is determined by the new information being written. Such a gating amplifier is easy to construct. The amplification required is small since the input is a pulse whose amplitude is of the order of one or two volts. Gating can be accomplished with standard techniques, and the circuit can be constructed using two or three vacuum tubes and about a dozen diodes.

In order to achieve acceptable efficiency, it is essential that the gating amplifier serve many basic storage elements. The buses to the diodes are made common to all the digits of a particular computer word, and a particular gating amplifier serves the same digit on each of many words. Thus, for 256 words of 50 binary digits each, there would be 256 pairs of leads to the diodes and 50 gating amplifiers. For reference to a particular word, the proper pair of buses is squeezed to zero voltage, while all the other pairs are held at their normal value of −4 and +4 volts. In this way, each gating amplifier receives a pulse from its particular digit of the selected word, so that the word is available in parallel at the gating amplifiers. These amplifiers can then write into this word or rewrite it without affecting the other words in the memory, since all diodes in other words remain with backward bias. After the squeezing buses on this word are returned to normal, any other word may be referred to in the same way. This is the basis of a fully parallel random-access memory. Regeneration is handled by having the memory control intersperse regeneration cycles—in which the words are read one after the other and rewritten into their former state—between the computer access cycles.

The system described achieves reasonable efficiency for the gating amplifiers but requires a selection circuit capable of squeezing the appropriate pair of buses for a particular word. This could be accomplished by the customary diode matrix, but the usual form of such a matrix requires large standby currents. In this memory, the squeezing buses call for relatively high currents; the resultant diode selection matrix is feasible but not practical because it draws a large amount of standby power. To avoid this, a selection matrix consisting of transformers and diodes is used which has no standby power requirement, although it does require more input drivers than would be necessary with a multidimensional diode matrix. For the "transformer and gate" matrix, developed at the NBS Electronic Computers Laboratory, $2n$ inputs are required to select from n^2 words. The matrix is made up of two sets of crossing buses, X and Y (Fig. 1); at each crossing a diode and transformer primary are connected in series, with the cathode of the diode tied to the X bus. Normally, all of the X buses are held at $+10$ volts and all the Y buses at -10 volts. This puts backward bias on the diodes associated with each transformer, so that normally no current flows through any transformer. If one X bus is dropped to -10 volts, still no current flows; but if one Y bus is simultaneously raised to $+10$ volts, then just one transformer at the crossing of these two buses will receive a signal, the transformer secondaries connected to the diode-capacitor will squeeze the buses together, and the desired word will be selected.

Complete repetition of the extremely simple basic circuit allows a new type of preventive maintenance. If the majority of failures have a single simple cause (low back resistance of a memory diode), a technique can be devised which will rapidly and thoroughly check for marginal diodes by means of a machine program. This routine loads the memory with a known pattern and then slows down the regeneration rate of the memory while checking for errors. Any cell which fails too soon will have its position typed out, and the cell can be replaced in a matter of seconds. The entire program could be run every hour, if necessary, without seriously detracting from computation time. Other types of marginal checks—such as voltage variation—are possible, but the regeneration check seems to be most direct.

The elements of the diode-capacitor system were tested individually. Then a laboratory model was built containing 16 words of four digits each. Several storage tests were successfully carried out with this model in its final form. On five occasions the unit was left running for three-day periods, and on another occasion for one week. It was found to have the correct information at the end of each period.

Results with the laboratory model have been sufficiently promising to justify the construction of a system more nearly approaching a full memory. The prototype unit is designed for a capacity of 256 words of 45 digits each, but a system capable of storing only 128 words of 8 digits has been built as a start. Because the words have only 8 of the customary 45 digits, it is not now possible to operate SEAC exclusively from this trial memory unit. However, since SEAC can operate from both the acoustic and diode-capacitor memories in integrated fashion, it is feasible to do extensive testing of the new memory by using test routines stored in the acoustic memory. With 40 words connected, a test run was carried out for 12 hours without a single memory malfunction.

Error Voltage Detector

(*Continued from page -12-*)

put and output circuits is essential, since a small leak from the r.f. source will greatly reduce the sensitivity. Adequate shielding is provided by milling the main body of the transducer from a block of aluminum. A solid partition between the milled-out cavities reduces r.f. leakage to a minimum, and thick walls furnish a heat sink for the two germanium diodes. Filters used in the circuit are well protected from stray fields of the bridge circuit, making it possible to achieve an unusually good null balance and thus insuring high sensitivity.

The transducer is not limited to a 30-mc. carrier frequency. The general principle is readily adaptable to the use of a u.h.f. carrier and will extend the bandwidth of the instrument if desired. If less bandwidth is required, a lower frequency signal may be utilized with consequent economy of construction.

Use of an r.f. carrier in combination with the transducer containing only passive elements makes multichannel operation unusually attractive with its complete freedom from switching transients. One possible practical scheme involves a rotating r.f. link coupling between a number of transducers and a single amplifier. All moving contacts are avoided, and it is merely necessary to sample synchronously the amplifier output coincident with the positioning of the link coupling. Moreover, this method of multichannel sampling permits the transducer units to be placed near the sources of the signals to be amplified. It is quite practical then to provide coaxial cable connections from the numerous units to a common point where the r.f. commutation into the amplifier is accomplished.

Bridge Transistor Tester

(*Continued from page -7-*)

It will be apparent, therefore, that the measurement of transistor parameters becomes a very simple and straightforward operation when the Type 561-D bridge is utilized. The range of the bridge, as quoted by the *General Radio Company*, enables the measurement of R_{11} and R_{22} values of from 50 ohms to 20 megohms. The α measurement range is 0.002 to 5000. R_{21} values of 100 ohms to greater than 10 megohms can be detected; and for R_{12}, values of from 10 ohms to 10 megohms may be measured. One restriction for the accurate measurement of both α and R_{21} is that the value of R_{11} must not exceed 1000 ohms. Since a fixed resistance (R_E) of 100,000 ohms has been used to describe the input resistance in both the α and R_{21} tests, an effective value of R_{11} of more than 1000 ohms would introduce an error of greater than 1%. As most point-contact transistors exhibit R_{11} values of 200 to 500 ohms, there is little need for concern.

Accuracy of the bridge as quoted by the *General Radio Co.* is ± 2% for the R_p test position for values of from 10^3 to 10^6 ohms. At lower and higher values, the error increases slightly. The expression $\mu = G_m R_p$ will check to ± 2% when the quantities are all measured by the bridge and when R_p is between 1000 ohms and 1 megohm.

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2. *Tuttle, W. N., "Dynamic Measurement of Electron-Tube Coefficients," Proc. I.R.E., Vol.* 21, *June*, 1933, *p.* 844.
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News Briefs

(*Continued from page -29-*)

tions in the Engineering Department of *Du Mont Television Network*, 515 Madison Avenue, New York 22, N. Y. They will be filled from the ranks by men with long experience in the network's technical operations: Michael Stefanik, John Auld, Robert Crossman and Kenneth M. Reichenbach. The four additional positions will enable *Du Mont* to have seven-day-a-week coverage at the top engineering administrative level.

IRE AWARDS

The Vladimir K. Zworykin Television Prize Award for 1954 has been awarded to Mr. Alda V. Bedford, *RCA Laboratories Division*, Princeton, N. J., by the Institute of Radio Engineers "for his contributions to the principle of mixed highs and its application to color television." This award is presented annually to engineers who have made the most important contributions to electronic television.

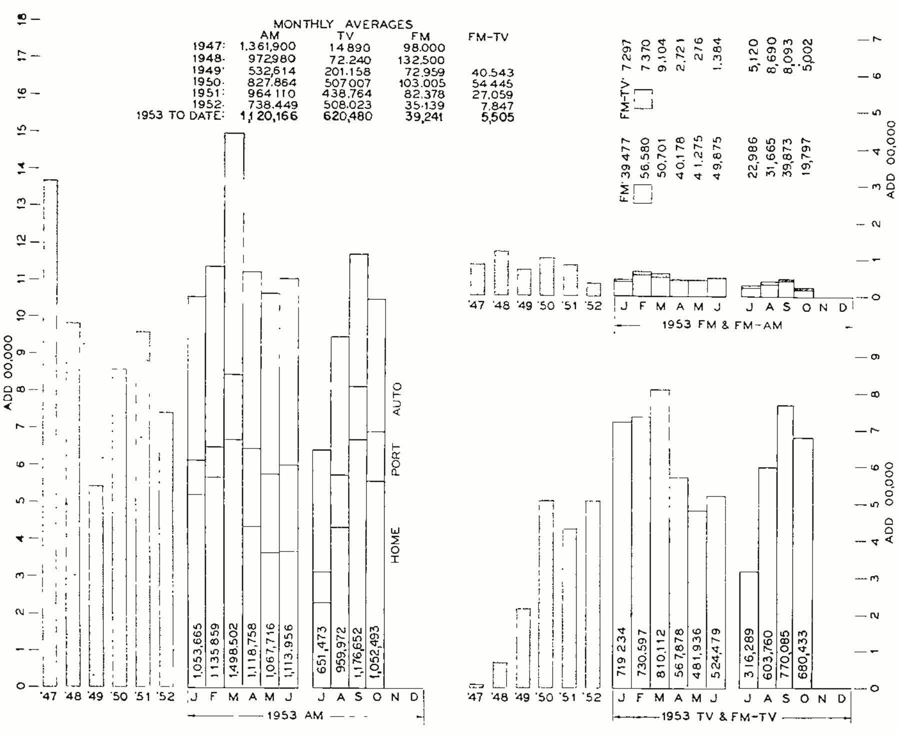
One of the highest awards in the radio engineering field, the Institute's Morris Liebmann Memorial Prize, was bestowed on Dr. Robert R. Warnecke, Technical Director of *Companie Generale de Telegraphie Sans Fil*, Paris, France, "for his many valuable contributions and scientific advancements in the field of electron tubes, and in particular, the magnetron class of traveling-wave tubes."

Dr. Harold A. Zahl, Director of Research, Signal Corps Engineering Labs., Fort Monmouth, N. J., was named the recipient of the Harry Diamond Memorial Award for 1954 "for his technical contributions, his long service, and his leadership in the U. S. Army Signal Corps research program." This award is given annually to persons in government service for outstanding contributions in the field of electronic research.

In addition, 76 radio engineers and scientists have been named Fellows of

TV-AM-FM SET PRODUCTION

Information based on latest reports from RETMA.

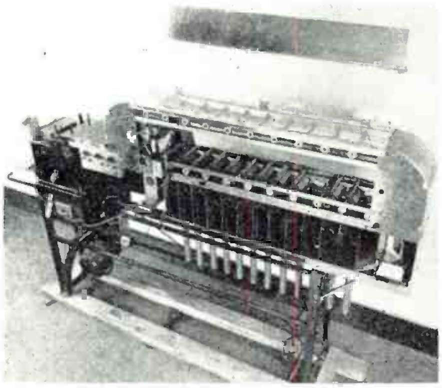


the IRE, the grade of Fellow being the highest membership grade offered by the Institute and bestowed only by invitation on those who have made outstanding contributions to radio engineering or allied fields.

Presentation of all of the above awards will be made at the annual banquet of the Institute of Radio Engineers on March 24, held at the Waldorf-Astoria Hotel, New York, N. Y., during the IRE National Convention.

CONVEYER BELT SORTER

An improved machine for sorting physical objects into a large number of categories has recently been developed by the National Bureau of Standards. Although the NBS conveyer belt sorter was built to sort punched cards at the rate of 420 cards per minute, its principle is also applicable to sorting such objects as mail, electrical and mechanical components, checks, invoices, and even farm produce.



The NBS machine consists of five major components: (1) a sensing unit that reads the data-bearing cards and decides where they should go; (2) an addressing device that loads the conveyer with the cards and their corresponding address numbers; (3) a conveyer belt that carries both the card and its address number; (4) a series of recognition devices, actuated by the information-bearing mechanism of the conveyer belt, which operate trip mechanisms to release the cards from the conveyer; and (5) a series of receptacles, or gates to other devices, into which the material borne by the conveyer is sorted.

TI PLANT EXPANSION

Texas Instruments Incorporated, producer of precision electronic, electromechanical and geophysical equipment, has added 90,000 sq. ft. to its main plant at 6000 Lemmon Avenue, Dallas, Texas. Total plant area is now 200,000 sq. ft., as compared to the 37,000 sq. ft. plant of 1946. An all-day "Open House" was held in November to mark the completion of the expansion program.

Power Line Carrier

(*Continued from page -9-*)

each location. In general, the following procedures are adhered to.

Voice channels are located in the frequency band of 70 to 150 kc., and are spaced ± 10 kc. apart. However, FM transmitters can operate at the same frequency at one location provided that they are coupled to the transmission line through separate couplers. Second harmonics can be serious if common coupling is employed. This condition is somewhat nullified because power amplifiers are now designed so that the second harmonic is 40 db down. The losses through the coupling capacitor and line tuning unit will increase this figure to approximately 50 db.

Telemetering is normally applied to frequencies above 150 kc., with protective relaying of the transmission lines below 70 kc. The general principles involving frequency allocation are flexible, however, and will depend largely on the type of equipment and conditions prevailing at the terminal location.

Impedance and Attenuation

Figure 1 illustrates the equipment line-up for impedance and attenuation tests. Modifications may be made, depending upon circumstances. Tests are performed on energized or de-energized lines. Measurements are conducted by voltage-current or substitution methods. An attempt was made to use an impedance-angle meter, but owing to extraneous voltage pickup, it was set aside.

Typical impedance values for a 100-mile single-circuit transmission line are as follows: phase-to-ground at 100 kc., 330 ohms; phase-to-phase, 370 ohms. The attenuation per mile for the same line was: phase-to-ground, 0.14 db; phase-to-phase, 0.10 db. From these values, it can be seen that the phase-to-phase coupling is preferable for long circuits. However, economy will dictate whether the extra gain is desirable.

Carrier Frequency Noise

The transmitting equipment is selected with adequate power output to insure a good signal-to-noise ratio at the receiving end. Noise in a carrier channel originates in the power line itself. Atmospheric noise is of no importance, and occurs only through lightning strokes on or near a transmission line. Normal noise in a transmission line occurs through current leakage over dirty insulators and loose joints, and the level increases during wet or snow weather conditions. Normally, on fair, dry days, noise levels are barely audible on carrier channels.

Noise may be classified into two categories: random and impulse. Random noise covers a continuous frequency band, with all frequencies at equal amplitudes. This type of noise is distinguished by its characteristic steady hissing sound in the output of a receiver. The r.m.s. value of this type of noise is proportional to the square root of the bandwidth of the receiver, i.e., the value of noise power is proportional to the bandwidth. This is true also for the average and peak amplitudes.

Impulse noise is of greater importance in carrier systems, and its effect is determined by the manner in which it is produced. If the pulses are irregular, and well separated, the frequency band is continuous and the noise will depend slightly on frequency. On the other hand, if the pulses are uniform and regularly spaced, the noise band contains well-defined frequency components that may shock the input stage of a receiver into damped oscillation. Power line noise is a combination of these two types of pulses, and their amplitude values set the criterion of a transmission channel.

No definite standards for quiet or noisy lines have been established. However, tests have revealed certain information that is useful. Noise levels at a receiver input will depend on the operating voltage of the circuit (115 or 230 kv.), and on the type of coupling employed. Noise in the carrier band (50 to 200 kc.) on 115-kv. lines is approximately 70 db below 1 mw. on energized and de-energized lines; the figure is somewhat higher on 230-kv. lines. The phase-to-phase noise voltages are less than the phase-to-ground voltages. On de-energized lines, the noise level decreases linearly with frequency; on energized lines, it increases linearly.

CONSTANT-AMPLITUDE OSCILLATOR

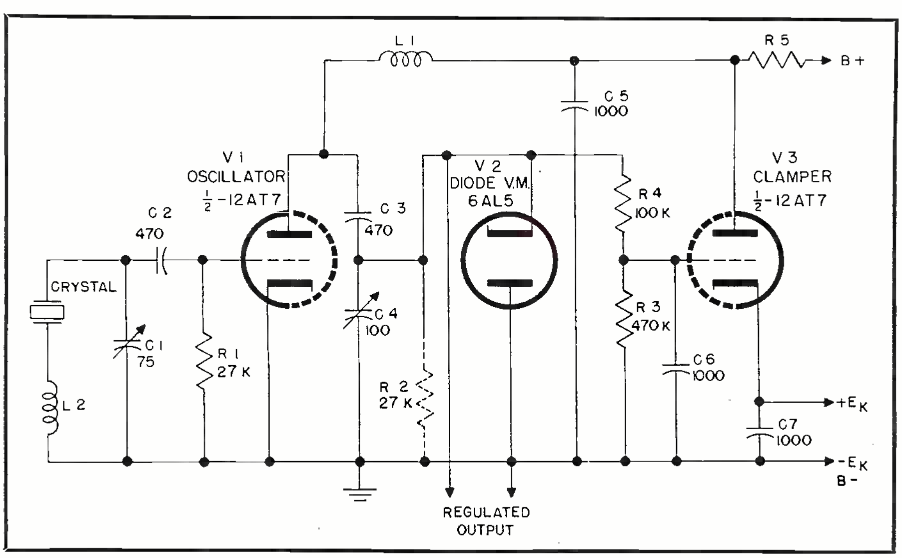
A CONSTANT-AMPLITUDE oscillator, developed by N. C. Hekimian of the National Bureau of Standards, provides an r.f. voltage that remains reasonably stable regardless of changes in tube parameters, supply voltage, heater voltage, or load impedance. This device consists essentially of a conventional oscillator with a diode connected across its output terminals. Output stability is provided by a biased control clamper tube sharing the same plate-dropping resistor with the oscillator.

The circuit is designed to maintain the apparent grid-plate gain of the oscillator reasonably steady. Input and output capacitances are held practically constant, and clipping of the output waveform is reduced to very low levels. The moderate amount of clipping that does occur is due only to the diode detector across the oscillator output.

Originally designed as a fixed-frequency local oscillator in a gain-stable receiver, the device utilizes both sides of a 12AT7 twin-triode as the oscillator and clamper tube, respectively, and a 6AL5 diode detector. The grid tank circuit is composed of a fifth overtone crystal (30 mc.), a frequency-shifting trimmer, and a crystal-peaking coil. A coil in the plate circuit of the oscillator section of the 12AT7 is designed to resonate at the crystal frequency.

The clamper tube is initially biased in the region of plate cutoff. After rectification by the diode, the oscillator output is applied as a positive voltage to the grid of the control tube—the other half of the 12AT7. When the oscillator output voltage reaches a sufficiently high level, the clamper begins to draw plate current and causes a reduction of plate voltage. Because the oscillator is connected to the same plate-dropping resistor, it too suffers a reduction of plate supply. Thus, the tendency of the clamper, as the oscillator output voltage increases, is to maintain the final output voltage at a relatively fixed level.

Circuit diagram and parts values for the constant-amplitude oscillator.



TECHNICAL BOOKS

"COMPLEX VARIABLE THEORY & TRANSFORM CALCULUS" by N. W. McLachlan, D. Sc. (Engineering). Second Edition. Published by Cambridge University Press, American Branch, 32 East 57th St., New York 22, N. Y. 388 pages. $10.00.

Originally published in 1939 under the title "Complex Variable and Operational Calculus with Technical Applications," this book is intended primarily for the mathematical technologist. It provides a modern treatment of the so-called operational method and illustrates its application to problems in various branches of technology.

The volume is divided into four parts: theory of complex variable; theory of transform calculus; technical applications and examples to be worked out by the reader; appendices and list of references. In this second edition, the chapters on complex variable theory have been rewritten, amplified, and made rigorous enough for all but the pure mathematician. The rest of the book has been revised completely and brought up to date, the number and variety of the examples to be worked out by the reader has been increased, and the reference list has been extended.

"TELEVISION RECEIVER DESIGN—Monograph 2—Flywheel Synchronization of Saw-Tooth Generators" by P. A. Neeteson. Published by *N. V. Philips' Gloeilampenfabrieken*, Eindhoven, Holland. Distributed in the United States by *Elsevier Press Inc.*, 155 East 82nd St., New York 28, N. Y. 156 pages. $4.50.

Part VIIIB in the Philips Technical Library series of books on electronic valves, this monograph gives an analysis of the flywheel action of resonant circuits, a study of automatic phase control, and a discussion of practical circuits. It is the second in the series which deals with the subject of television receiver design.

In addition to providing a comprehensive treatment of the principles governing the action of flywheel synchronizing circuits, Part VIIIB includes an elementary discussion which serves as an introduction to the subject for those not fully acquainted with the generation of saw-tooth voltages and currents. A number of practical applications are given, as well as a survey on a number of electronic valves which have been specially developed for use in these saw-tooth generator circuits.

Telecommunications

(*Continued from page -18-*)

u.h.f. transmission in paths within the earth's atmosphere over this distance becomes a matter of considerable significance from the viewpoint of future international telecommunication in all of its forms.

In addition to the use of high power in the u.h.f. and v.h.f. bands as a means of increasing the range of relay stations in sparsely settled geographic areas outside of the United States where this is necessary or desirable, advantage may also be taken of the principle of "obstacle gain" in mountainous country in order to extend transmission range further.

In this propagation technique, use is made of the knife-edge ridge of a mountain located between transmitting and receiving stations and extending well above the horizon of both the stations (as illustrated in Fig. 1A) to increase the interstation distance greatly or reduce power requirements. By this method, measured "obstacle gains" of 73 db greater than the field strength to be expected over a smooth spherical earth have been reported recently by Dickson, Egli, Herbstreit and Wickizer[5] in the Proceedings of the I.R.E., August, 1953. This transmission principle, which promises to be of considerable aid in applying radio relay methods in the international field, also is important because of the relatively small amount of fading that has been found to exist in v.h.f. communication circuits where the "obstacle-gain" effect has been utilized. In one instance, reported in the paper to which reference has been made, for a period of 30 days recordings of v.h.f. signals received over an obstructed path between two stations 160 miles apart showed that the instantaneous transmission loss varied from its mean value by less than ± 2 db.

By employing the "obstacle-gain" principle and placing relay stations at strategically located mountain sites, transmission range between relay stations may further be increased (as indicated in Fig. 1B). By this combination of techniques, which appears to be of particular significance on international relay routes where it may be desirable or necessary to integrate radar and omnidirectional v.h.f. communication services at selected elevated points to obtain maximum range, the transmission range with a given amount of effective radiated power can be substantially extended as compared with a relay system in which stations are at relatively low elevation (Fig. 1A).

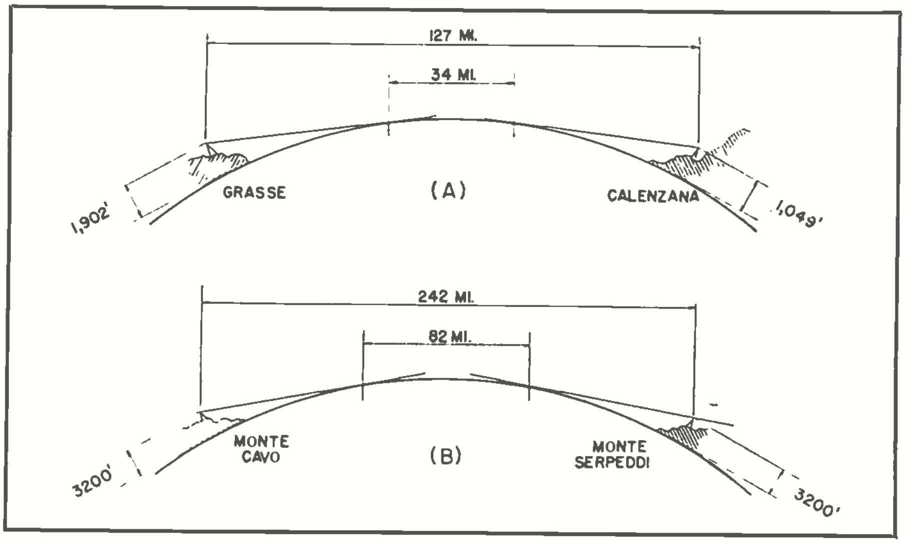


Fig. 2. Profile of v.h.f. relays using transmission paths beyond radio horizon.

Operational Data

In order to provide evidence of the practicability of wide-band v.h.f. transmitting systems now in operation over superoptical paths, data has been assembled as shown in Tables 1 and 2. Referring to Table 1 and Fig. 2A, the wide-band v.h.f. system between Grasse, France, and Calenzana, Corsica, utilizing an over-water transmission path of 127 miles between stations (as shown in Fig. 2A) provides 24 carrier telephone channels in each direction, utilizing two r.f. carrier frequencies. Employing 100-watt transmitters at each end of the circuit, with effective antenna gain of 10 db at operating frequencies of 97 and 107 mc. at the two stations—which are located at elevations of 1902 feet and 1049 feet above sea level, it is reported that measured signal-to-noise ratio in the telephone channels is about 60 db under normal operating conditions[6]. It is stated that fading limits are such that they can be accommodated by the equipment and do not present an operational problem.

Another v.h.f. wide-band system now operating between Mt. Cavo, Italy, and Mt. Serpeddi, Sardinia (shown in Fig. 2B), employs an over-water path of 242 miles between stations which are located at elevations of approximately 3200 feet at each end of the circuit. It is stated that the system accommodates 48 carrier telephone channels in each direction, and provides a signal-to-noise ratio in excess of 50 db. It is understood that transmitting equipment has a power output rating of approximately 500 watts, with antenna gain of about 20 db. Operation is reported to be satisfactory.

In addition to the data based on experience with operation of these two wide-band v.h.f. systems over superoptical distances, reports on long-range transmission of television signals over distances of 250 miles have been received from Texas (as summarized in Table 2). The reports of consistent reception of KGUL-TV, Galveston, at Brownsville, Texas, for a period of 11 days during the initial operating period of the station are significant, as the transmission path in this instance is predominantly over water. An effective radiated power of 235 kw. was employed at the transmitting station, at a video frequency of 199.25 mc. Standard television broadcast receivers were employed throughout the Brownsville area in receiving the programs from Galveston. Quality of the television image and sound was reported to be comparable to that of a local station at Matamoros, Mexico.

In field studies of long-range v.h.f. transmission conducted by *Unitel, Inc.*, additional data has been assembled (as shown in Table 2) to indicate further that signal intensities adequate for reception of television images with commercial television broadcast receivers have been observed at points located at distances up to 330 miles from the transmitter. No multipath effect was noted at these superoptical distances, and in each case a directional antenna —positioned toward the horizon in the direction of the transmitter—was employed at the receiving point. These two factors indicate that the propagation path was predominantly within the earth's atmosphere, and that the signals arrived at the receiver by normal atmospheric refraction and—to a varying degree, dependent on the terrain—by diffraction caused by obstacles in the transmission path. On v.h.f. transmission paths over water or over land up to distances of 300 miles, it would appear that problems due to multipath effects should be minor compared with those experienced at lower frequencies in transmission systems in which dependence is placed on reflection of wave energy from the ionosphere.

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2. *Fine, H., and Higgins, F. V., "Long Distance Tropospheric Propagation in the Ultra High Frequency Band* 288-700," *Federal Communications Commission T.R.R. Report No.* 2.4.10, *October* 13, 1950.
3. *Gerks, Irvin H., "Propagation at* 412 *megacycles from a High-Power Transmitter." Proc. I.R.E.. Vol.* 39, *No.* 11, *November*, 1951, *pp.* 1374-1382.
4. *Bullington, Kenneth. "Radio Transmission Beyond the Horizon in the* 40 *to* 4,000 *mc Band," Proc. I.R.E., Vol.* 41, *No.* 8, *January*, 1953, *pp.* 132-135.
5. *Dickson, F. H., Egli, J. J., Herbstreit, J. W., Wickizer, G. W., "Large Reductions of VHF Transmission Loss and Fading by the Presence of a Mountain Obstacle in Beyond-Line-of-Sight Paths," Proc. I.R.E., Vol.* 41, *No.* 8, *August.* 1953, *pp.* 967-969.
6. *Rivère, P., "La Liaison Radiotéléphonique Multiplex Continent-Corse," Annales de Radioelectricite, Vol.* III, *No.* 13, *July*, 1948.

(*To be continued*)

CALENDAR
of Coming Events

JANUARY 27—IRE - IAS - ION - RTCA Conference on Electronics in Aviation, Hotel Astor, New York, N. Y.

FEBRUARY 4-6—Sixth Southwestern Conference and Electronics Show, Tulsa, Okla.

FEBRUARY 4-6—"1954 Audio Fair—Los Angeles," Alexandria Hotel, Los Angeles, Calif.

MARCH 22-25—Radio Engineering Show and IRE National Convention, Kingsbridge Armory and Waldorf-Astoria Hotel, New York, N. Y.

APRIL 24—Annual Spring Technical Conference of the Cincinnati Section, IRE, Engineering Societies Bldg., Cincinnati, Ohio.

MAY 3-7—Society of Motion Picture and Television Engineers, 75th Annual Convention, Hotel Statler, Washington, D. C.

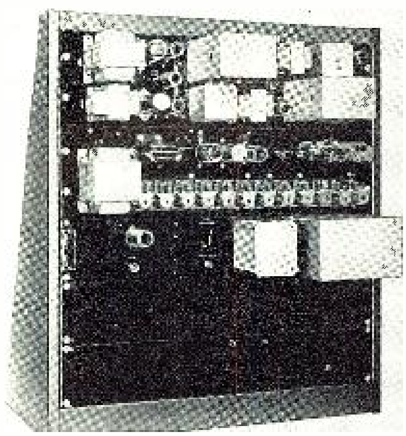
New Products

(*Continued from page -25-*)

servative design and small number of components provide for a minimum of maintenance. Only two controls are required, plus the "on-off" switch. For full details, specifications, and application information, write *Dage Electronics Corporation*, 69 North 2nd St., Beech Grove, Ind.

REMOTE CONTROL SYSTEM

Equipment for the remote control of transmitters and receivers used for air-ground communications has been introduced by the *Hammarlund Manufacturing Co., Inc.*, 460 West 34th St.,



New York 1, N. Y. Using tones in the a.f. spectrum and eliminating the need for d.c. circuitry, the remote control system is intended for installation both at airports and along the air routes.

The system requires only a single telephone line having conventional voice characteristics to carry all the standard operations needed for rapid switching between transmitter and receiver, and for switching between equipment groups to cover the various frequency channels. A high frequency radio signal or a microwave link are equally suitable as transmission media. Multiple telephone circuits are no longer necessary.

POWER METER

A new type of power meter is available from *Polarad Electronics Corporation* which measures r.m.s. power over the d.c. through X-band frequency range without the need for frequency-limited bolometer mounts. Incorporating a power sensitive element that does not utilize a hot wire barretter or other delicate components, this instrument can withstand 150% overload without burnout or other ill effects.

The *Polarad* power meter is completely self-contained as it employs a single power probe for all frequencies. One terminal of the probe is connected permanently to the meter, while the other terminal is fastened directly to the equipment under test, thus avoiding the errors involved in the use of r.f. connecting cables. For complete information, write to *Polarad Electronics Corporation*, 100 Metropolitan Avenue, Brooklyn 11, N. Y.

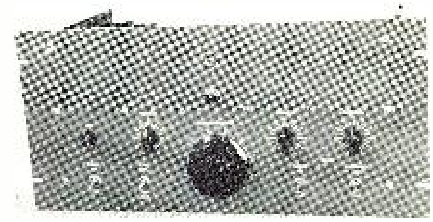
TAPPED DELAY LINES

Excellent transient response is featured in the wideband tapped delay lines introduced by *Advance Electronics Co., Inc.*, P. O. Box 394, Passaic, N. J. In addition, light weight, small size, and hermetically sealed construction make these delay lines particularly suitable for use in electronic circuits. They are available in six different types, with various time delays.

A unit of tapped delay line consists of ten sections of *m*-derived networks, and a capacitor with one-half the normal shunted capacity is connected at each end of a network. Each section is designed to give linear phase shift beyond 70% of the cutoff frequency, and to give a frequency response curve approaching Gaussian in shape. Thus, both the rise time and overshoot of the tapped delay lines are much smaller than any other lines having equal time delay.

"MONITRAN"

The "Monitran," a low-powered r.f. TV transmitter designed to meet broadcasting station monitoring needs, is



now available from the Broadcast Equipment Section of the Engineering Products Department, *RCA Victor Division*, Camden, N. J. Consisting of a 12-channel crystal-controlled oscillator, frequency multiplier, and amplifier turret, the "Monitran" develops both a picture and a sound carrier on any one of the v.h.f. channels.

Several units can be employed simultaneously on different channels to provide a selection of signals at TV monitor receivers by tying their outputs together with an inexpensive resistor matching network.

CORRECTION NOTICE

There were two omissions in the circuit diagram, Fig. 2, of the article entitled "Constant-Output Broadcast Amplifier" which appeared in the November, 1953, issue. There should be a connection from the junction of C_6 and R_{16} to the bottom end of R_{19}, and from the junction of C_{10} and R_{18} to the bottom end of R_{20}.

PHOTO CREDITS

PAGE	CREDIT
-5-	Sylvania Elec. Prod. Inc.
-9- (top & ctr.)	General Electric Co.
-10-, -11-	Sightmaster of Calif. Co.
-12-, -20-	Nat. Bureau of Standards

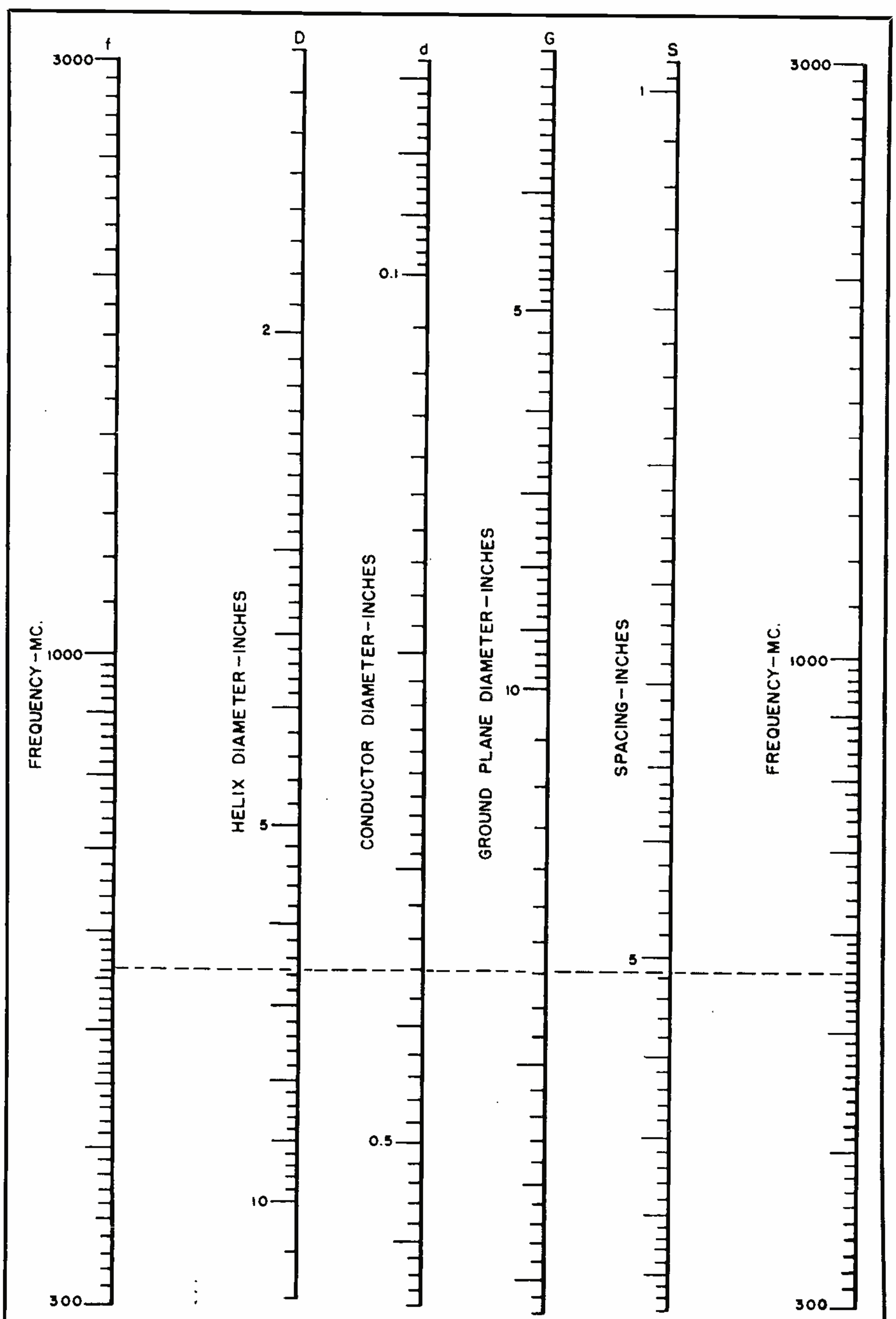
HELICAL ANTENNA DESIGN

By

JOSEPH SODARO

Nomograph for determining the optimum dimensions of a six-turn helical antenna at various frequencies.

Fig. 1. The nomograph. Symbols are identified in Fig. 2.



A HELICAL ANTENNA can be used with vertically, horizontally, or circularly polarized radiation. In some cases, it covers a frequency range as high as 2 to 1, with nearly maximum gain throughout the entire range[1]. More than 10-db gain has been measured with this type of antenna[2]. It is well suited for the u.h.f. TV band as well as for v.h.f. and s.h.f. regions.

Basic construction of a helical antenna is shown in Fig. 2. Dimensions to be determined include the helix diameter D, spacing between turns S, conductor diameter d, distance to the first turn g, over-all length l, and ground plane diameter G.

Investigation has shown that an optimum helix consists of six turns with a winding pitch of 14 degrees[1]. Furthermore, a helix circumference of the order of one wavelength is required. Dimensions for this type of helical antenna can be obtained from the nomograph shown in Fig. 1. To use this nomograph, the center operating frequency is located on both f scales and a straightedge or ruler placed through these two points. Dimensions D, d, G, and S are read at the intersection of the straightedge with the corresponding scales. The value of g is $S/2$, while the value of l is $6S + g$.

For example, assume that a u.h.f. antenna is to be designed with the center frequency at 560 mc. The 560-mc. point should be located on both f scales and a straightedge placed through these points. Dimensions are then read at the respective intersections as follows: $D = 6.55''$, $d = 0.362''$, $G = 16.8''$, and $S = 5.13''$. The value of g is $S/2$, or 2.57″, while the over-all helix length is $6 \times 5.13'' + 2.57''$, or 33.4″.

The frequency range can be extended by multiplying or dividing the f scales by 10; the opposite operation is performed on the answer scales.

REFERENCES:

1. *Kraus, J. D., "A Helix Theorem," Proc. IRE, May,* 1951, *p.* 563.
2. *Kraus, J. D., "Helical Beam Antennas for Wide-Band Applications," Proc. IRE, Oct.,* 1948, *pp.* 1236-1242.

Fig. 2. Identification of symbols.