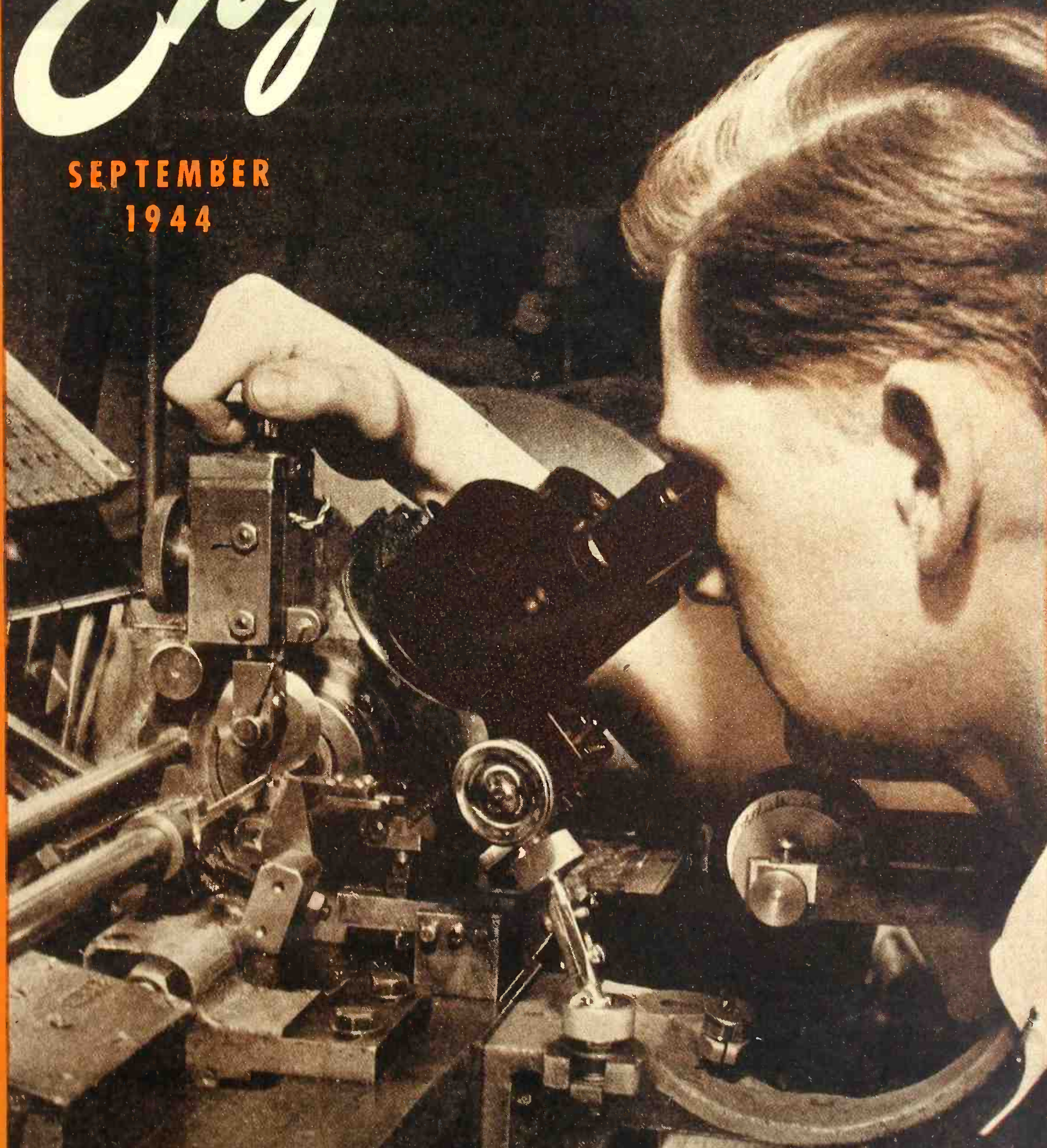
RADIO NEWS

RADIO-ELECTRONIC *Engineering* DEPARTMENT

SEPTEMBER 1944



TELEVISION ★ RADAR ★ ELECTRONICS ★ RESEARCH

COMMUNICATIONS ★ MAINTENANCE

RADIO NEWS

RADIO-ELECTRONIC Engineering

DEPARTMENT

"Reg. U. S. Pat. Off." (pending)

ELECTRONICS • COMMUNICATIONS • TELEVISION • RESEARCH • MAINTENANCE

SEPTEMBER, 1944

DEPARTMENTS

RADIO-ELECTRONIC ENGINEERING is published each month as a special edition in a limited number of copies of RADIO NEWS, by the Ziff-Davis Publishing Company, 540 N. Michigan Avenue, Chicago 11, Ill.

VOLUME 3 NUMBER 3

Cover Photo—By HYTRON CORPORATION

The microscopic setup of a grid-winding machine used in the manufacture of precision tubes. The microscope is used because the spaces between the grid wires are of the order of one ten-thousandth of an inch.

The manufacture of WIRE MOUNTED CRYSTAL UNITS

Quartz crystal plate previous to spotting and silver-plating.

Examining raw quartz under polarized light in the inspectoscope for determination of Z axis.

By R. S. CALLVERT
Hawthorne Works, Western Electric Co.

The steps in the manufacture of crystals mounted by means of wires.

IN ANY future history of the nation's wartime industrial record, it now seems probable that at least one chapter will be devoted to the phenomenal development and expansion of the quartz crystal industry, and to its contribution in the field of military communications.

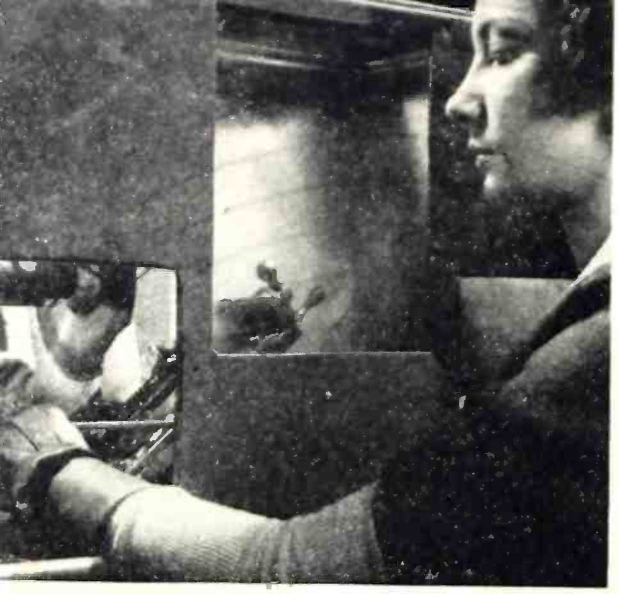
The industry is new. As recently as 1925 quartz was still used primarily for ornamentation, and to a small extent for lenses and prisms. Only within the last decade has quartz found extensive application in carrier telephony and in commercial radio broadcasting. Its use in range finders, seismographs, chronometers and in ultrasonic equipment is of still more recent date.

Before the war the relatively small demand for quartz oscillator plates was filled by a few manufacturers whose product was essentially "hand-tailored" under laboratory conditions. The war changed the entire picture. During the year following Pearl Harbor military requirements for crystal units were multiplied again and again, and it was recently estimated that the entire industry has expanded 200 times.

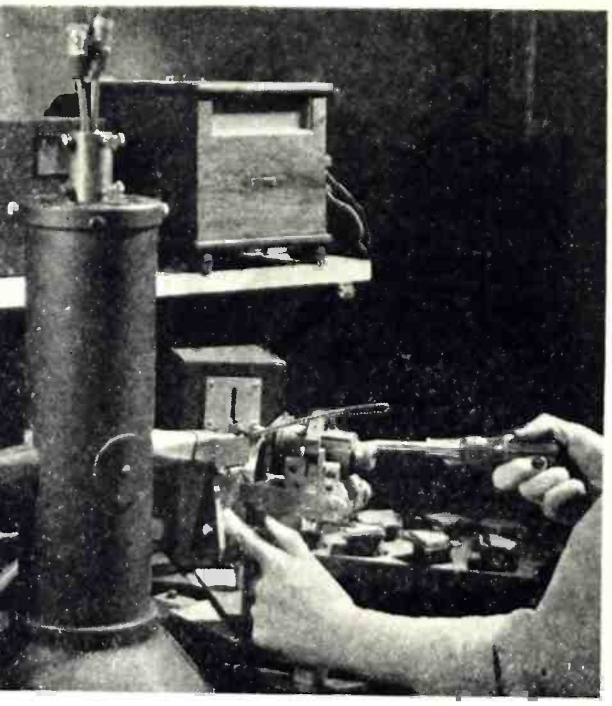
Much of the research, design and development in the fabrication of quartz oscillator and filter plates has been conducted by the Bell Telephone Laboratories, and one of the largest manufacturers of crystal units has been the Bell System's peacetime supplier, the Western Electric Company. Mass production of crystal units to fill military needs was initiated in their shops during the pre-war National Defense program, and current output now totals millions of units annually. Several types of quartz oscillator and filter plates are manufactured by Western Electric; however, discussion will be confined to methods utilized in fabricating the wire-mounted type required for the multi-channel frequency modulation transmitters used widely in the Armed Forces.

Described by the chemist as silicon dioxide (SiO_2), quartz that is of suitable quality for radio frequency-control comes only from the interior of Brazil. From other sources the supply is negligible, or the defects too predominant. In physical terms, the "perfect" quartz crystal is a brittle, glass-like, six-sided prism with pyramidal terminations. However, available crystals commonly have all but one or two faces broken away, and are frequently "unfaced."

A crystal has one axis of three-fold symmetry and three axes of two-fold symmetry. Crystallographers refer to the first-named axis as the *c* axis, and to the three other axes as the *a* axes.



The crystal, oriented by X-ray diffraction, is cut with a diamond-charged saw.



Adjusting the orientation of crystal for the proper reflection of X-rays.

Among radio engineers, the three-fold axis is known as the Z or optic axis, and the three two-fold axes as the X or electrical axes. The X axes are perpendicular to Z and 120° apart, and the Y direction, referred to as the mechanical axis, is perpendicular to Z and X. The crystal does not have a center of symmetry.

It is also important to the crystal manufacturer that the atomic structure of quartz may be arranged in either of two forms related to each other in the manner of mirror images, so that crystals are described as being either right-handed or left-handed. For use as a crystal circuit element, left-hand quartz is just as satisfactory as right-hand, but each oscillator plate must be of one "hand," and must not contain the other.

Among the various interior abnormalities of quartz, both optical twinning and electrical twinning are extremely common in all raw material received. Optical twinning, recognizable in the quartz inspectoscope, may be described as the intergrowth of right and left-handed forms in an apparently homogeneous crystal. In electrical twinning, crystals of the same "hand" are joined together with their respective X axes reversed to each other. Electrical twinning can not be identified in the quartz inspectoscope, and is recognized through examination of etched slabs in the twinoriascope.

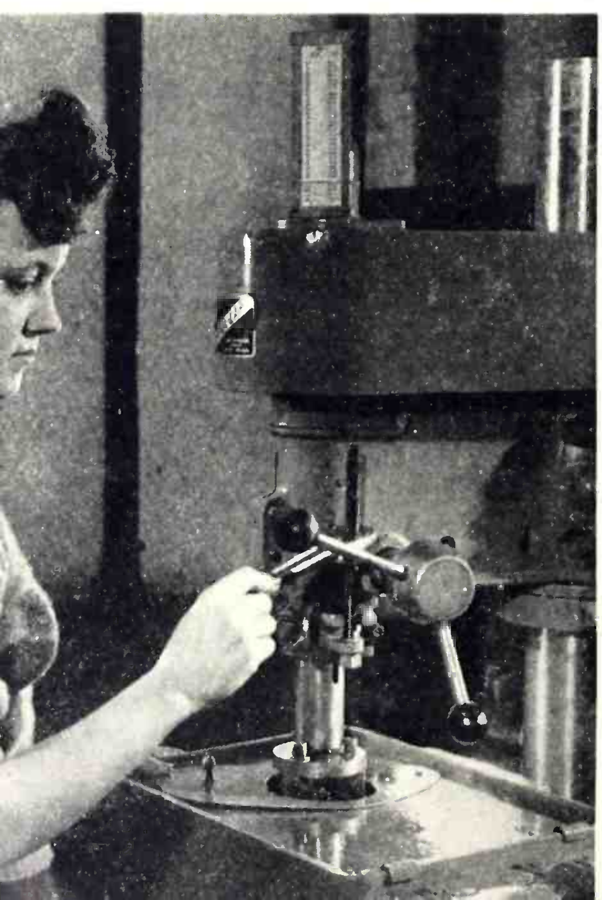
In crystal units intended for military purposes, the temperature coefficient, or fractional change in frequency per unit change in temperature, is of the utmost importance. The temperature coefficient is greatly influenced by the particular angle at which the crystal plate is cut. The earliest plates were X and Y cut, and were subsequently developed for high frequencies. These types of cuts still have applications, but both require close regulation of temperature. For example, the frequency of a Y cut crystal increases about 86 parts in a million for every degree of increase in Centigrade temperature.

Out of efforts to improve on the performance of Y cut crystals, Lack, Willard and Fair of the Bell Telephone Laboratories developed the now familiar AT and BT cuts. The orientation angle of the AT cut is plus 35° 15' from the Z axis, and the BT angle is minus 49°, both vibrating in thickness shear, and both with very low temperature coefficients. For lower frequency work, the CT and DT crystals investigated by Willard and Hight are now in use. The CT plate, cut at plus 38°, and vibrating with face shear, is the type now in greatest volume production in the Hawthorne Works crystal shop. It is useful for controlling frequencies from 100 to 1000 kilocycles, and has a very low temperature coefficient.

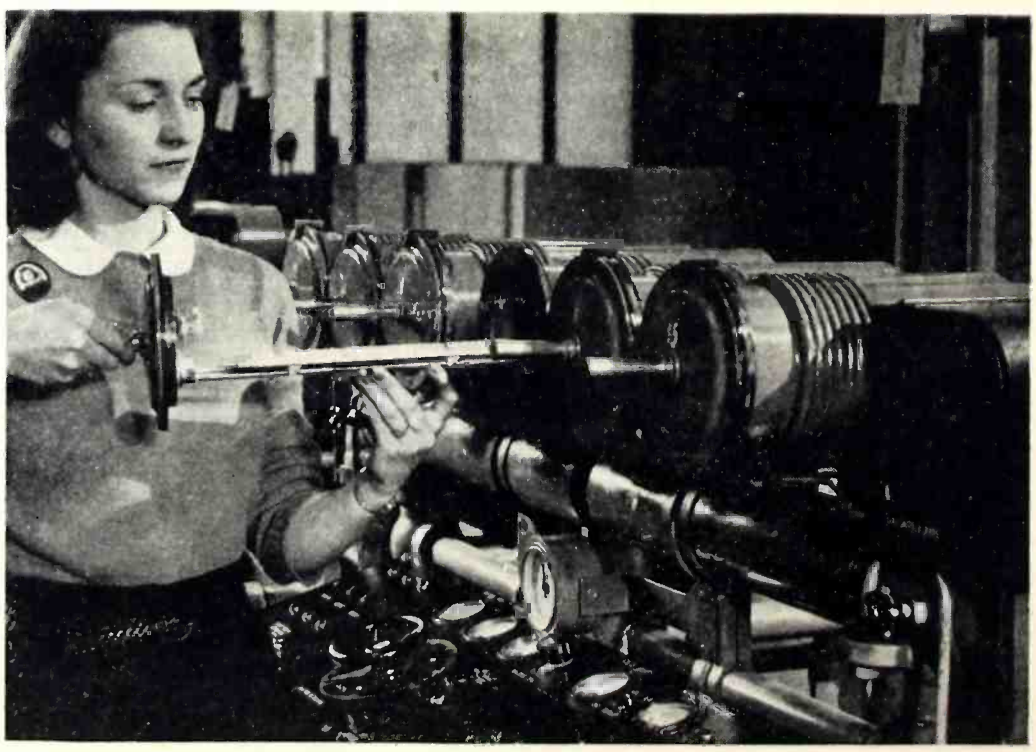
Techniques of orienting, cutting and lapping radio quartz have been well documented, hence, these procedures will merely be outlined briefly, with a more detailed summary devoted to the plating and soldering operations which have been developed for the fabrication of wire-mounted units.

First, raw quartz received at the crystal shop is inventoried and cleaned. The first major step in the

The ultra-lap machine for surfacing crystals to the required dimensions.



Silver plating the crystals by the evaporation process. Lengths of pure silver wire may be seen clamped to the molybdenum heating unit.



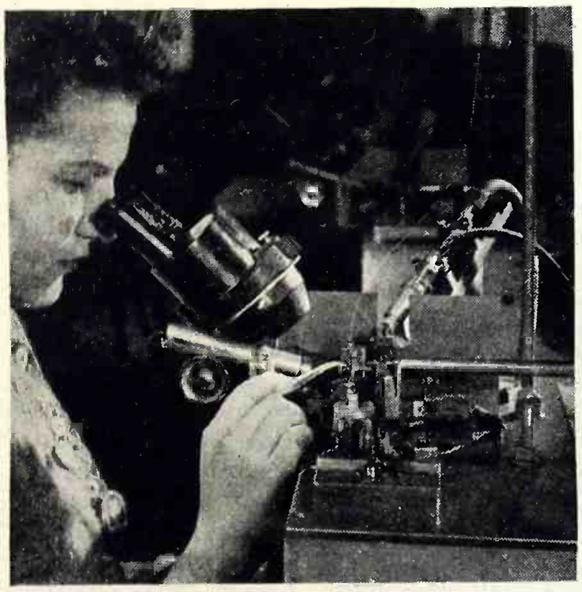
manufacturing process is to make an approximate determination of the crystal's Z or optic axis by means of the quartz inspectoscope. The inspectoscope is essentially a tank in which the quartz is immersed in oil and examined under polarized light. In the case of a crystal with well-developed apex faces, the apex is pointed at the polaroid window, and the Z direction is identified by colored rings which fringe the crystal. A crystal which lacks apex faces but which shows recognizable prism faces may be tilted on X until the optic axis comes in view.

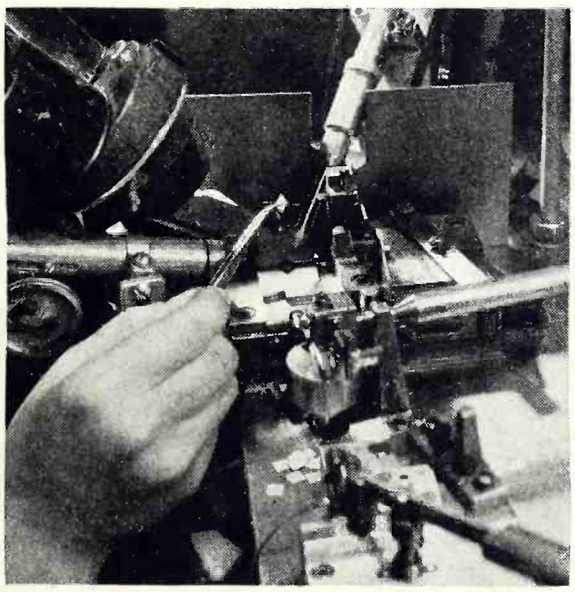
In actual practice, few crystals have well-defined faces, and the unfaced rock must be rotated in the oil bath until the Z direction is identified. The operator then marks the crystal so that a small flat or face can be ground parallel to Z on the grinding wheel. The rock is then returned to the inspectoscope, and the flat is now utilized as an approximate reference in determining the Z direction. The crystal is marked at right angles to Z.

tion of the crystal section is accomplished by X-ray diffraction. Although even a resumé of X-ray techniques is beyond the scope of this article, it is significant to note that the use of X-rays for precise angular correction is to a large extent responsible for the development of mass production methods in crystal manufacture. Previous to the adoption of X-ray methods, it was customary to utilize the natural faces of crystals for locating the X and Y axes. With the development of the AT and BT low temperature cuts, the need for accurate and quick determination of orientation became so urgent that techniques and apparatus were developed in the Bell Telephone Laboratories and introduced into the Western Electric factory process.

Under the present X-ray routine in the Hawthorne Works shop, the crystal section is mounted on the cap of an adjustable barrel-type fixture, and the assembly is placed in the X-ray machine at the approximate angle at which a reflection should occur. The

Close-up of calibration and hand lapping to final frequency.





(Left) Soldering of fine lead wires to the electrode surfaces of the crystal. (Center) Close-up of the specially designed soldering machine shown at left. (Right) Inspecting wire-mounted crystal units with the aid of a special microscope.

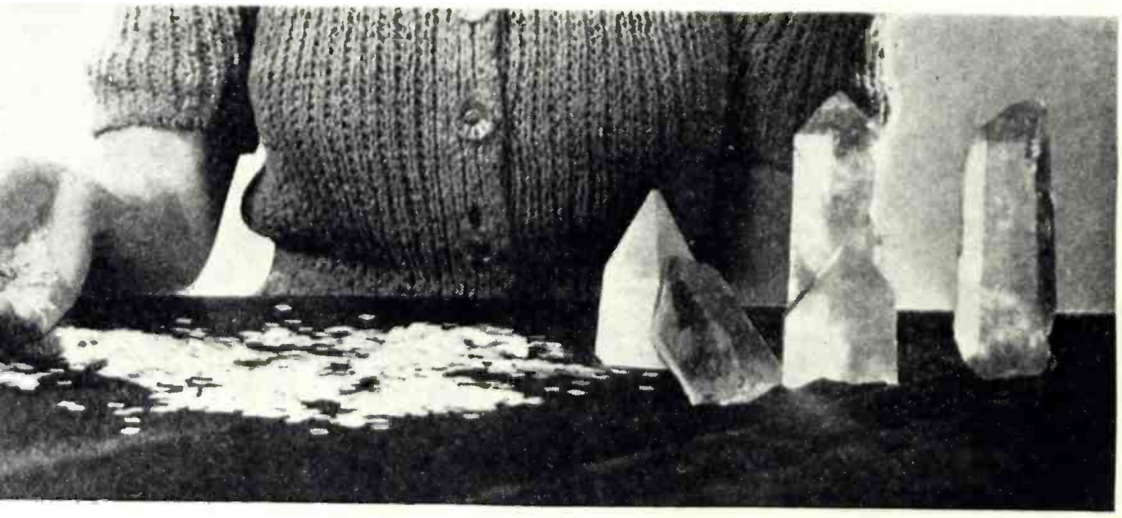
The crystal is next cemented to glass, with Z perpendicular to the short reference edge of the glass plate. The rock then goes to the diamond charged sectioning saw, where it is aligned with the orienting table set at 0-0, and a very thin wafer is cut from the end. This wafer is then examined in the conoscope, an optical instrument which utilizes monochromatic, polarized light for determining the optical or Z axis of quartz crystals. With data thus obtained, the operator marks on the wafer the correction in both planes that the rock is off true orientation from Z. The saw table is then readjusted to the indicated conoscope correction, and the rock is cut into sections.

True determination of the orienta- barrel is adjusted until the required reflection is found; the assembly, with the crystal section now exactly oriented, is taken to the Ultra-lap machine, and the section is surfaced correctly.

The section is then removed from the barrel cap, etched in hydrofluoric acid, and inspected in an optical instrument, known as the oriascope. In this instrument a characteristic pattern of light, which results from the scattering of a needle-like beam of light traversing the crystal from beneath and striking its etched upper surface, discloses electrical "twinning." If the electrical twinning boundary separates the crystal into approximately equal parts, the section is divided; useless parts of twins are marked for rejection. By means of light the approximate direction of the X axis is also determined in the oriascope, and the section is glass-mounted to adjustable saw plates in the proper position for X-ray measurement. It is then X-ray oriented for the X axis direction.

With X corrected, the saw plate is locked, and the section is sawed into slabs. Depending upon the extent of electrical twinning, some slabs will be entirely "good," and some will be partly "good" and partly "bad." In order to determine the usable portions, the slab is etched and examined in the twinoriascope. This instrument, like the oriascope, utilizes a needle-like beam of light. But in the twinoriascope, the beam is projected against the etched surface of the crystal from above. The reflected light discloses

Calibrating and hand-lapping wire-mounted crystal units to final frequency.



Left, crystal "dice"; right, rare specimens of faced quartz.

Using a conoscope to determine correct orientation of Z axis.

the surface texture and unusable areas, so revealed, are marked and removed.

The slab is then cemented to the cap of an adjustable lapping fixture and after orientation by X-ray diffraction, the slab is correctly surfaced on the Ultra-lap machine. It is next removed from the barrel cap, re-cemented with the corrected face down to a paralleling plate, and ultra-lapped to parallelism and thickness.

Henceforth known as a *wafer*, the crystal is removed from the paralleling plate, re-cemented to glass, and aligned in a cooling jig. When cool, the wafers are taken to the dicing saw and diced to the approximate square dimensions. The dice are then removed from the glass and cleaned of all cement. They are stacked in groups of about 30 in an edge-lapping fixture and are edge-lapped to within 500 to 4000 cycles of final frequency. After etching to remove all crystal and abrasive debris, the dice are inspected for twinning, cracks, chips, bubbles, and other miscellaneous defects, and are now ready for fabrication into wire-mounted units.

In designing a mounting for oscillator plates, it is an obvious assumption that there must be no restriction on the vibration of the crystal. It has been found that on all known types of crystal cuts there are nodal points, or points of zero motion. The first holders clamped the crystal plate at these nodes. In the case of the longitudinally vibrating crystals the nodal area constitutes a nodal "line," permitting a type of mount consisting of four edges, with pressure applied by a phosphor bronze spring. However, this type of pressure mounting is not satisfactory for face shear cuts, such as the CT, which have but one nodal point in the center of the plate which will permit clamping.

Moreover, in manufacturing oscillator plates for use in military equipment, not only should the supporting device have low electrical impedance, but it is desirable that it should also protect the crystal against shock and rough treatment that might hinder its operation. The wire-mounted type of crystal unit meets these requirements. In the wire-mounted unit, the fine supporting wires provide a spring mount for protection against shock, and at the same time the wires function as a connection between the electrical circuit and the electrode plating of the crystal. Slight changes in the position of the crystal and alterations in contact resistance, both encountered in pressure-type mountings, are obviated in the wire-mounted type.

From a manufacturing standpoint, the wire-mounted unit requires more

(*Continued on page* 35)

GRAPHICS OF THREE TERMINAL BRIDGE CIRCUITS

By ROBERT C. PAINE
Production Test Engineer

Graphic analyses of three terminal bridge networks which permit a clear visualization of circuit operation.

ALTERNATING current bridge circuits, in general, have two input terminals which connect to the source of a.c. voltage and two output terminals to the null indicator. If each of these circuits is not perfectly balanced to ground, stray capacities are apt to cause erroneous indications. To avoid these troubles, various devices, such as a shielded transformer or the Wagner ground, have been used in conjunction with the usual type of bridge. This problem can be avoided for some types of measurement by the use of bridged T networks with which null measurements can be made with the a.c. source and null indicator connected to a common terminal (usually grounded).

A three terminal "bridge" circuit of this type is shown in Fig. 1(A). This circuit is used in a commercial instrument for matching r.f. coils. For this use, the oscillator can be a modulated signal generator, and the null indicator a small inexpensive radio receiver. The reactors, X_1 and X_2, are two equal ganged variable condensers, and R_x is a non-inductive rheostat. These elements are adjusted for a null, or minimum signal, with the receiver tuned to the generator frequency and a standard coil in the X_LR_L position. The standard coil is then replaced by a coil to be tested and the condensers and rheostat readjusted as may be necessary for a null. To meet given tolerances, limits can be marked on the condenser dial and rheostat. To balance this circuit, the condensers and rheostat must be adjusted to satisfy the following equations:

$$X_1 = X_2 = 2X_L\left(\frac{Q^2+1}{Q^2}\right) \quad (1)$$

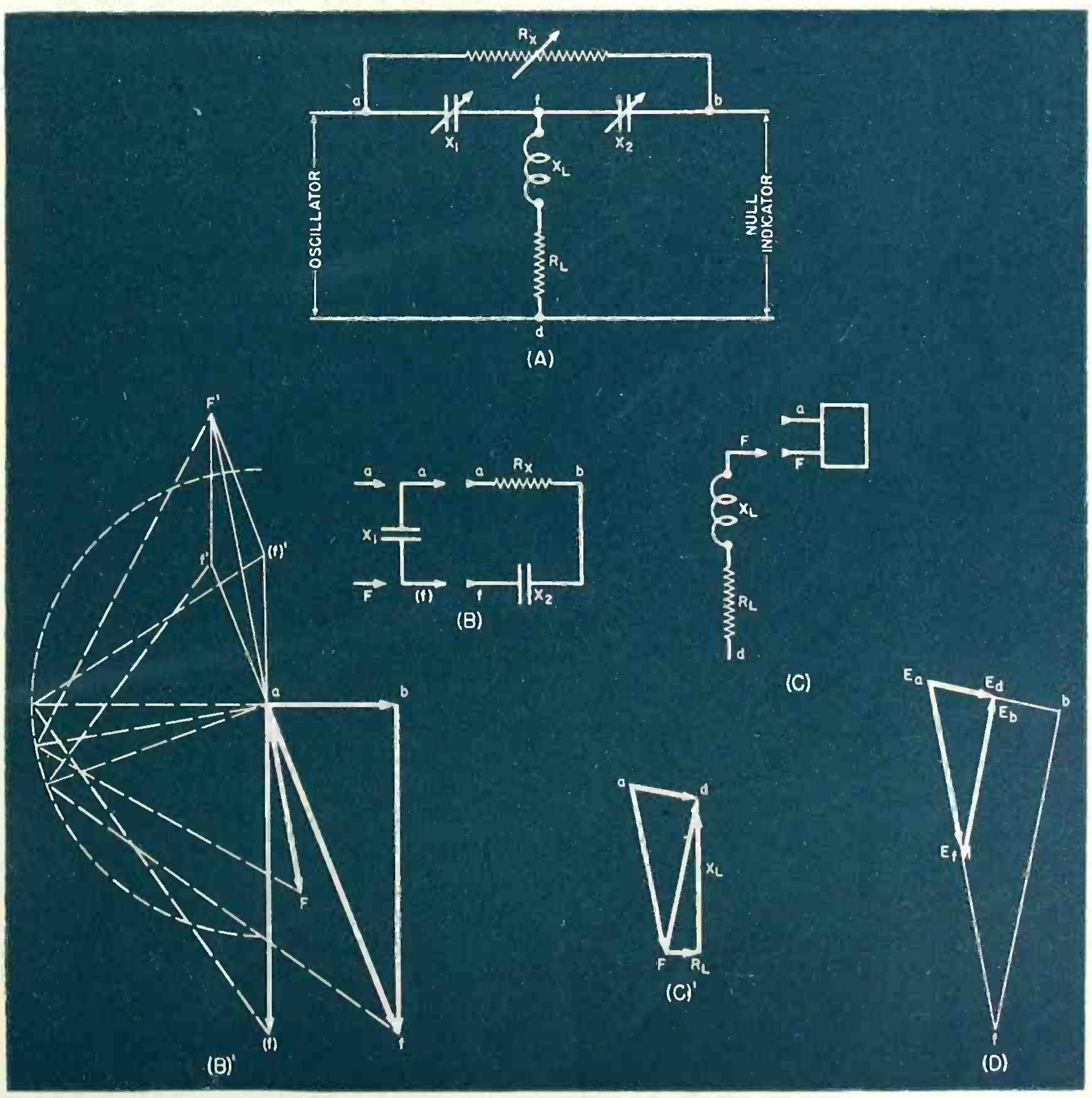
and

$$R_X = 4\,R_L\left(\frac{Q^2+1}{Q^2}\right) \quad (2)$$

Q, of course, being equal to X_L/R_L.

The operation of this circuit can be analyzed mathematically, but graphic constructions can be used to make its operation clearer. For this purpose, Fig. 1(A) is separated into its elements in Fig. 1(B) and Fig. 1(C) and values for X_1, X_2 and R_x at a condition of balance are assumed. In Fig. 1 (B)′, corresponding to the elements of Fig. 1(B), the vector *ab* is drawn to scale to equal the resistance R_x, and *bf*, the reactance X_2; these vectors added in series equal the impedance represented by the vector, *af*. The vector *a(f)* is drawn equal to the reactance, X_1, and added in parallel to the vector, *af*. This is done by striking an arc about *a*, erecting perpendiculars to *af* and *a(f)*, and construct-

Fig. 1. (A) Three terminal measuring network used for matching coils which avoids difficulty due to stray capacities. (B) and (C) show circuit separated for graphic analysis; (B)′ and (C)′ are the corresponding vector diagrams, and (D) is the voltage vector diagram.



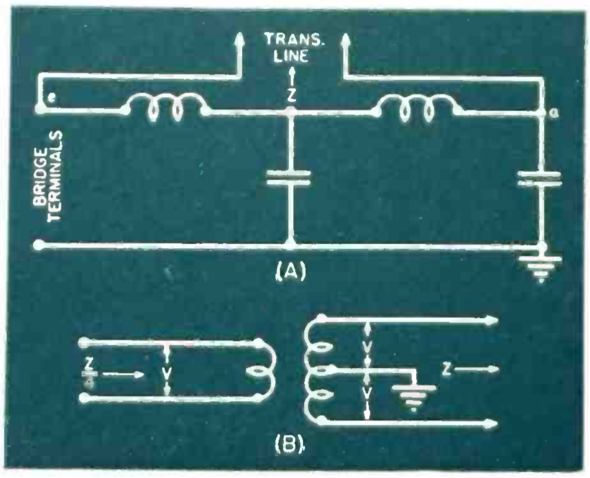


Fig. 2. (A) is a measuring network used with ordinary bridges for applying balanced voltages when making measurements on balanced equipment. (B) shows equivalent circuit.

ing the right triangles as shown, to obtain the reciprocal functions, *af'* and *a(f)'*. These functions are added vectorially in the parallelogram *af'F'(f)'* to find the reciprocal function *aF'* of the required parallel impedance vector *aF*. These operations for finding parallel impedance have been explained in more detail by the author in a previous article.[2]

The next step is the series addition of the elements of Fig. 1(C). This is done in Fig. 1(C)' by adding the impedance vector for the coil, *Fd*, to *aF* to obtain the total input impedance between *a* and *d*, represented by the vector *ad*. In Fig. 1(D), the impedance triangle, *adF*, has been redrawn as the corresponding voltage triangle, $E_aE_dE_f$, then E_aE_d represents the input voltage, and E_aE_f equals the voltage from *a* to *f*. The impedance triangle *afb* of Fig. 1(B)' is applied to the voltage triangle so that the line *af* lies along its corresponding vector of voltage, E_aE_f. Then the line E_fE_b is drawn parallel to *fb* to form the voltage diagram for the impedance triangle *aFd*. The voltage between *d* and *b* equals E_dE_b, but these points coincide, showing there is no voltage between them which is the condition of balance.

The diagrams for Fig. 1 have been drawn to scale with the following assumed values, $X_1 = X_2 = 2000$ ohms, $X_L = 960$ ohms, $R_L = 192$ ohms, $Q = 5$ (a low value is used to make the diagrams clearer), and $R_x = 800$ ohms. The impedance at balance *ad* seen by the oscillator is about 390 ohms, and since the circuit is symmetrical, the null circuit sees the same value of impedance. As the ordinary r.f. coil has a much higher Q than in the example given, this input impedance will usually be much lower, thereby reducing the tendency of the receiver to pick up stray fields at the null point.

If the elements of the above network are rearranged as in Fig. 3(A) it becomes a three terminal null circuit which has a very high impedance at the null point. The conditions necessary for balance are then represented by the following equations:

$$X_L = 2X_1 = 2X_2 \qquad (3)$$

and

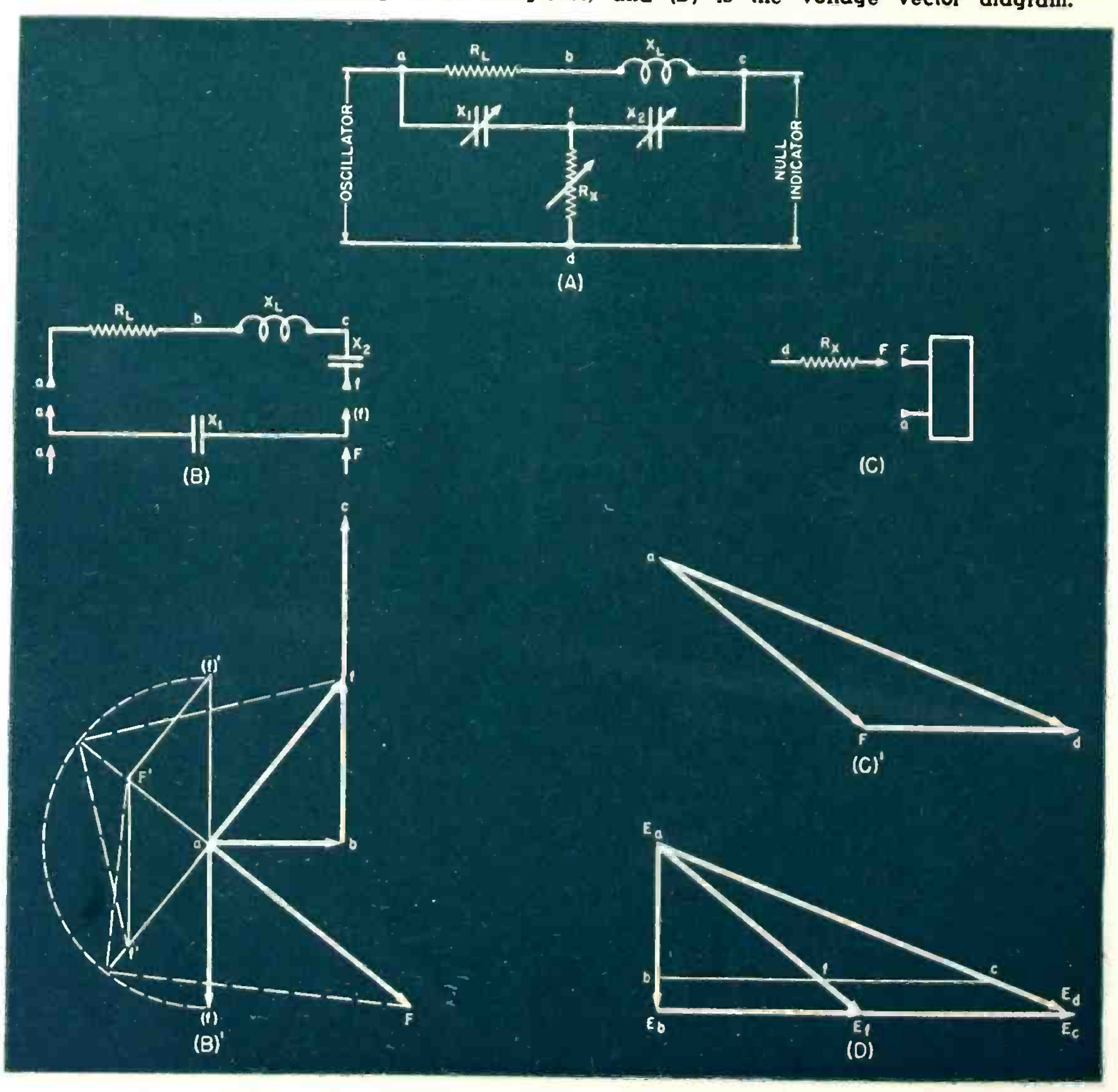
$$R_X = \frac{Q^2 R_L}{4} \qquad (4)$$

These equations show that this circuit requires variable condensers of greater capacity and a rheostat of much more resistance than the previous circuit, making it less desirable in the application mentioned. However, the graphic solution of this circuit also is of interest.

To obtain a convenient diagram it is necessary to assume a very low value of Q, 2½ has been taken for this example. Other values assumed at balance are, $X_L = 1000$ ohms, $X_1 = X_2 = 500$ ohms, $R_L = 400$ ohms, and $R_x = 625$ ohms. This circuit of Fig. 3(A) has been separated into its elements in Figs. 3(B) and 3(C). In the vector diagram Fig. 3(B)', corresponding to Fig. 3(B), the line *ab* has been drawn to scale to equal the resistance of the coil, R_L, and *bc*, to equal its inductive reactance, X_L. From *bc* is subtracted the reactance, *cf*, of the condenser X_2 to obtain the net reactance, *bf*. The vector sum of *ab* and *bf* is *af*, the impedance of the branch *af* in Fig. 3(B). The vector *a(f)* is drawn equal to the reactance of X_1 and added in parallel to the vector *af* by means of the parallelogram of reciprocal functions, *af'F' (f)'*, by the method previously referred to. The sum of these vectors, *aF*, represents the impedance of Fig. 3(B). The vector *aF* is redrawn in Fig. 3(C)' and added to the resistance R_x of Fig. 3(C), represented by the vector *Fd*, to obtain the total input impedance *ad*.

In Fig. 3(D), the impedance triangle *aFd* has been redrawn to represent the corresponding voltage diagram $E_aE_fE_d$, in which E_aE_d is the input voltage and E_aE_f is the voltage from *a* to *f*. The vector E_aE_f represents the voltage across the impedance *af* of Fig. 3(B)', so the impedance diagram *afbc* of Fig. 3(B)' has been redrawn in Fig. 3(D) with *af* along the line of E_aE_f. By drawing the line E_bE_c parallel to *bc*, the voltage diagram for the *af* branch of Fig. 3(B) is obtained. E_cE_f is the voltage across the reactance X_2 and the voltage between *c* and *d* is E_cE_d. Since these points coincide, it is shown

Fig. 3 (A) Three terminal network similar to Fig. 1 (A), but of high instead of low impedance. (B) and (C) shows circuit separated for graphic analysis; (B)' and (C)' are the corresponding vector diagrams, and (D) is the voltage vector diagram.



that there is no voltage between them at the point of balance.

The input (and also output) impedance of this network, *ad,* equals about 1180 ohms for the example given. This impedance would have been very high (and difficult to show on the diagram) had the value of Q been assumed at the much higher value of coils commonly used.

Another three terminal circuit is useful in conjunction with ordinary alternating current bridge circuits when it is desired to make measurements on equipment, the input terminals of which are balanced to ground.[3] This circuit is shown in Fig. 2(A) in which, as an example, the impedance of a transmission line is shown being measured by an impedance bridge. In this circuit the reactance of each of the inductors equals twice the reactance of each of the capacitors, at the frequency of measurement. Under these conditions, the network acts similarly to a no-loss half wave transmission line if inductors of high Q are used, then the testing voltage applied to the equipment under measurement at *a* is equal and opposite to the voltage at *e,* as referred to ground potential. The equivalent circuit is shown in Fig. 2(B) in which the network is replaced by an ideal transformer and the bridge sees an impedance equal to the actual impedance divided by four.

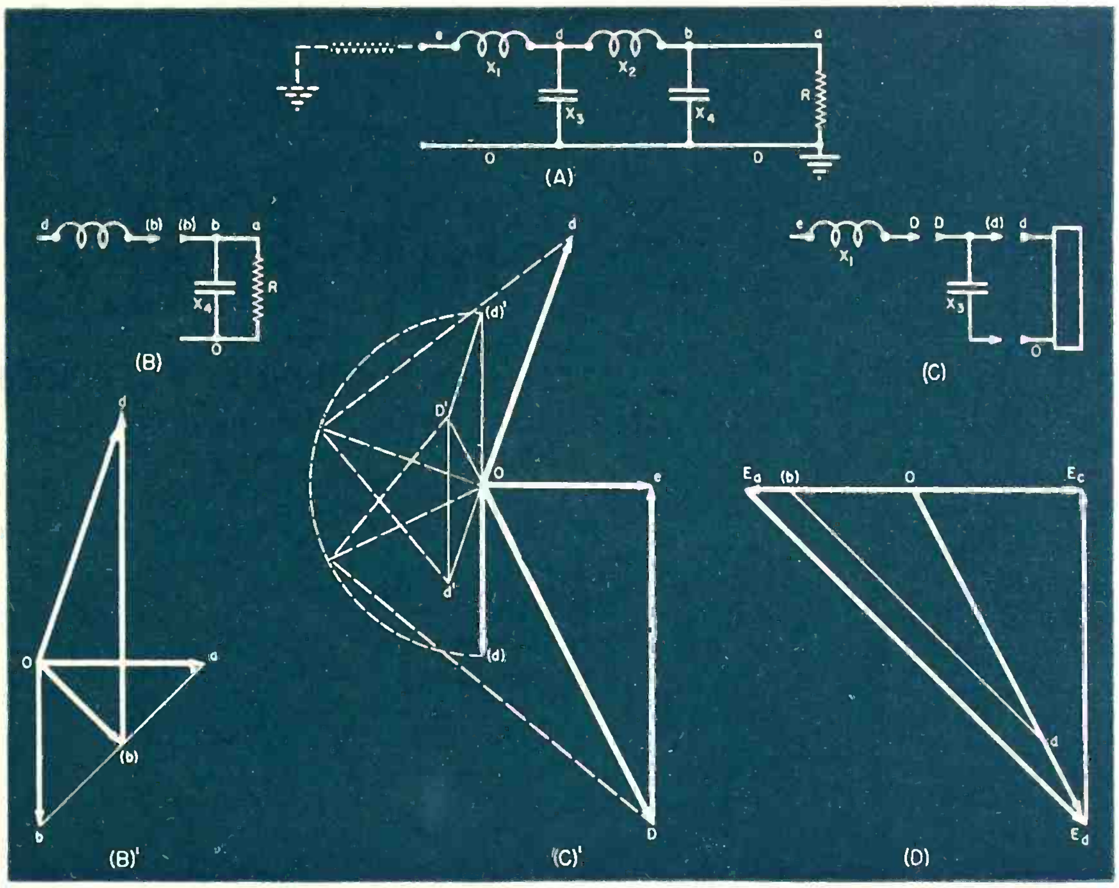


Fig. 4. (A) is Fig. 2 (B) redrawn for graphic analysis. (B) and (C) show the circuit separated into its elements; (B)' and (C)' are the corresponding impedance vector diagrams, (D) is the voltage vector diagram showing equal and opposite voltages at points *a* and *e.*

The action of this network can be demonstrated graphically as shown in Fig. 4. In Fig. 4(A), the measuring network is shown with the impedance to ground, presented by the equipment under test at *a,* represented by the resistance R. This circuit is separated into its elements for analysis in Figs. 4(B) and 4(C). The parallel impedance of X_4 and R of Fig. 4(B) is found graphically in Fig. 4(B)' by drawing the vector *oa* equal to R, to a suitable scale, and *ob* equal to the reactance X_4. The line *o(b)* perpendicular to the line *ba* then equals the parallel impedance of these elements. This construction for parallel impedance has been previously described in more detail in the article previously mentioned.[2] The reactance of the inductor X_2 is represented to scale by the vector *(b)d* and the series impedance of *o(b)* and *(b)d* is the sum of these vectors, *od.*

In Fig. 4(C) the elements of Fig. 4(B) represented by the impedance from *d* to *o* are connected in parallel with the capacitive reactance, X_3. The corresponding diagram is shown in Fig. 4(C)' in which the vector *od* is redrawn and *o(d)* drawn to scale to equal the reactance X_3. The reciprocal functions of these elements are combined in the parallelogram *od'D'(d)'* to obtain the parallel impedance *oD,* by the method previously referred to.[2] The vector, *De,* is drawn equal to the reactance X_1, and added in series with the vector *oD* to obtain their sum *oe,* the imput impedance seen at *e.* This impedance is equal to the load impedance at *a,* as would be expected if the testing network was a half wave line. Another equal impedance due to the other side of the line under test is also seen by the bridge at this point. Figs. 4(B) and 4(C) could, of course, be combined but they have been shown here separately to avoid confusion.

The voltage diagram is shown in Fig. 4(D), where the triangle oE_cE_d is drawn similar to the impedance triangle *oeD.* The input voltage at *e* is equal to oE_c and E_dE_c is the vector of voltage across the inductor X_1, and oE_d, the vector of voltage across *od.* The impedance triangle *od(b)* is drawn with its side *od* coinciding with the line oE_d, and the similar triangle oE_dE_a is the corresponding voltage diagram. It is seen that the vector of voltage at *a* to ground, oE_a, is equal and opposite to the voltage at *e,* oE_c, so these voltages have been shown graphically to be equal and opposite as was originally stated.

It might be of interest to note that the circuit of Fig. 3(A) may be used for measuring incremental inductance. When used for such a purpose, provision is made for inserting d.c. at the input terminals, along with the a.c. The d.c. current is not affected by balancing the bridge, and may be measured either at the input or the output of the bridge. The entire a.c. voltage will appear across the unknown inductance, since there is no voltage across the input terminals at balance.

The above circuit may also be used for measuring the Q as well as the inductance of radio-frequency coils. Assuming X_1 and X_2 to be equal capacities, C, then $Q = 2\omega CR_x$.

The circuit of Fig. 1(A) may be used for evaluating high resistances, if the inductance is replaced by a standard resistance, R_s, and the unknown resistance placed at R_x. This arrangement does not provide a true null, but if the ratio R_x/R_s is high, a sufficiently sharp balance may be obtained. Under these conditions, $R_x = 1/R_s(\omega C)^2$.

The method of graphic analysis for the above networks is useful in visualizing just what makes them function as they do in test circuits. Similar analyses of resistance-capacity networks for audio oscillators were made by the author in a previous article.[4]

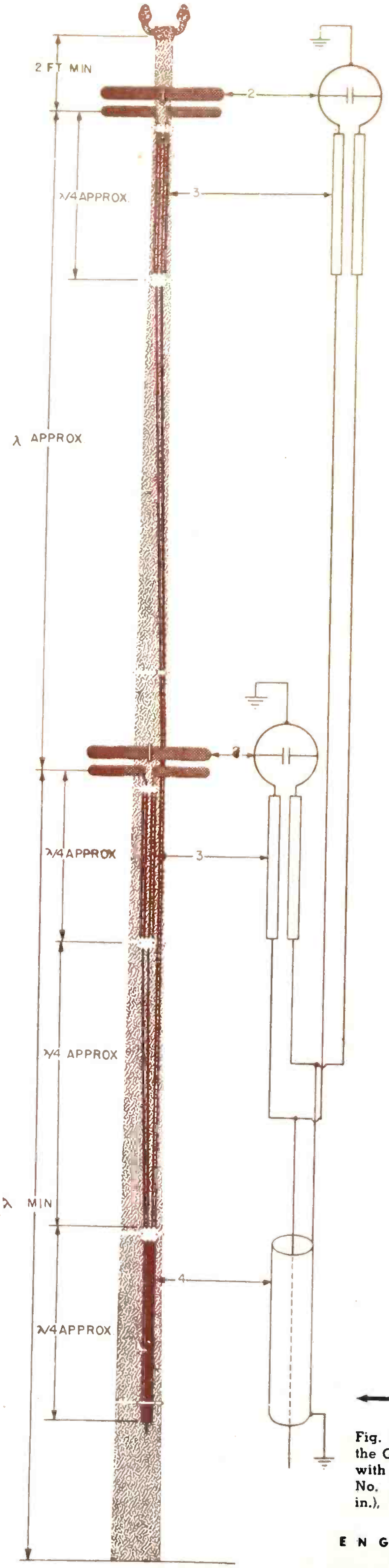
REFERENCES

1. *Tuttle, W. N., "Bridged T and Parallel T Null Circuits for Measurement at Radio Frequencies," Proc. of the I.R.E., Jan., 1940.*

2. *Paine, Robert C., "L Type Matching Networks," Radio-Electronic Engineering, Jan., 1944.*

3. *Sinclair, D. B., "Measuring Balanced Impedances with the R.F. Bridge," General Radio Experimenter, Sept., 1942.*

4. *Paine, Robert C., "Graphics of RC Networks," Radio-Electronic Engineering, May, 1944.*



ANTENNA DESIGN for U.H.F.

By HAROLD E. ENNES
Station Eng'r., Station WIRE, Indianapolis

A discussion of some of the problems encountered in installing antennas for television and FM receivers.

THE present indicated interest in u.h.f. development of broadcasting services, such as frequency-modulation and television, foreshadows a post-war situation which will find a far greater emphasis placed on antenna design than has been customary to this date. With the shift toward the ultra-high frequencies, a large portion of the burden for satisfactory performance will necessarily be placed on the design of suitable antenna systems for both transmitting and receiving stations.

It is, therefore, the intent and purpose of this article to present the basic problems involved in antenna design for specific performance characteristics, and to review briefly the design considerations in existing types of u.h.f. broadcast transmitting and receiving antenna systems for FM and television services.

Basic Problems Involved in FM Reception

In general, the fundamental requirement for the satisfactory performance of an FM receiver is a sufficient signal at the grid of the limiter tube such that limiting action is complete over the entire frequency deviation range of the transmitter. This is illustrated in Fig. 8 (A), where it may be observed that although the frequencies farthest from the resting carrier frequency are amplified less than those nearer the carrier frequency due to the i.f. stage characteristics ahead of the limiter, still the amplitude at the ±75 kc. point is sufficient to cause proper limiter action. The associated response-curve (theoretical) shows that the limiter action is complete over the 150 kc. deviation range of transmission. Thus, the limiter output to the discriminator circuit will be correct for both soft and loud passages of the program content. Fig. 8 (C) illustrates the relationship of the limiter slope and response curve when a weaker signal is present at the grid of the limiter tube. This figure shows that for soft passages of program content where the frequency deviation in this example is less than ±30 kc., perfect fidelity results, although noise components will be passed. On the louder passages where up to ±75 kc. deviation occurs, serious distortion results, similar to that resulting from a badly overloaded audio stage.

The distance between the transmitter and receiver is not the only factor determining field strength at a particular point. Due to the high frequencies used for these transmissions (42 to 50 megacycles for FM broadcast), multipath conditions of signal transmission exist owing to reflections from such obstacles as hills and tall buildings. Thus, it is entirely possible, in fact somewhat common, that a receiver located well within the specified service area of an FM transmitter will not perform satisfactorily with a given antenna system due to this multipath condition.

Consider, for example, the condition illustrated in Fig. 8 (D), where the principal signal is transmitted to the receiving position over the path d_1. A condition exists in which a reflected wave traveling a distance d_2 is also present at the receiving point so that the receiver responds to the vector sum of the two voltages. Assume that d_2-d_1 = 600 meters, or 100 wavelengths of a station on 50 megacycles or 6 meters; under this condition the signal voltages would add in phase and result in a stronger signal than that of the principal wave alone. It is obvious, however, that a very slight alteration of this ideal condition could result in a

←

Fig. 1. A pictorial and schematic diagram of the General Electric two-bay circular antenna with a frequency range of 42-50 megacycles. No. 2 is the radiator (outside dia. 37½ in.), 3 is the matcher, and 4, the elevator.

displacement of ½ wavelength in which case the out-of-phase component would decrease the resultant voltage by an amount equal to the magnitude of the reflected wave voltage. Under these conditions, although the receiver is within the prescribed service area of the transmitter, an insufficient signal is apt to result unless the receiving antenna is designed and operated to achieve a specific performance. Assuming that d_2-d_1 is a certain number of wavelengths plus a fraction (less than half) of a wavelength such that the resultant signal is only slightly above the required limiter level at resting frequency, when modulation is applied, it is possible that the signal in the receiver will be reinforced on one phase and partially or wholly annulled on the opposite phase. This results in serious distortion that is apt to be interpreted as a defective receiver circuit. It becomes apparent that application of receiving antenna design to these problems assumes a magnitude of utmost importance, especially where more than one station is to be included in the design consideration.

Television Reception

The problems of television reception closely parallel those of FM, the distinguishing factor being that multipath phenomena are even more troublesome in television reception than in FM. While a time delay between multipath FM signals of up to 50 microseconds difference is hardly noticeable to the ear due to the comparative time interval of the highest transmitted audio frequencies, a 10 microsecond difference in television multipath transmission will cause a "ghost" image on the receiver tube displaced one inch from the primary image.[1]

Design Application

With the above presentation of the basic problems involved, it will become apparent to the engineer that substantial improvements in general transmission can be obtained by limiting radiation or reception to a small solid angle which includes the direction of the desired primary signal path. It is entirely possible that antenna design will, in some instances, be the determining factor in the practicability of certain transmitting or receiving locations.

The limitation of antenna response to a small solid angle results in three important characteristics in general:

1. Signal gain
2. Directivity gain
3. Higher Q

and due to the reciprocal relationships may be considered true for either transmitting or receiving antennas. The first two features are desirable for a given setup; the third feature, especially in the case of television, may be very undesirable. The high Q is undesirable because of the extreme wide-band response necessary for television transmission and reception.

Fig. 5 (A) and (C) represents the transmitting case for two antennas, where antenna No. 2 is a hypothetical antenna with spherical radiation pattern and reference gain, and with no heat loss.

The definition for signal gain gives:

$$\frac{S_1}{S_2} = \frac{P_{i(2)}}{P_{i(1)}} \qquad (1)$$

where

S = signal gain
D = directivity gain
P_i = antenna input power in antennas No. 1 and 2

and the directivity gain:

$$\frac{D_1}{D_2} = \frac{P_{R(2)}}{P_{R(1)}} \qquad (2)$$

where P_R = radiated power of antennas No. 1 and 2.

Combining Eqts. (1) and (2) gives:

$$\frac{S_1}{S_2} = \frac{D_1}{D_2}\left(\frac{P_{i(2)}}{P_{i(1)}}\right)\left(\frac{P_{R(1)}}{P_{R(2)}}\right) \qquad (3)$$

By definition, the receiving case, Fig. 5 (B) and (D), may be written as:

$$\frac{S_1}{S_2} = \frac{W_1}{W_2} \qquad (4)$$

where W = power received in antennas No. 1 and 2.

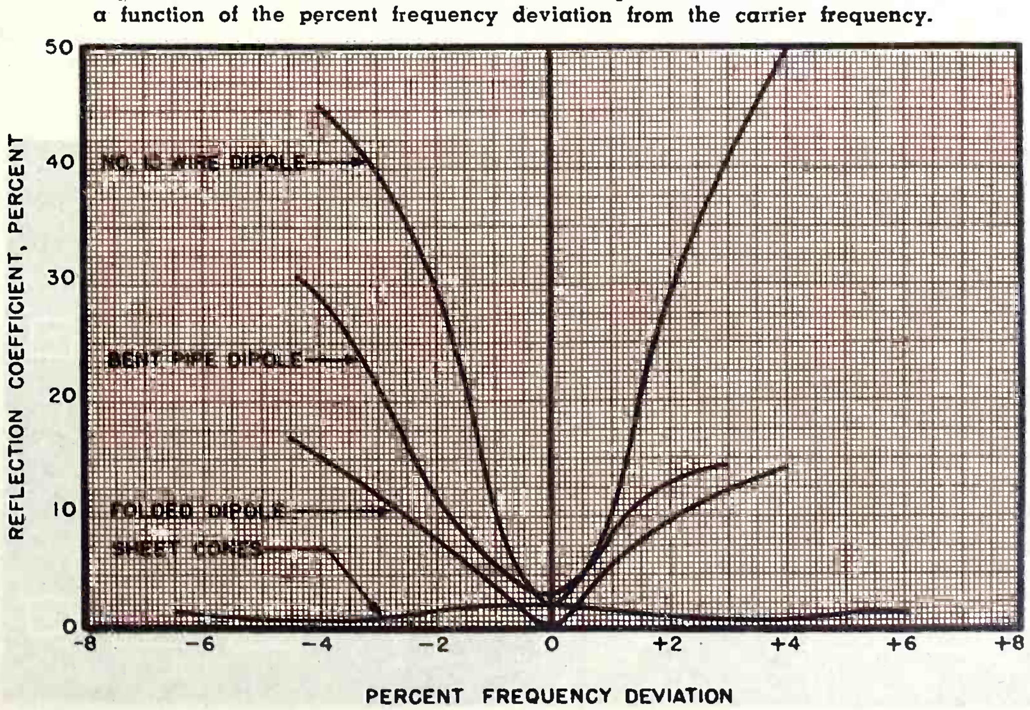
From the reciprocity theorem:

$$\frac{W_1}{W_2} = \frac{P_{i(2)}}{P_{i(1)}} \qquad (5)$$

Fig. 2. General Electric two-bay circular antenna as described in Fig. 1.

It may now be observed from Eqts. (1), (4), and (5) that the transmitting and receiving signal gains are identical. This does not indicate, however, that equivalent improvements in per-

Fig. 3. The reflection coefficient for various types of antennas plotted as a function of the percent frequency deviation from the carrier frequency.



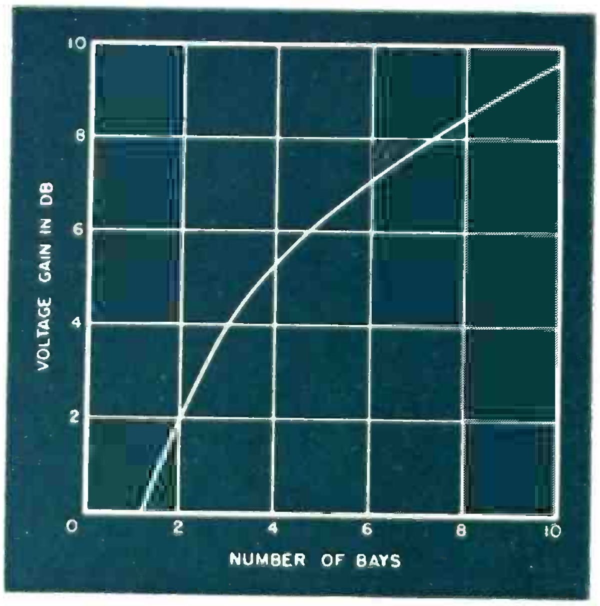


Fig. 4. Gain of circular antenna as a function of the number of bays.

formance result from a given increase in signal gain at either transmitter or receiver position. It is, of course, obvious that an increase in antenna signal gain at the transmitter will increase the magnitude of the received signal relative to received atmospheric and circuit noise, thereby effectively increasing the signal to noise ratio. However, at the receiving point, should the receiver antenna gain be raised while holding the directional discrimination constant, the amplitude of the received signal would be raised with reference to the receiver circuit noise, but would not improve the signal relative to static. On the other hand, if the directivity gain is raised, and the receptivity in directions other than the desired reception path is decreased, then noise or multipath signals from these angles will be greatly reduced with respect to the desired signal. This may be visualized mathematically as:

$$\frac{S/N_1}{S/N_2} = \frac{D_1}{D_2} \qquad (6)$$

where N is the noise signal strength. The S/N improvement may be seen to be equal to directivity gain.

It may be concluded from the above arguments that:

1. the chief design problem is the attainment of high signal to interference ratios,
2. high signal gain at the transmitter reduces the effect of received noise and receiver circuit noise,
3. high signal gain in the receiver antenna reduces the effect of internal receiver noise, and high directivity gain reduces the effect of received noise and multipath signals.

Wide-band Design

The broadband operation of television transmission is a highly important factor in the design of television receiver antennas and many times more so in the case of the transmitter antenna. This is true due to the problem of impedance match from transmission line to antenna over a 5 or 6 megacycle range. The vector ratio of reflected wave voltage to incident wave voltage in the transmission line is commonly termed the *coefficient of reflection* and is expressed as:

$$\text{Coeff. of reflection} = \frac{(Z_L/Z_0) - 1}{(Z_L/Z_0) + 1} \qquad (7)$$

and is seen to depend on the vector ratio of the load impedance to the characteristic impedance of the transmission line. Under practical transmitter practice this ratio must never exceed 5%, thus it becomes apparent from the graph of Fig. 3 that the conventional type of antenna is completely inadequate for television transmitting systems. The conical antenna is the only one shown on the graph entirely suitable for the purpose, although folded dipoles arranged in a

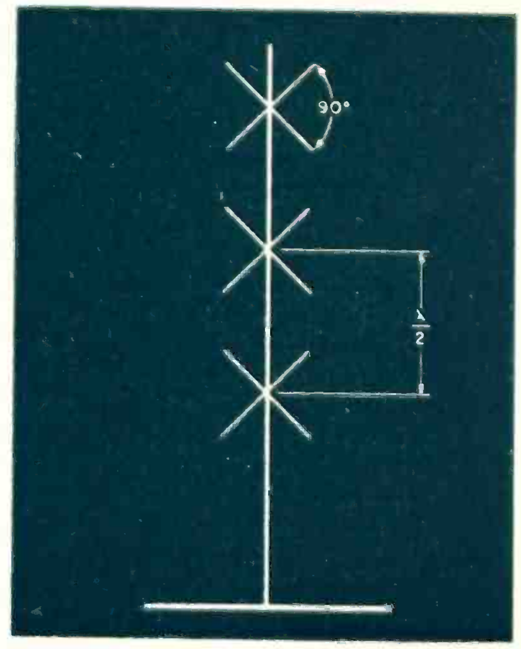
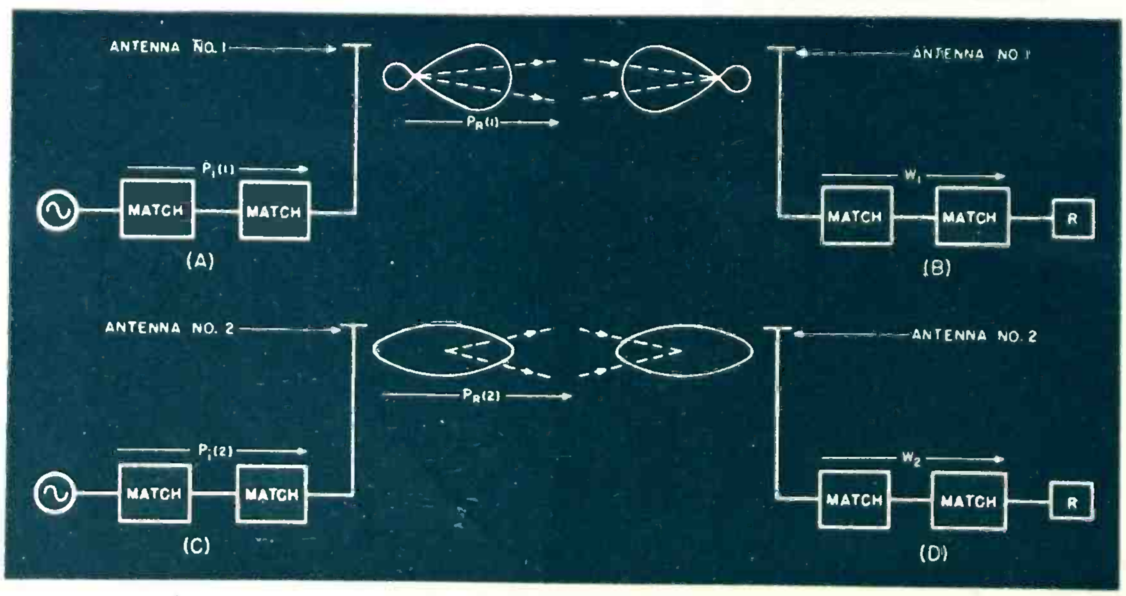


Fig. 6. Diagram of turnstile antenna, probably the most common form of radiator for FM.

turnstile form are also suitable. It is obvious that low Q antennas are required for this service, and in practice, the reactive component of the impedance does not exceed 10% of the resistance component. It is well also to keep in mind that a bandwidth of 20 megacycles may be required for high-definition color television.

In receiver practice, where a greater reflection coefficient may be tolerated over the transmission band, a pipe dipole or folded dipole is adequate. In cases where it is necessary to cope with noise or multipath signals, an antenna must be designed which has some directivity, such as the reflector type, and in this case the design becomes a compromise between bandwidth characteristics and interference problems. In this connection it is well to remember that the ordinary dipole is directive, and it may be possible, by proper orientation in space, to allow the major lobes to fall in the desired path or paths of transmission, with the nulls toward the interference. Where sharper directivity is necessary, the dimensions of the system become more critical in that they must be proportioned to resonate at a particular frequency within the television band so that image quality will not suffer excessively, while attempting to receive more than one station with a given antenna. It may become necessary at some receiver points in the future to install several directive antenna sys-

Fig. 5. Directional transmitting antenna (A) and corresponding directional receiving antenna (B), for calculating signal and directivity gain with respect to a hypothetical transmitting antenna with no heat loss (C) and receiving antenna (D). Power input to antenna, radiated power, and received power are indicated.



tems, each so adjusted and oriented in space as to perform properly for their respective signal paths, and with provisions for switching the proper antenna to the receiver terminals as stations are changed. In some instances, where all stations within the receiver range except one give satisfactory performance, it is possible that a single dipole would be used for all the satisfactory signals, and a separate antenna of highly directive design be used for the troublesome signal. It becomes apparent to the engineer that an infinite variety of problems in this category will present themselves when television begins to expand into a major industry. The antenna system is going to carry a tremendous burden in the "proof of performance" of television to the general public.

Types of Transmitting Antennas

In general the antenna system for the u.h.f. broadcast transmitter is designed to give a strong uniform signal in all directions in the horizontal plane, while providing directivity in the vertical plane. This enables the transmitting antenna to concentrate the signal strength into the plane of usefulness for the receiving antennas, thus the gain contributed by the antenna is meant to utilize the higher angle of elevation waves in such a way as to add their voltages to the more useful low angle waves.

The turnstile antenna is probably the most common form of radiator for the FM services. As is observed from Fig. 6, this antenna consists of a number of bays of two-element half-wave radiators crossed at right angles and excited 90° out of phase by means of transmission lines of different electrical lengths. An arrangement of several bays of this type gives marked directivity in the vertical plane with consequent large signal gain in the horizontal plane. The turnstile arrangement is comparatively easy to adjust since when the various transmission lines are combined, an impedance mismatch at any one part will tend to be compensated by the corresponding mismatch of opposite character by the quadrature portion of the system.

G.E. Circular Radiator

The General Electric Co. has developed a circular type of FM antenna of high gain in the horizontal plane which is illustrated with its feed system in Fig. 1. The element immediately beneath each bay matches the antenna to the transmission lines in a balanced circuit. The elements near the base are the familiar phase inverting networks used to connect the balanced load to the single ended transmission line. The term elevator is employed since the addition of the outer shield elevates the potential of the outer conductor of the transmission line above ground.[2] The gain of this antenna as a function of the number of bays is illustrated in Fig. 4.

The problems encountered in the design of u.h.f. receiving antennas will become more and more evident as various services, such as television, shift to still higher frequencies. The proposed standards for color television would require an antenna capable of receiving a much larger bandwidth at a higher frequency than the present standards require.

If any conclusion is reached from the discussions presented in this paper, certainly the outstanding one would be the fact that the engineer and the service man in the near future will necessarily become thoroughly antenna conscious. The antenna system will very likely show rapid advancement in the few years immediately following the war.

REFERENCES

1. *DuMont, Allen B. and Goldsmith, Thomas T. Jr., IRE Proceedings, April, 1944.*
2. *Scheldorf, M. W., General Electric Review, March, 1943.*

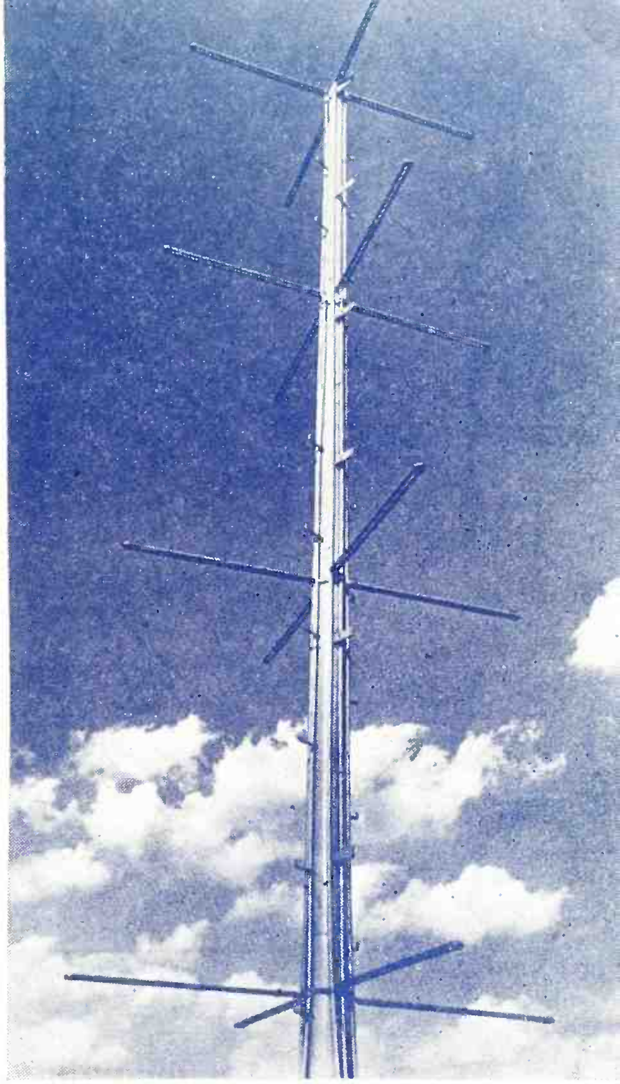
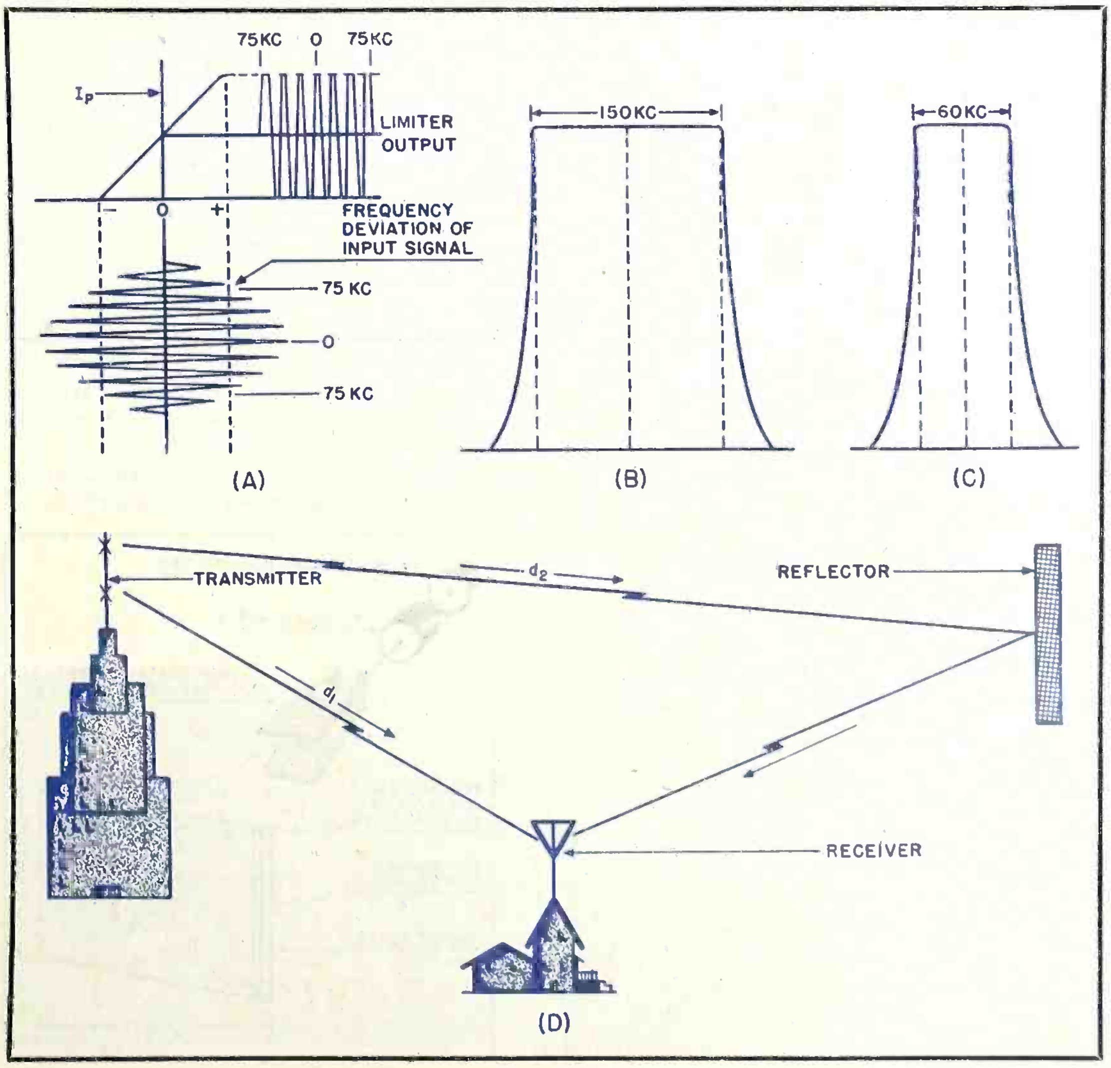


Fig. 7. Typical turnstile antenna installation.

Fig. 8. (A) shows how limiter action is complete over entire deviation range. (B) is an ideal theoretical response curve, and (C) action when insufficient input signal is applied to limiter grid. (D) indicates how two signals may reach the receiver out-of-phase.



SOUND ON VIDEO

By JAMES E. ROBINSON

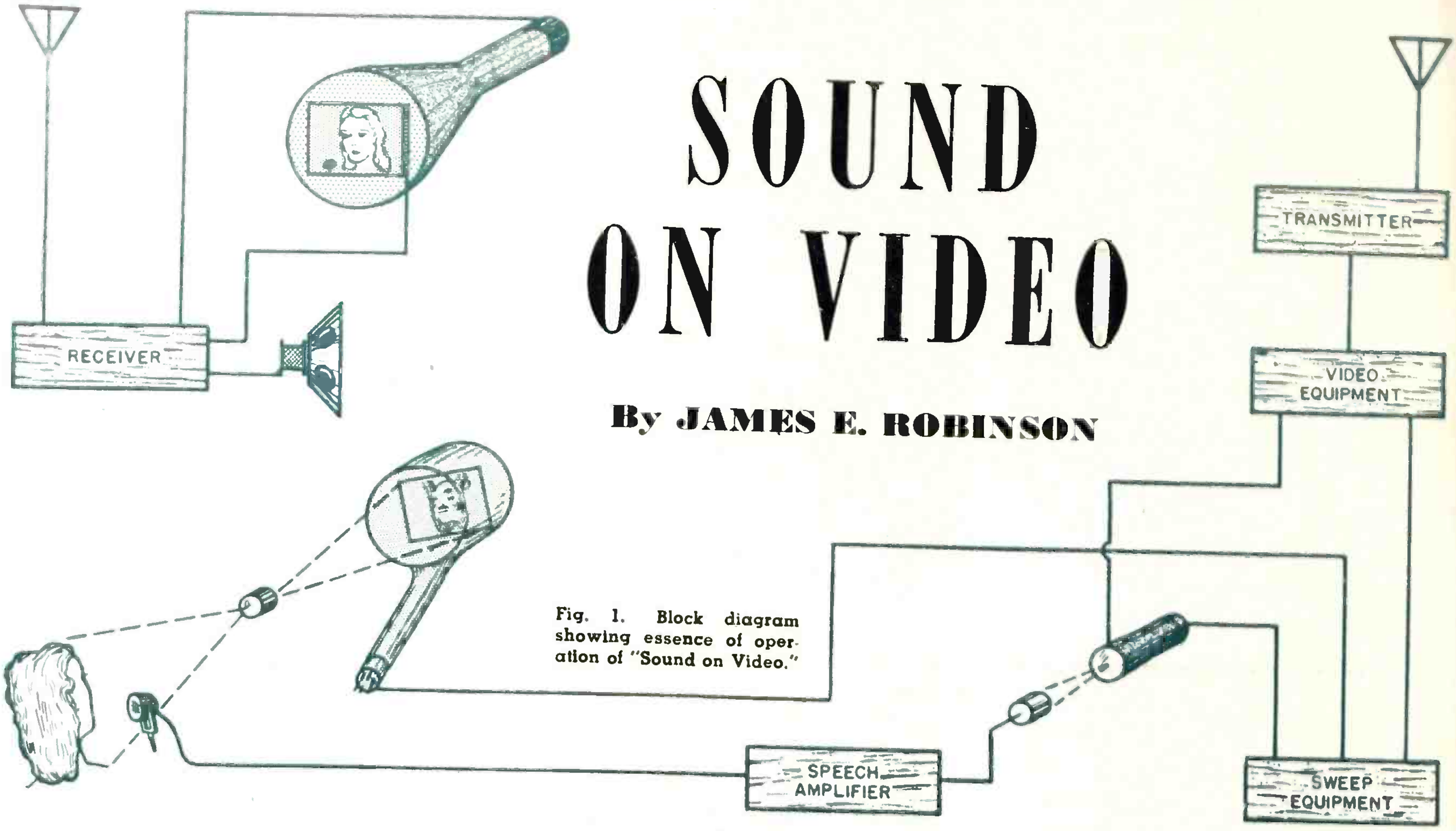


Fig. 1. Block diagram showing essence of operation of "Sound on Video."

A new method of television transmission whereby the sound modulation is combined with the picture modulation.

RECENTLY a leading authority in the television field, when called upon to answer the question of why, in present practice, it is deemed necessary for both the video and aural signals to occupy separate channels, thereby requiring the use not only of dual transmitters and antennas in a television system, but also receivers, replied that inasmuch as video and aural are two distinct types of modulation, completely divorced from one another, it necessitates their being handled in such a prescribed manner.

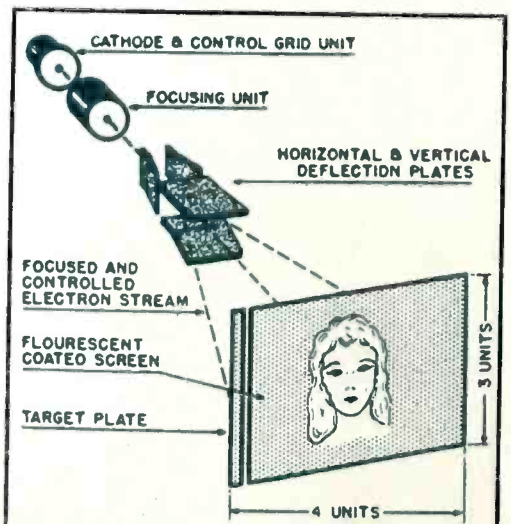
Today, with the industry planning for the post war era a system of relay broadcasting stations extending throughout the country, thereby establishing the medium for a national television broadcasting service, it is obvious that these present, existing standards would render this proposal expendable as to frequency allocations, personnel required and cost; not only from the standpoint of initial requirements, but also maintenance, for here duplicate spare equipment and personnel would be required for its successful operation.

Also, as previously stated, there is the problem of receivers. They by the same token are affected, as the employment of additional parts is necessary in their construction.

In keeping with the present demand for simplified technical explanations, it is the purpose of this article to present an outline covering a system free of the inefficiencies stated. This system is feasible through the combining of the previously described and so-called two distinct types of modulation into a singular type. This new type of modulation being introduced at this time is known and distinguished from other systems as "Sound on Video."

> EDITOR'S NOTE
> *In view of the fact that the first formal demonstration of this unique method of transmitting voice frequencies for television will be held in Buffalo on September 5th, there is a rather remote possibility that unforeseen difficulties will present themselves. The author has assured us that preliminary experiments have proved the method described herein to be very successful. If the demonstration proves favorable and this method is accepted, it will simplify many of the problems encountered in the transmission of television sound.*

Fig. 2. Combined video and aural television broadcast reception.



Transmission

As "Sound on Video" presents a new system for instantaneous recording, it is well to first examine some of the present, outstanding recording systems as to their merits regarding recording speed or wavelength, understanding, of course, that wavelength is of prime importance if high fidelity recording is to be achieved.

Motion picture film heads the list with the shortest constant recording speed, that is, 90 feet per minute. Next comes the newly revived wire-recording, with its maximum, non-constant recording speed of 174 feet per minute, followed by the popular 12-inch diameter, 78 revolutions per minute disc recording, with its maximum, non-constant speed of 245 feet per minute. By contrast, compare these to "Sound on Video," with its constant, instantaneous speed of 600 feet per minute. This figure is derived from the present iconoscope having a mosaic of the 4 by 6 inch size, or 3 units vertically and 4 units horizontally, as required by present standards. Thus, based on the present system of 30 frames per second for television, 4 inches are available every $1/30$th of a second for recording purposes, or, as stated, 600 feet per minute.

Fig. 1 illustrates the "Sound on Video" working principle. It can be seen that this system is analogous to the practice of sound on film recording, originally set forth and now adopted by the motion picture industry, that is, the converting of sound vibrations to light variations and photographing or televising them for future reconversion. These light variations are filmed or televised as having either a variable area or density characteristic and so allocated as to continuously occupy only a narrow vertical margin of a frame, thereby assuring the accompanying picture of no loss in its detail information, but only a slight decrease in its horizontal size, which when combined with the sound track equals a frame having the present desired raster scanning size or aspect ratio. Fig. 2 clearly illustrates this point.

As stated, this system is only analogous to the practice standardized by the motion picture industry, with regard to the conversion of sound vibrations to light variations. The major differences arise from the fact that "Sound on Video" is entirely dependent upon increments for transmission, and not wave form. For those who do not clearly understand the increment theory it can best be described by comparison, i.e., a person when submitting to a blood test is not required to furnish the physician with the total amount of blood in his body, but merely a sample, which serves to establish its identity. Thus, an increment is a sample or part of the whole, retaining all the characteristics of the original, but in proportion. This phenomenon was recently brought to light by Peter Goldmark and Paul Hendricks in their recent Synthetic Reverberation development; that is, they discovered that phosphorescent substances excited by light or electronic bombardment have a decay characteristic which is approximately logarithmic, similar to the decay of reverberant sound.[1]

"Sound on Video" has a repetition rate of approximately 15,750 increments per second besides a phasing action rendered by the delay produced through the dissection process. Although the scanning rate is today standardized at 15,750 lines per second, a certain percentage of these scanning lines are lost due to the lag of the blanking impulses. This condition is the only limiting factor in the reproduction of a 15,750 cycle note by the "Sound on Video" system, since the

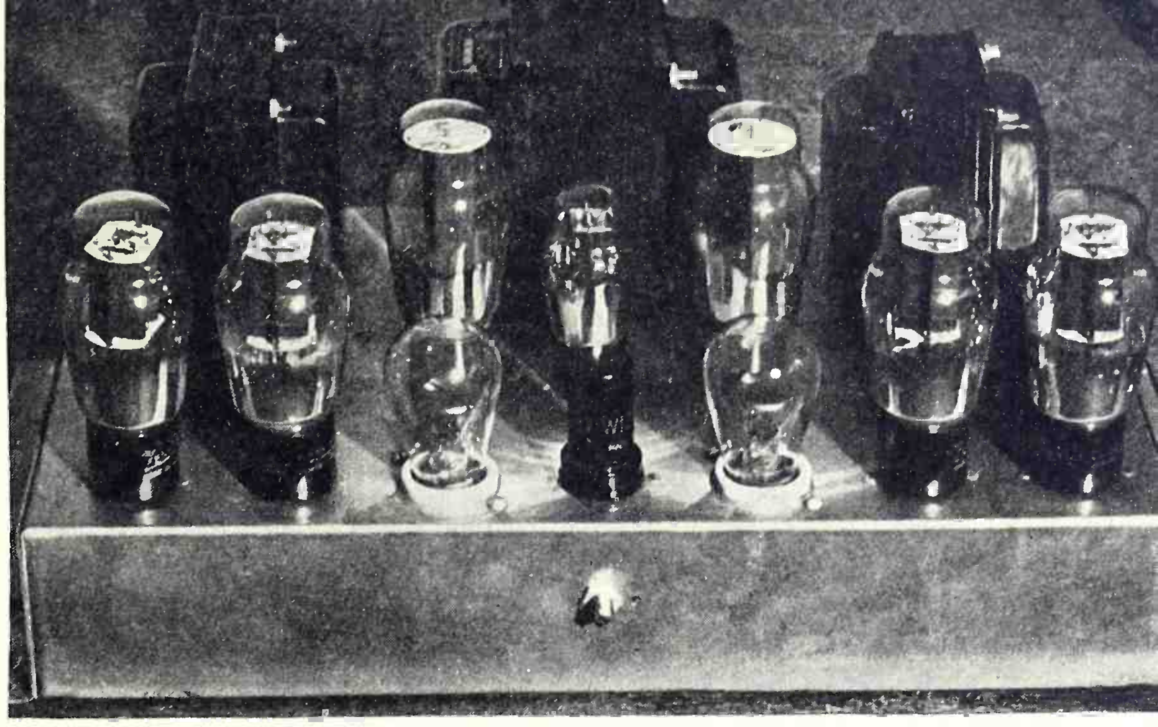


Fig. 3. Electronic voltage regulated power supply, employed in observation tests.

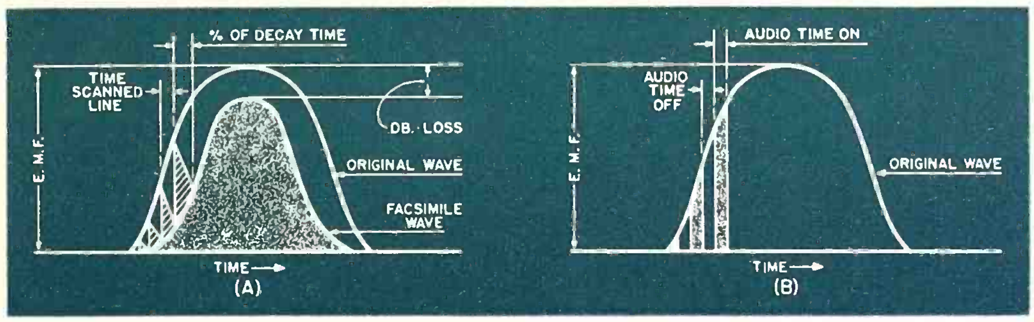
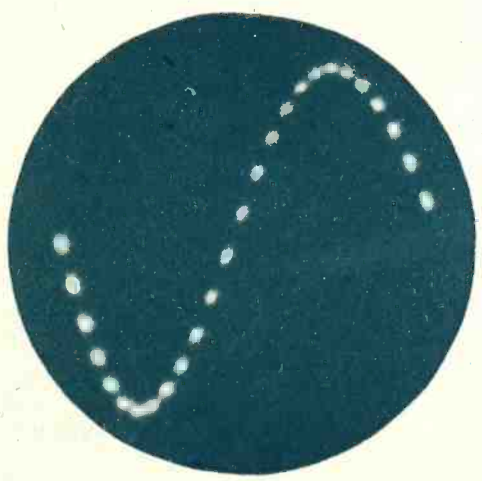


Fig. 4. (Left) "Sound on Video" audio waveform analysis, compared with integration waveform analysis (Right).



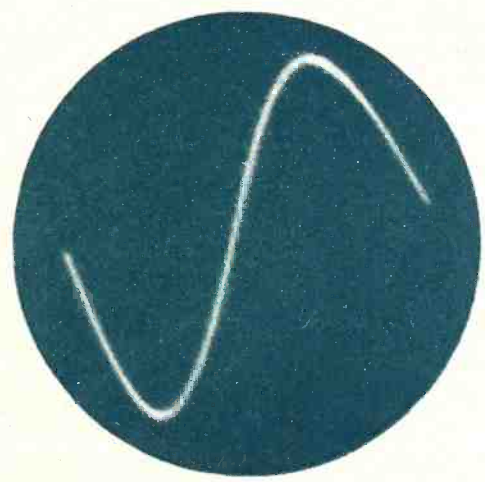
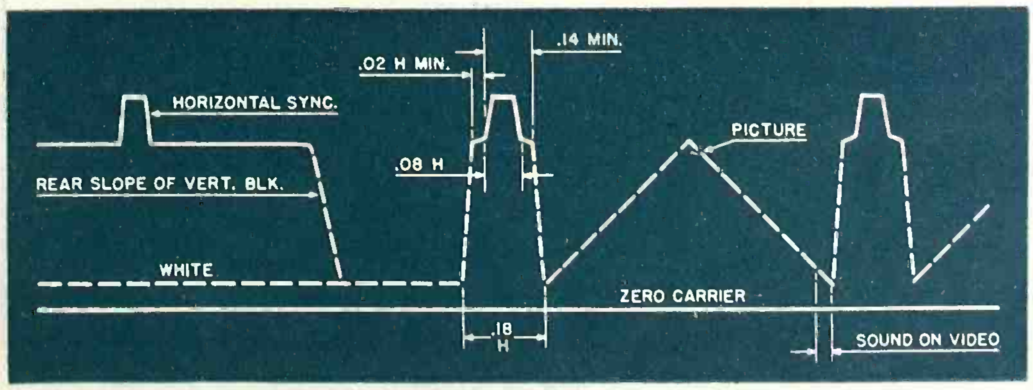


Fig. 5. Sine wave produced through integration. Fig. 6. Wave produced by increment theory.

Fig. 7. Complete television synchronizing waveform, showing all of the various components required for synchronizing, and producing the sound and picture.



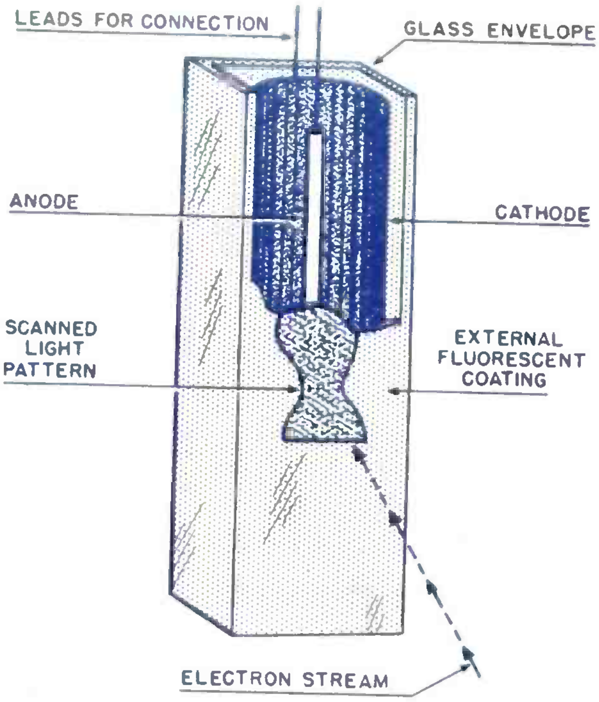


Fig. 8. Target plate construction for reception of sound impulses.

loss of scanning lines results in an equal reduction of available increments.

"Sound on Video" is practically instantaneous compared to the permanency of film, and in addition has a higher available recording speed and also affords a new, more efficient means of reconversion or reproduction.

However, the motion picture practice can best be used to express the alternate types of light variations or modulation involved insofar as transmission is concerned, that is, the "Sound on Video" system lends itself very readily to the conversion of either variable area or density variations to electrical impulses for transmission purposes.

It has been mentioned that "Sound on Video" is an instantaneous type of recording. This statement may give rise to doubt so it is well to examine the sequence of operation of this system, starting first with the camera unit. Based upon the understanding that instantaneous recording is not new as far as other fields are concerned, it has been proven and demonstrated by the recently developed electronic system for producing synthetic reverberation or echo. This development is able to control the time duration or lag between the principal and secondary sound emanations.

Fig. 5 illustrates the process used to introduce variable area modulation upon the mosaic of the iconoscope employed for sound televising only. This procedure was used for the reason that it enables a single unit to be built into the controlling rack for handling multiple sound outlets, thereby eliminating any interference that might arise from shading correction in the viewing iconoscope, and at the same time, eliminating the possibility of any microphonics from vibration when employed in a movable camera unit.

It may be seen that light produced from a direct current source, after focusing by a lens system, is made to pass through two movable apertures, staggered in line one behind the other, for projection upon the mosaic.

Since a separate iconoscope is employed for sound insertion it is necessary to use only horizontal scanning in this tube. Although the sound strip in the receiver is intended to occupy a narrow, vertical marginal area of the viewing tube, it is not necessary in the insertion iconoscope to limit the modulated light to the corresponding marginal area, inasmuch as the centering controls can move the scanned line to any position without upsetting the horizontal aspect ratio.

This single horizontal line scanning procedure is necessary in the storage type tube in order to eliminate any possibility of introduced light modulation being stored from one frame to the succeeding, as is clearly shown by Fig. 13. However, this adaptation is not necessary when employing the non-storage type camera tube for the reason that the electrons free themselves from the photo-sensitive surface and form an electron cloud for image dissection.

As stated previously, the direct current light source is made to pass through two apertures, which are in turn so arranged that in the absence of modulation they cause the light beam to be broken. However, upon the introduction of modulation they are immediately caused to open, and width of the gap produced increases in proportion to the amplitude of the modulation. Thus a ribbon of light is developed which narrows with low modulation levels and widens with high levels of modulation.

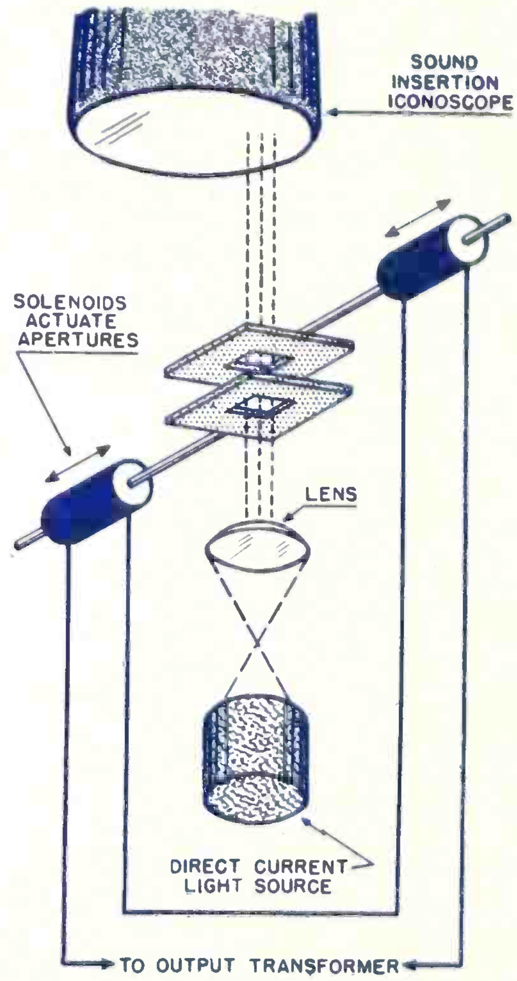
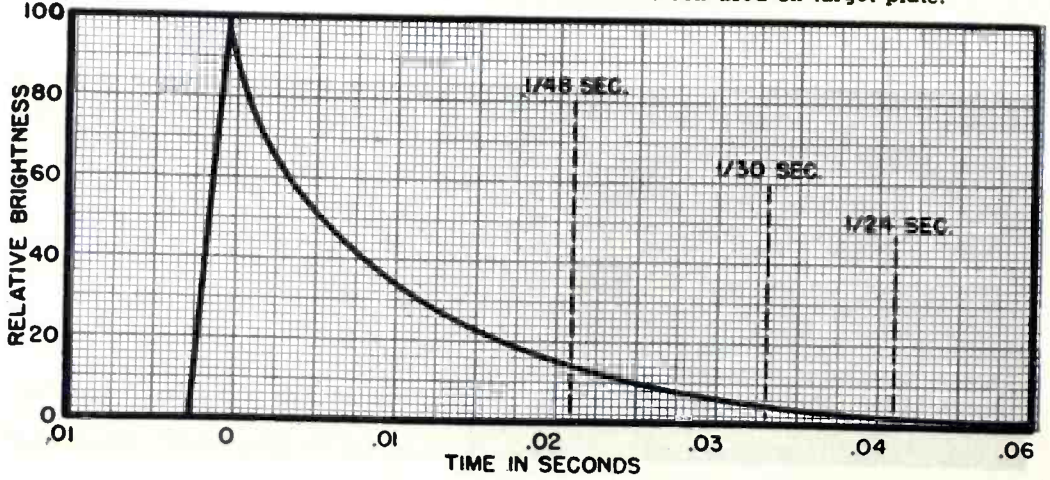


Fig. 10. Method of modulating light beam in accordance with impressed sound.

This system was preferred for the reason that it presents black and white variations, and not shades of gray, as variable density affords. It had been previously found, in actual tests of both these systems, that due to the black and white characteristics of variable area modulation a greater gain and an improved signal to noise ratio could be attained on the reconversion for lower levels of introduced modulation. This system was selected in preference to variable density modulation because the light source may be completely shut off during inactive periods of modulation, thereby eliminating shot noise. This shot noise is produced even though the direct current light source is unmodulated. As the dissecting process is employed, whether of the electron stream or image dissector type, this unmodulated light beam creates a succeeding potential, which results in the production of increments equal to the rate of repetition of the

Fig. 9. Light decay characteristic of fluorescent screen used on target plate.



number of scanned lines per second, which when passed through an audio amplifier produces this noise effect.

It should not be inferred that variable density is incapable of functioning, for this nearly sub-audible introduced effect could be made inaudible by increasing the number of scanned lines per frame, or by attenuation produced by a filter, to a level below the threshold of human hearing.

From these conclusions one can understand how an instantaneous recording effect is produced, that is, in the storage type of camera tube or iconoscope the introduced modulation can be stored or recorded during the interval when the electron stream is active over the adjacent area. In the non-storage type there is no delay, and consequently the electron cloud is freed instantaneously for image dissection.

These controlling conditions and the fact that image dissection lacks the ability to differentiate between the two introduced pictures, the system operates in a manner similar to that used for one composite picture, thus creating the working principle for "Sound on Video."

From the conversion point on, it only becomes necessary to consider this as a single type of signal, which can be handled like the present video signal used for transmission purposes, without conflicting with existing standards as to aspect ratio, band width, wave form and synchronization.

"Sound on Video," in addition, is not only capable of meeting the requirements for high fidelity reproduction, but also frees a portion of the frequency spectrum, equal to a quarter megacycle, which heretofore was allocated for the audio signal. This additional frequency spectrum can be employed for either additional scanning lines, to increase the guard zone between stations, or could result in the adding of one additional station for every 24 stations employing existing standards. Figs. 7 and 16 show idealized synchronizing and transmission wave forms.

It might be added at this time that, from a practical operating viewpoint, the light modulation level at higher frequencies can be increased by equalization and also by employing a compression type amplifier which reduces the volume range of modulation logarithmically to improve further the signal to noise ratio at low modulation levels before conversion to modulated light.

Reception

As stated earlier, "Sound on Video" affords a more efficient means of reconversion or reproduction than the present systems employed by the motion picture industry, their practice being the reconversion of light variations into electrical impulses by means of a direct current light source, a photo-electric cell, and associated amplifiers to actuate a loudspeaker. In the "Sound on Video" principle this external application could be employed, but this would be a needless procedure, inasmuch as these electrical impulses are already present to produce light emanations and require only the use of a target plate. This target plate corresponds in aspect ratio to the original allocated strip used in transmission, and may be used to collect and convert these impulses, which in turn are fed into a matched impedance amplifier for reproduction purposes, insuring the maximum transfer of energy with minimum distortion. This type of amplifier is necessary due to the low current potential characteristics employed in the conversion tube mounted inside the kinescope used for visual reproduction.

This system is entirely dependent upon increments or picture element electrical impulses for transmission

(*Continued on page* 39)

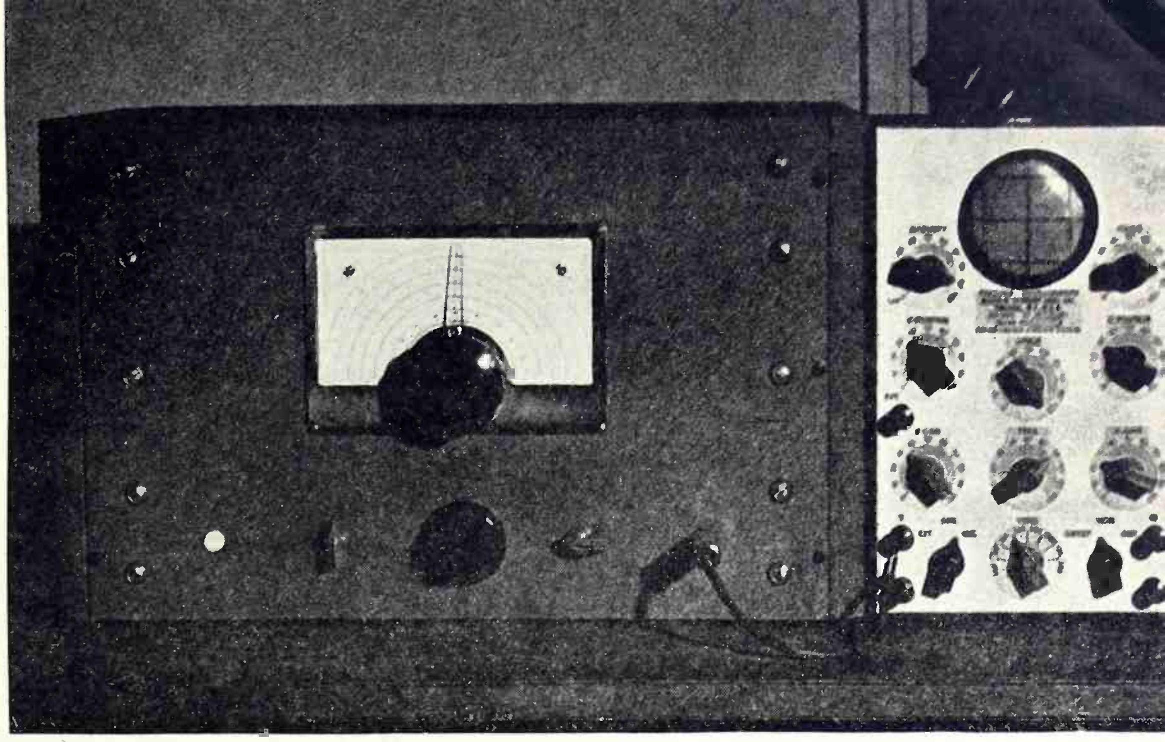


Fig. 11. Square wave generator and cathode ray oscillograph used in analysis.

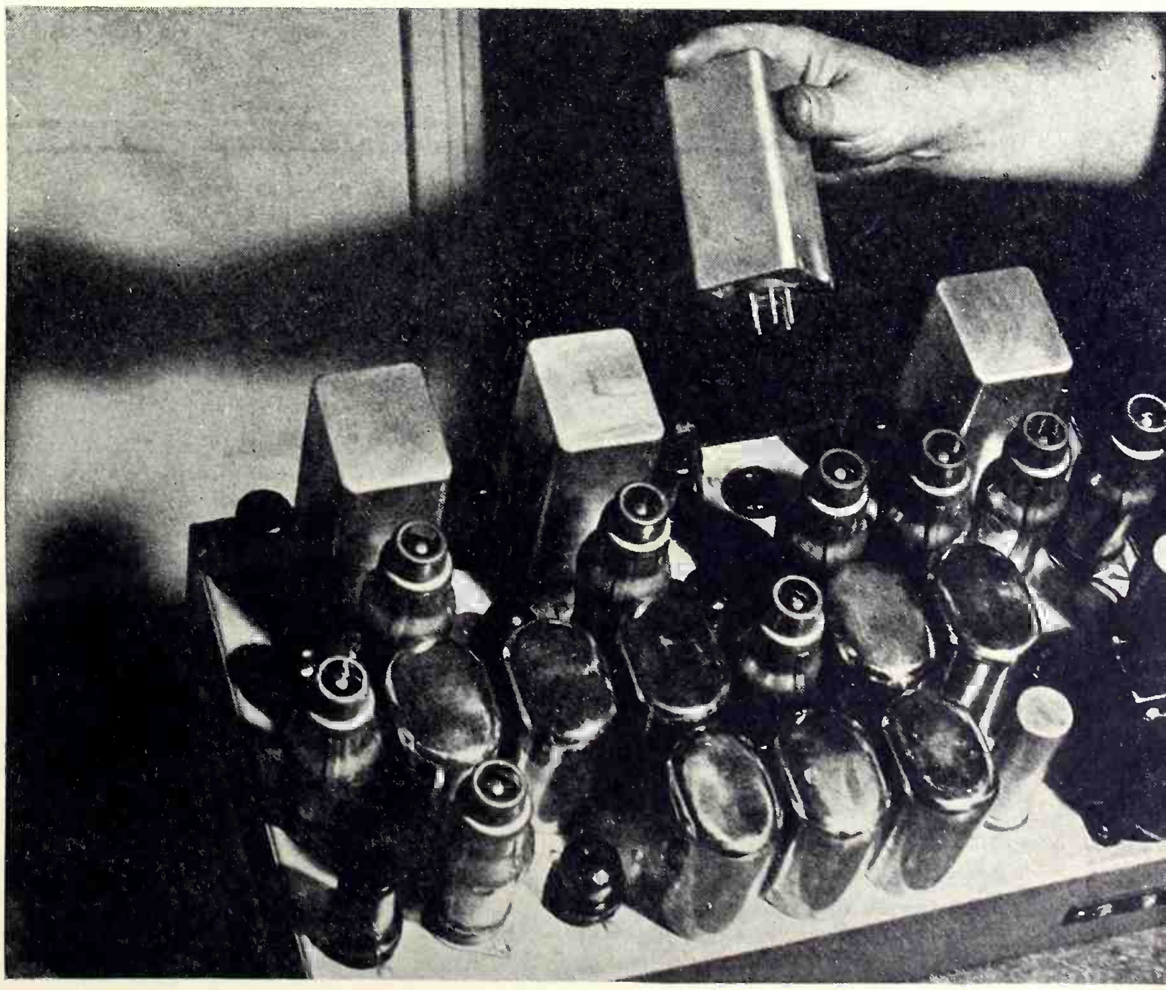
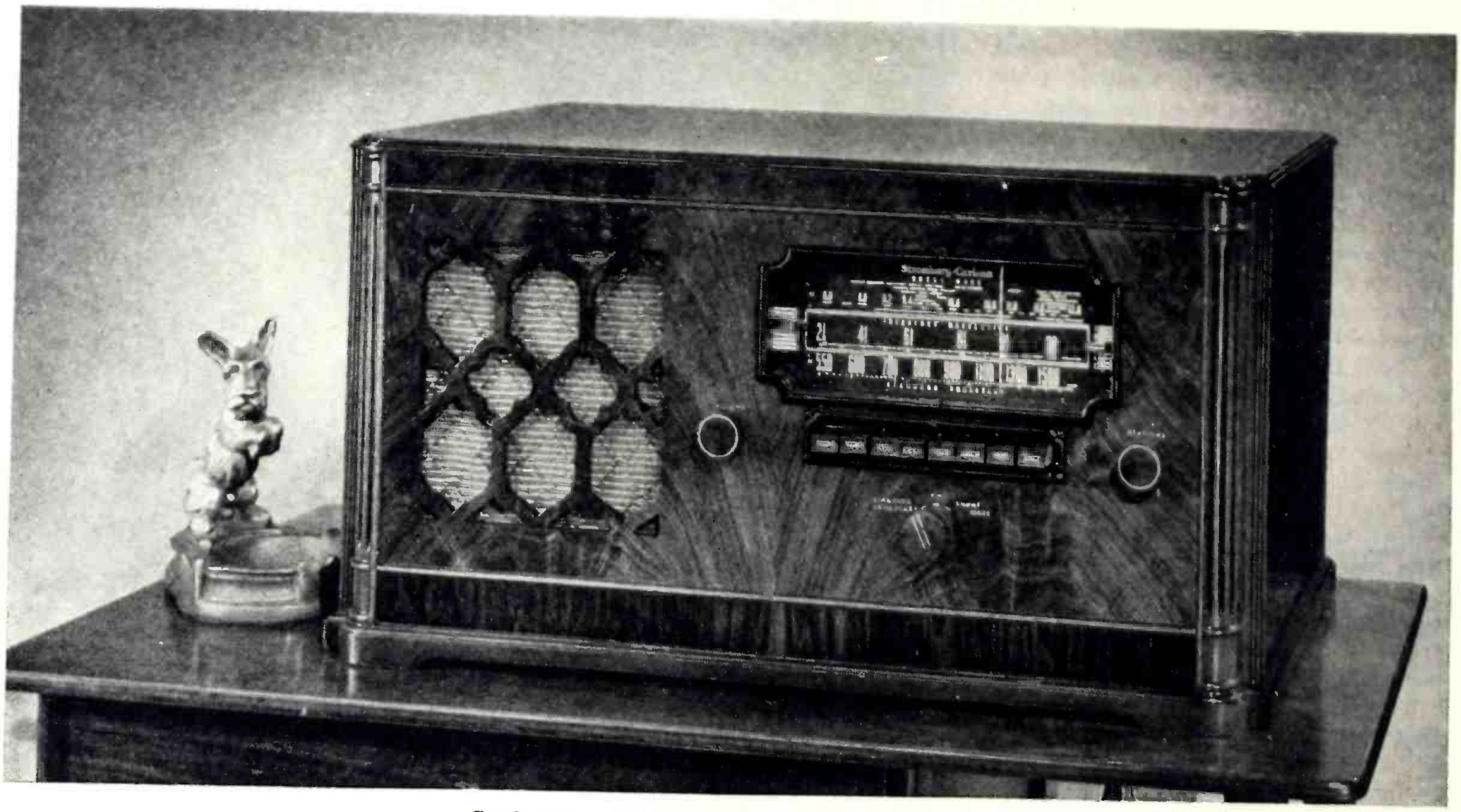


Fig. 12. Timer unit employing counter circuit for developing increments.



Combination AM-FM-Short Wave radio receiver.

FM RECEIVER DESIGN CONSIDERATIONS

By V. G. MARTIN
Design Engr., Stromberg-Carlson Co.

Some factors which must be taken into consideration in the design of quality FM receivers.

THE construction of broadcasting stations for the transmission of programs through the medium of frequency modulation (FM), and the introduction of radio receivers designed to receive these programs constituted one of the important phases of the radio broadcast art in the period immediately prior to the war. All indications point to a large increase in the number of such transmitting stations after the war with the consequent demand for radio receivers in a wider market. Because these transmissions are radiated at frequencies heretofore not commonly used for broadcast purposes (42-50 mc.) and because the design requirements of apparatus used to receive these transmissions are peculiar to a new art, this discussion is presented.

Standards of Design

To take full advantage of frequency modulation principles, there are a number of fundamental considerations [1] confined to FM reception in addition to other considerations common to reception by either FM or amplitude modulation (AM) that must be heeded. At the outset, this discussion will be on the basis that transmission is by wide band FM under present-day regulations of the Federal Communications Commission.

Quiet reception by FM through reduction of electrical noise and interference is made possible in large part by the use of a limiting tube and circuit which acts to remove disturbing AM components in the received and amplified wave and leave undisturbed the desired FM components. The characteristic of this device is shown in Fig. 3 where it is observed that beyond a certain value of input voltage the changes in amplitude due to noise or other amplitude effects give rise to little change in output, thus cancelling largely their disturbing effects. Changes in frequency introduced as a result of FM are passed through the limiter with no change in form.

From Fig. 3, however, it will be noticed that a relatively large value of radio frequency (r.f.) voltage (as the radio receiver engineer views it) is required to bring about this limiting action. This is a restriction common to vacuum tubes presently available. In order to arrive at the desired degree of noise reduction through limiter action, it is necessary, therefore, to provide r.f. amplification sufficient to raise the value of voltage intercepted by the antenna to an amount sufficient to cause limiter operation. Since the amount of amplification is confined to the limitations of vacuum tubes and associated circuits, it may be concluded that effective reception to an exceedingly low value of intercepted antenna voltage is possible with present-day components and to a degree far in excess of that realized in conventional AM design. This is, indeed, one of the very valuable properties of this system of FM transmission. Fig. 5 illustrates the voltage gain distribution in a well-designed type of broadcast receiver for the FM band. The term "sensitivity" serves to define the overall voltage amplification provided.

Having provided limiting action for noise reduction and sufficient sensitivity for adequate limiting and quiet reception, it is now necessary to introduce means whereby the desired station may be received and the undesired stations eliminated as a source of interference. The regulations of the FCC, previously referred to, restrict each station to a band of frequencies plus and minus 100 kc from an assigned carrier frequency and require that modulation effects be confined to a band plus and minus 75 kc from the assigned frequency. This regulation automatically defines the selectivity characteristic of the radio receiver, requiring it to pass a band of frequencies 150 kc. wide and attenuate rapidly thereafter so as to be unaffected by the presence of stations in the adjoining channels. Figure 6 shows the ideal selectivity characteristic as well as a practical characteristic realized in well designed broadcast receivers.

The output of the limiter is the desired FM signal substantially free of disturbing impulses. It is now necessary to derive the a.f. components from the frequency modulated wave. This is done by means of an FM detector termed a discriminator in which frequency changes at the input of the device result in direct current changes at the output which are directly proportional to the a.f. modulation at the source.[2] A typical discriminator characteristic is shown in Figure 2. Here it will be observed that its characteristic fulfills the band-pass requirements in that a linear relation of input frequency change and output current change is realized to a value beyond plus and minus 75 kc. from the carrier. This insures distortion-free detection.

The fidelity of reproduction in a well-designed frequency modulating receiver is limited only by the capabilities of the audio amplifier and acoustic system associated with the receiver. The phenomenon of high audio frequency attenuation by r.f. selective circuits as commonly experienced in receivers designed for AM is not present in any degree in FM receivers. This is due, of course, to the fact that frequencies at the extremes of the band represent those caused by high modulation levels at the transmitter and may be of any value in the a.f. spectrum. Attenuation of these

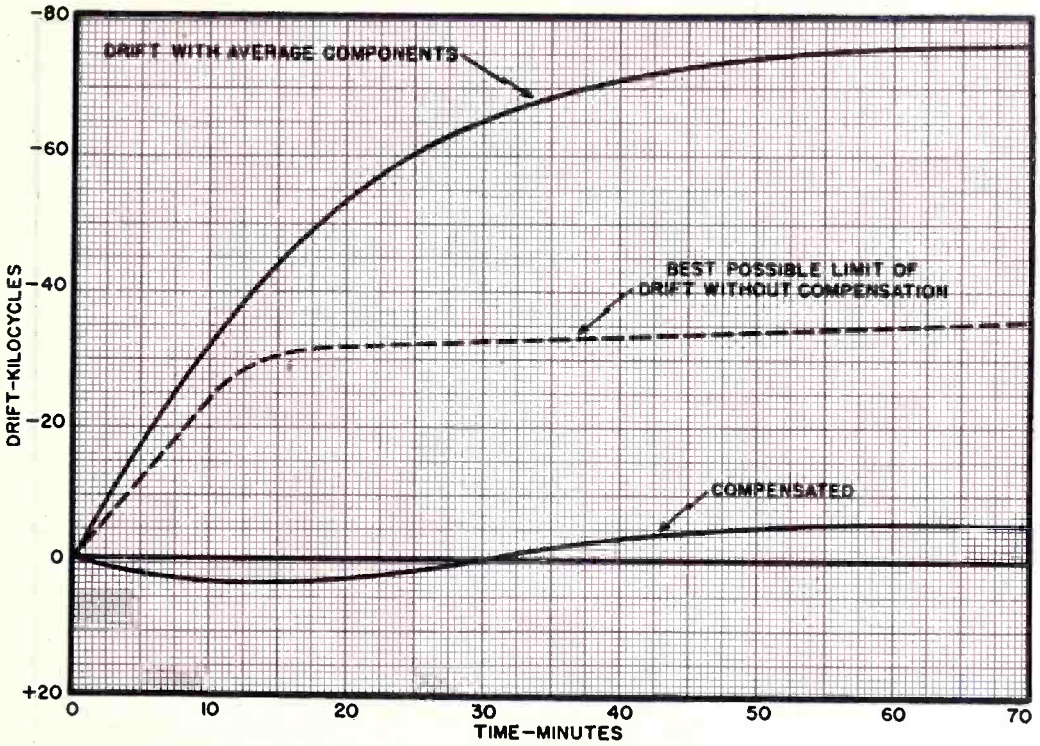
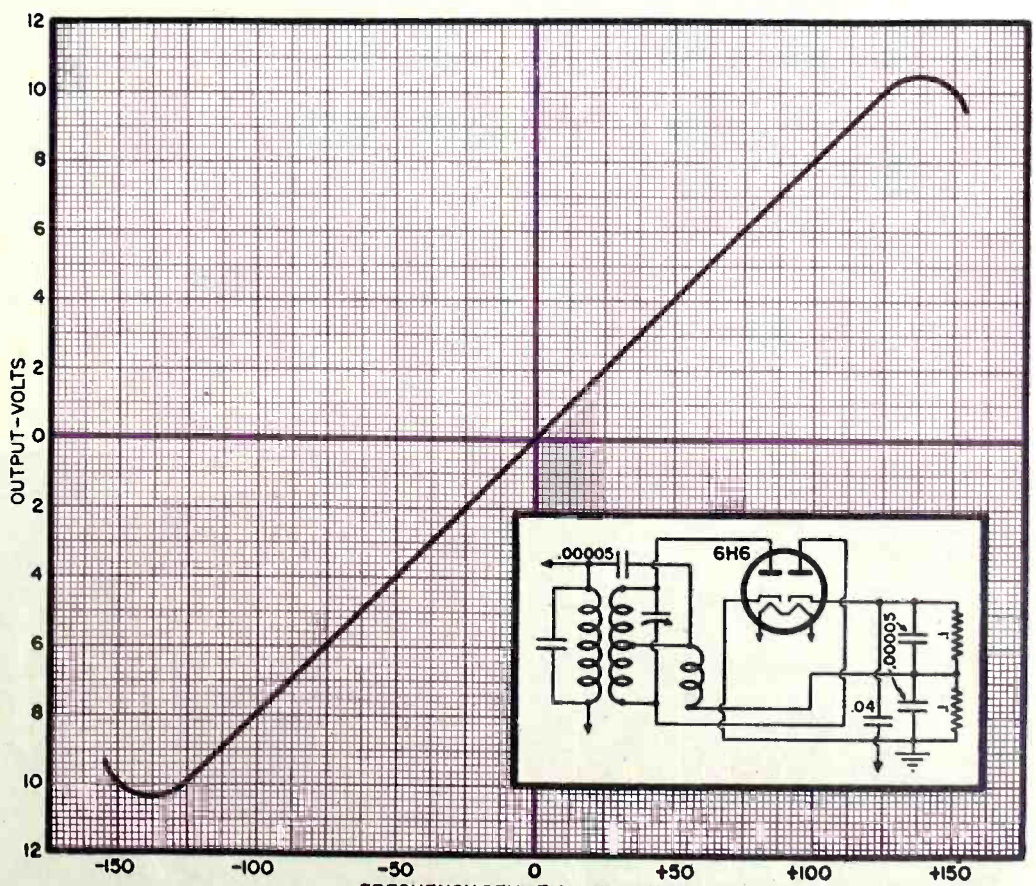


Fig. 1. Frequency drift in uncompensated and compensated oscillators.

frequencies by excessive r.f. selection will give rise to phase shifts through the r.f. amplifier with consequent distortion. Experience has indicated that attenuations at the extremes of the band to a value of 6 db may be tolerated as the consequent distortion is not appreciable to the careful listener. It is the practice, therefore, to design so as to allow reproduction of a.f. to an upper limit of 10,000 cycles per second. This is the limit of reproduction in conventional loud speaker systems. Using specially designed loud speaker systems, an overall reproduction of a.f. to a limit of 15,000 cycles per second has been attained. Suffice to say that high fidelity reproduction is a normal by-product of reception by FM.

The high sensitivity customarily designed into FM receivers will result, in the absence of a received carrier, in an excess of noise caused by fluctuation effects in tubes and associated circuits as well as by the antenna pickup of electrical disturbances usually present. These effects are observed when tuning between stations and are

Fig. 2. Typical discriminator circuit (insert) and characteristic.



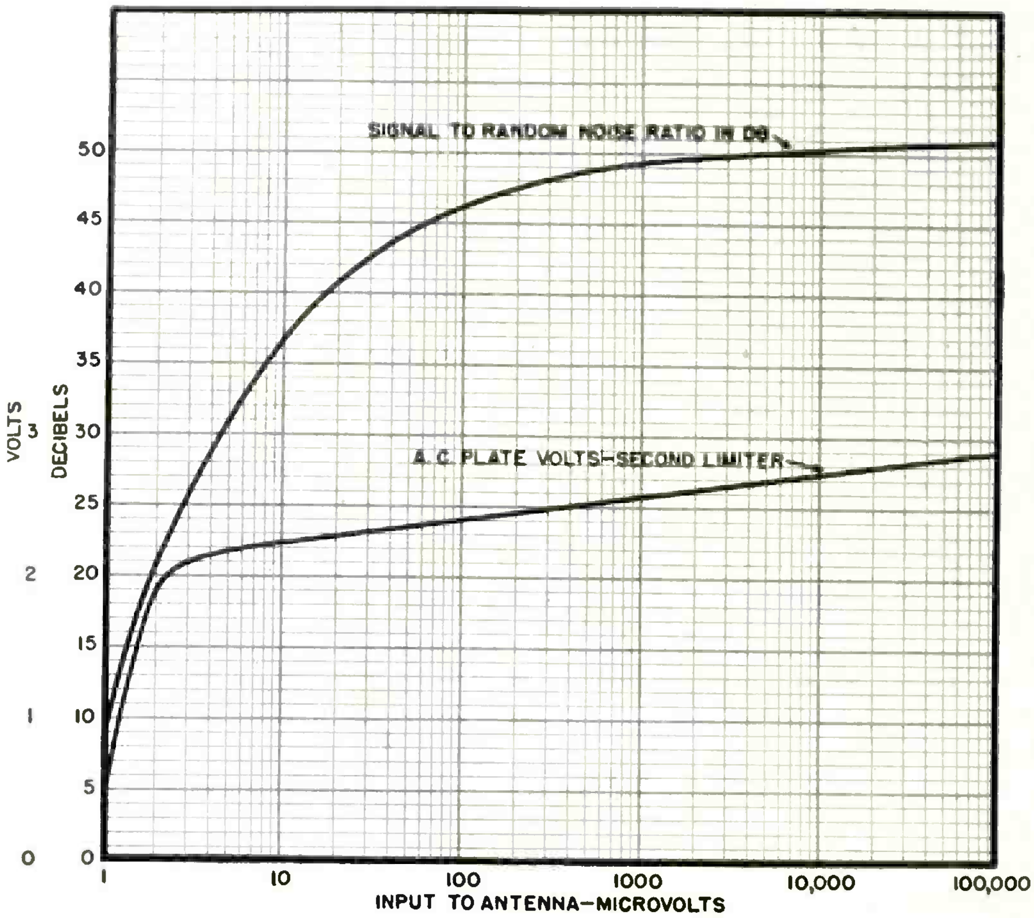


Fig. 3. Limiter characteristic, showing variation in limiter output with antenna input.

annoying to the user of the receiver. It is good practice to design means in the receiver whereby these disturbing effects are nullified. Details of several possible methods are given later in the article.

The ability of an FM receiver to retain an adjustment to a broadcast station, once this adjustment is properly made by the user, is an important characteristic in design. The deviation or drift of the receiver from exact tune results in distortion similar to that previously described for excessive selectivity. In this instance, the transmission characteristic of the receiver is no longer symmetrical about the desired carrier wave. Distortion is, therefore, a function of the deviation of the receiver from exact tune.

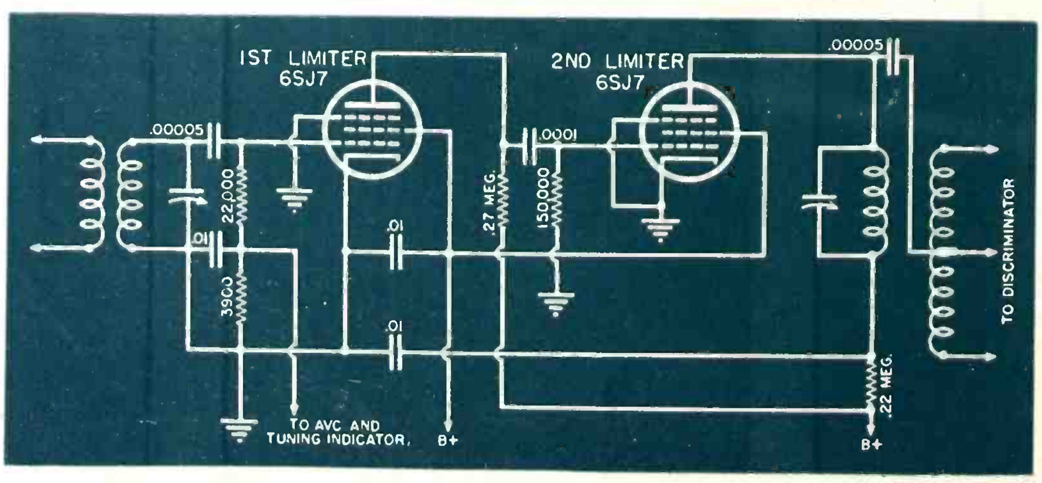
The introduction of an FM band incorporating the characteristics outlined above should not compromise any of the accepted standards of performance of the AM band. The required voltage gain of about 2,000,000 times between antenna and limiter on FM, coupled with low gain per stage caused by high operating frequencies, and broad i.f. transformer design, necessitates many high mutual conductance tubes in cascade. Having designed for best FM performance, it is a difficult matter to eliminate distortion on the standard broadcast band using conventional high mutual conductance tubes. As is the case in many designs, the engineer is faced with the problems of making the best possible compromise.

The sensitivity of the receiver to FM signals should be made as high as possible in order to make the greatest use of the broadcasting station coverage. An antenna sensitivity of one microvolt is readily obtained in a single-band FM receiver with generous use of high mutual conductance tubes, but is not as simply obtained in a combination AM-FM receiver. High mutual conductance tubes operating at best efficiency are characteristically sharp cut-off which makes for poor automatic volume control action on the standard broadcast band which in turn causes r.f. distortion at the high antenna voltages experienced in the vicinity of powerful broadcasting stations. The use of one remote plate current cut-off tube or the operation of one or two high mutual conductance tubes with series screen resistors to extend the cut-off point is possible with consequent reduction in gain. It was experimentally determined that a type 6SK7 tube (remote cut-off and average gain) used in the first i.f. stage, actually resulted in more stage gain with its lower grid-plate capacity at 4.3 mc. i.f. than a type 6AB7 or type 6AC7 with a series screen resistor to extend cut-off. A 6SG7 or 6SH7 tube with appropriate circuit constants would give further improvement. Loss in long leads to the switch used for changing from AM to FM also reduces gain. Therefore, in order to attain FM sensitivity of the order of 1 or 2 microvolts, in a combination AM-FM receiver, special emphasis must be given to the design of r.f. and i.f. transformers and to the disposition of circuit components to obtain the greatest efficiency.

If the FM band is extended to include 42 to 56 mc. the intermediate frequency will undoubtedly be increased to 8:25 mc. in order to keep the image outside the band. An increase in frequency represents a potential loss in gain per stage because of (1) lower inductances in the coupling transformer resulting in lower tube loading impedances, (2) increased coupling through the plate-grid capacitance, and (3) low circuit efficiency because of increased r.f. resistance. To keep the inductances as high as possible, a lower value of tuning capacitor may be chosen, but it should not be made so small as to permit tube and other incidental shunt capacitance to be a large part of the total capacitance. Too small a trimmer capacity would allow mis-tuning with tube temperature changes and tube replacement.

Instability is always a limiting factor in stage gain. If all stray circuit paths are eliminated, the theoretical stage gain cannot be realized, particularly at high frequencies, but must be held to a value where feedback through the tube plate-grid capacitance does not seriously affect the symmetry of the selectivity curve. The best amplifier tube for FM would

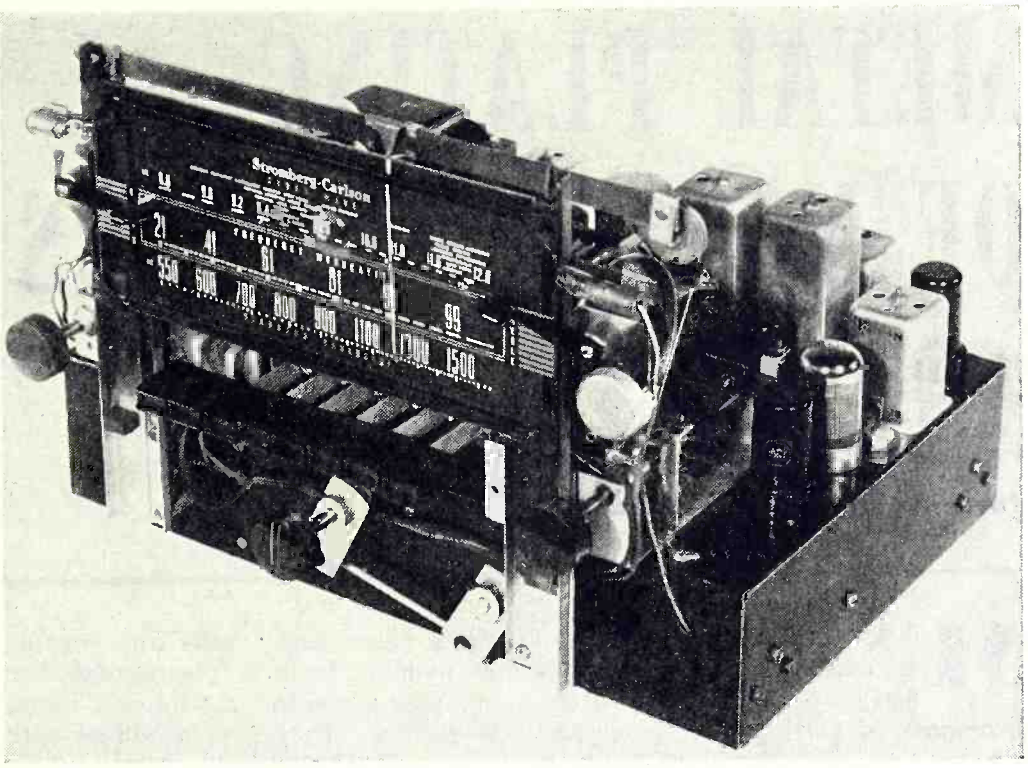
Fig. 4. Schematic diagram of a typical double limiter circuit.



be one with the highest mutual conductance and the lowest grid-plate capacitance with consideration given to its AVC characteristic on the AM bands.

Selectivity describes the ability of a receiver to provide a desired signal free of interference from other signals. The number and quality of the tuned circuits and the choice of the intermediate frequency determine the degree of selectivity. One type of interference is minimized by making the i.f. a value slightly more than half the range of the FM band so that the image falls outside the band. The i.f. tuned circuits, more than the r.f. or pre-selection tuned circuits, determine adjacent channel selectivity because of the larger number of tuned circuits in the i.f. amplifier. While interference between stations on adjacent channels does not usually exist with good receivers, the increase in the number and power of FM stations may require better selectivity. An increase in i.f. from 4.3 mc. to 8:25 mc. for the proposed extension of the FM band presents a problem in obtaining adequate selectivity because the higher frequency reacts in several ways. First, the circuit Q, or efficiency, would be less. Second, doubling the frequency would double the width of the pass band, even if the Q remained the same, since for a given Q the ratio of pass-band to center frequency is a constant. And third, feedback through the plate-grid capacitance, which is regenerative on one side of resonance and degenerative on the other, would have a greater effect on symmetry of the selectivity characteristic. The desired selectivity characteristic is one which passes all frequencies equally well within a range of 75 kc either side of resonance (the maximum FM swing) yet gives as much attenuation as possible beyond.

As stated before, the tuned circuits of the r.f., or pre-selection stages, contribute little to adjacent channel rejection, their main function being the rejection of spurious responses. When a station is heard at more than one setting of the dial, the additional points are called spurious responses. A spurious response is created by a combination of harmonics of the signal and oscillator frequencies in the modulator to produce a resultant frequency equal to the receiver i.f. The response nearest in frequency to the resonance point of the receiver is the strongest. Whether or not the degree of rejection attained at present will be adequate with the anticipated increase in number and power of stations is difficult to determine, but some indication could be obtained by surveys in the vicinity of existing high power FM broadcast stations.



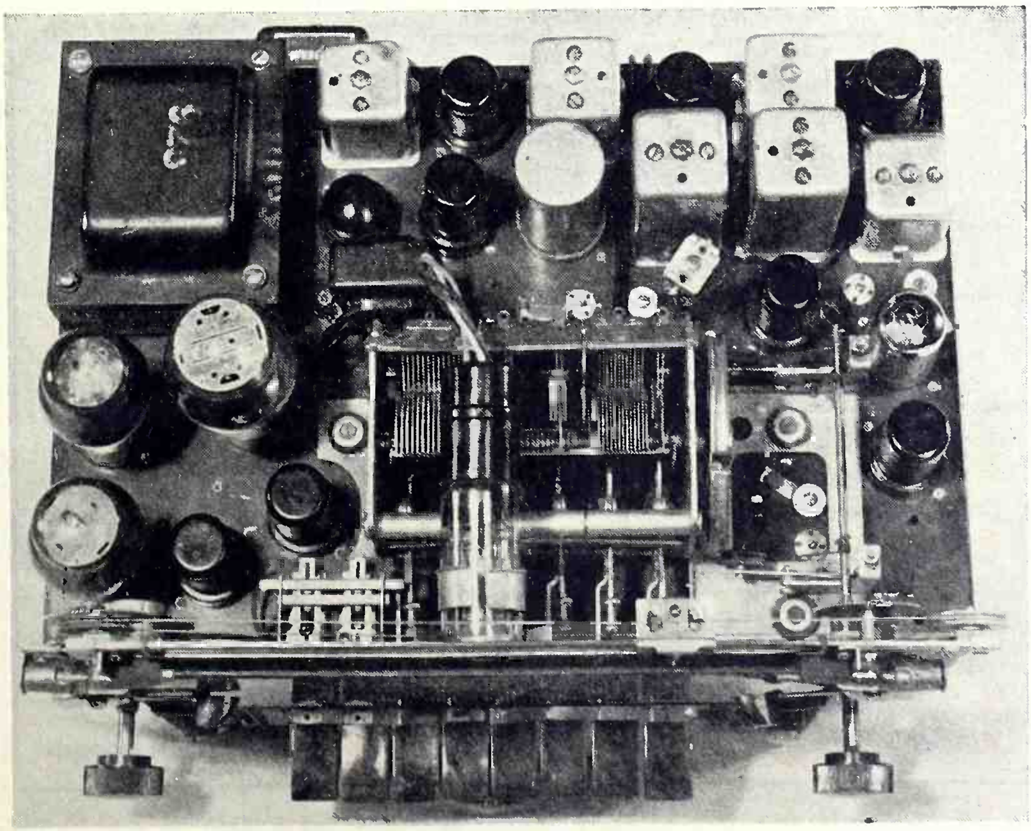
Chassis of combination AM-FM-Short Wave receiver.

To show, for example, how a 45.1 mc. signal would appear at 47.25 mc. on the dial with a 4.3 mc. i.f., it may be assumed that the oscillator is tracking on the low frequency side of the signal or at a frequency of 42.95 mc. The second harmonic of the undesired signal (90.2 mc.) minus the second harmonic of the oscillator (85.9 mc.) produces 4.3 mc. or the intermediate frequency. Other spurious responses are determined by similar combinations. The proposed 8.25 mc. i.f. would double the frequency separation between responses and the resonant frequency, and hence would improve the rejection.

Improved oscillator stability is a subject which should receive attention. During the period of an hour after a receiver is turned on, the oscillator progresses to a lower frequency and if this "drift" is large, the station to which the receiver was originally tuned may be well out of tune in a few minutes. The causes of drift and the measures for its correction are

(*Continued on page* 28)

Top view of chassis of receiver pictured above.



METAL PLATING OF NON-CONDUCTORS

By D. FIDELMAN

Various methods for plating metals on non-conductors and some of the applications of this art.

MANY phases of electronic design are considerably simplified by the application of the techniques of plating metals on non-conducting surfaces. The process of plating non-conductors makes available to the electronic industry a group of materials combining the advantages of non-conductors with the desired properties of metals.

The design and construction of many complicated assemblies can be made much simpler, at the same time saving weight, space, time, and conserving critical materials. For example, electrostatic shielding can be accomplished by means of a separate metal shield. In this manner it is also possible to construct electrical contactor units, and hermetically sealed bushings.

Many small parts which ordinarily are made of solid metal can be fabricated much more easily and cheaply by molding them of plastic and then applying a coating of whatever metal is desired. They can be plated with any metal that can be electro-deposited. A number of such applications are already standard in military equipment. Aircraft antennas are being made of impregnated wood upon which is plated a film of metallic copper. The loop antenna coil is being put into a plastic housing upon which is plated a metal coating to act as an electrostatic shield. Similar techniques have long been of great importance in making possible the large-scale production of commercial recordings. Many other possible applications will suggest themselves immediately to anyone who has the problem of designing radio and electronic equipment for either military or post-war civilian applications.

In view of the many possible applications, it is quite important that anyone designing component parts be familiar with the techniques of plating metallic films on dielectric surfaces. The purpose of this article is to present a survey of the available techniques of performing this process, in order to facilitate their application to specific problems that are encountered in practical design.

The methods of depositing metals on non-conducting surfaces fall into three general categories:

1. Vacuum deposition,
2. Chemical deposition,
3. High-temperature deposition.

Each of these methods has its own particular advantages and disadvantages, which will be clearly indicated.

Until very recently, the vacuum deposition methods were the most widely used for scientific applications. These methods fall into two distinct categories: (a) cathode sputtering, and (b) evaporation. The basic apparatus set-up for plating by cathode sputtering is shown in Fig. 1. When high voltage (usually ranging from 1000 to 20,000 volts) is applied between the anode and cathode, the cathode disintegrates and a thin film of the cathode metal becomes deposited uniformly upon the surface of the specimen to be plated. Best results are obtained at inert gas pressures ranging from 1 to 10^{-2} mm. Hg.

The evaporation method consists primarily of vaporizing the metal which is to be deposited. This metallic vapor then condenses upon the surface of any object which it encounters within the vacuum. Typical apparatus for accomplishing this is shown in Fig. 3. The metal is evaporated by placing small bits of it into a small crucible, which must necessarily be of some material of much higher melting point than the metal to be distilled. A heating coil or any other suitable means (for instance, high-frequency induction heating) is used to raise the temperature of the crucible to a point

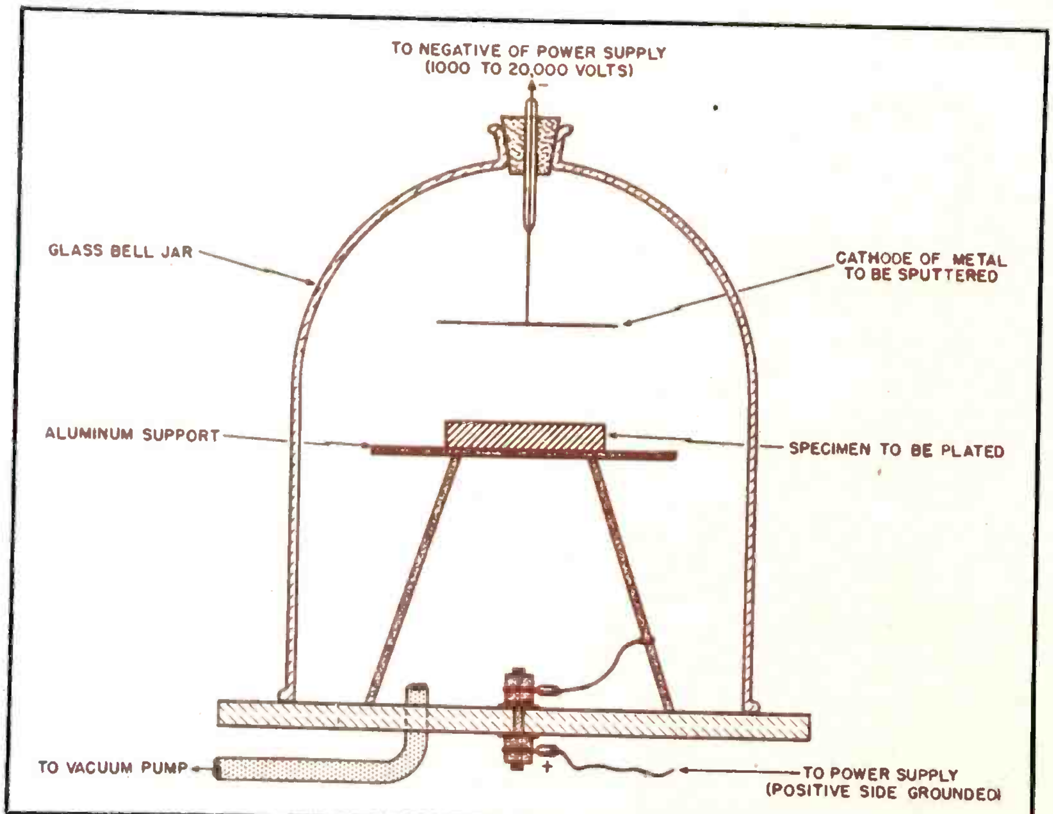


Fig. 1. Apparatus set-up for cathode sputtering of non-conductor.

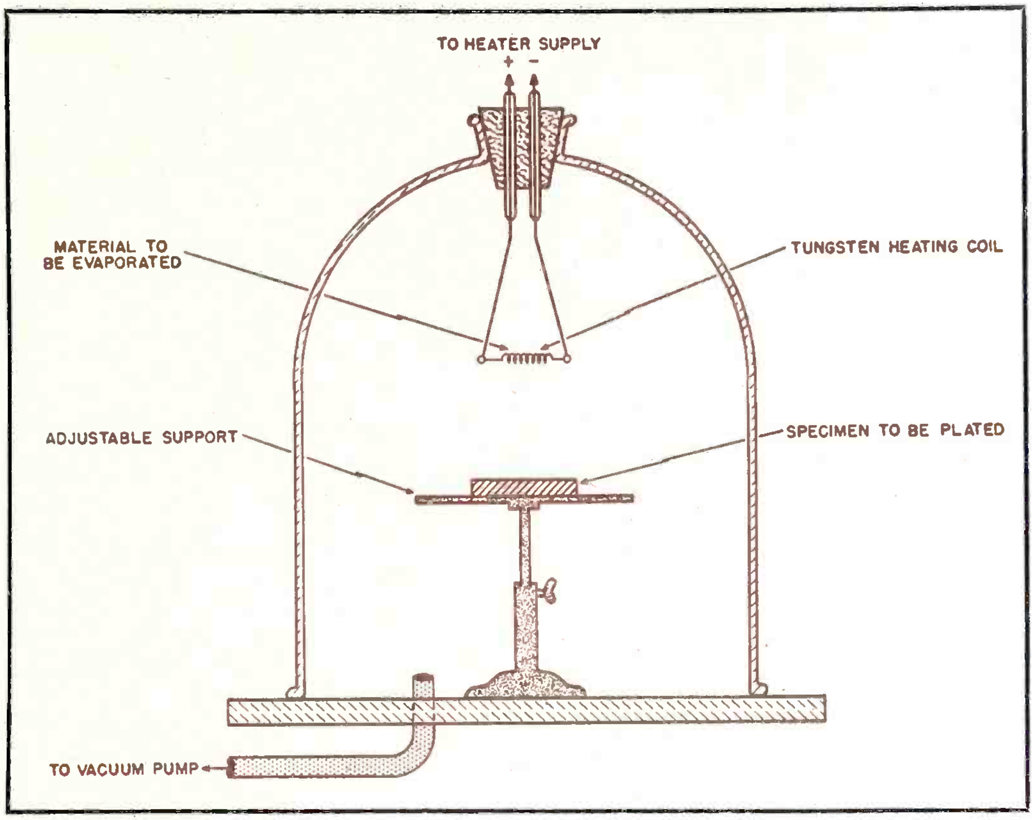


Fig. 3. Apparatus set-up for metal plating by the evaporation process.

necessary for vaporization of the metal. An alternate method of vaporizing the metal is to electroplate it upon a filament of some material such as carbon, molybdenum, or tungsten; when the filament is heated by current passing through it, the plated metal vaporizes and fills the space inside the vacuum chamber. The object to be plated is set upon a glass platform supported upon a movable clamp which may be raised or lowered to the optimum position. The evaporation process should be performed in a vacuum of 10^{-3} mm. Hg., or better.

Vacuum deposition methods are widely used in commercial and scientific applications. In the production of commercial phonograph reproductions, the original recording is first sputtered, then electroplated with a suitably hard metal for use in stamping large quantities of records. Front-surface mirrors which do not tarnish and which have very good reflection characteristics are produced by depositing a film of aluminum on a glass surface. Vacuum methods are also convenient when extremely thin films are desired, thin enough to be used as optical filters and at the same time be electrically conducting. The specimen can be observed through the walls of the bell jar to insure that the deposited film has the proper transparency. Very often it is not possible to use liquid or chemical deposition methods because the specimen is attacked by mild acids or alkalis, or is damaged by immersion. Under such circumstances, vacuum methods are the only ones that can be employed. Another usefulness of vacuum deposition is that it is possible to sputter or evaporate metals which ordinarily cannot be precipitated out of solution. Sputtering is particularly suitable for preparing films of the platinum metals; the evaporation process is suited to the application of aluminum films.

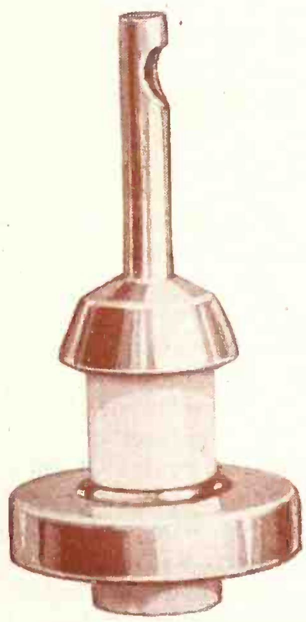


Fig. 2. Ceramic bushing for hermetic solder sealing to metal cover plates.

Unfortunately, the vacuum deposition methods are slow and tedious compared to other methods, and are inconvenient to use when a large number of objects is to be plated, as in production manufacturing operations. In addition, the surface of the specimen must be cleaned very carefully if the metallic film is to adhere well. Because of these objections, chemical plating methods are being substituted in a large number of applications.

In chemical metallizing, the metal film is deposited in a liquid medium rather than in a vacuum. Processes of this type are applicable to any material that is not attacked by mild acids or alkalis. Generally speaking, this includes all the usual organic plastics (bakelite, polystyrene, etc.) and plastic coated substances, and such materials as impregnated wood, quartz crystal, and ceramics. They cannot be applied to surfaces like rock salt, which are attacked by water.

Very often the deposition of the initial metallic film is followed by electrodeposition of a thicker film of some other metal by conventional electroplating methods. The success of this final plating operation depends upon the adherence between the first metal coating and the surface upon which it is deposited, and considerable care must be taken in the preparation of the specimen and in the deposition process.

The first step is to roughen the surface which is to receive the plating. This is done by means of coarse pumice, sand blasting, or etching agents, and enables the metal coating to have

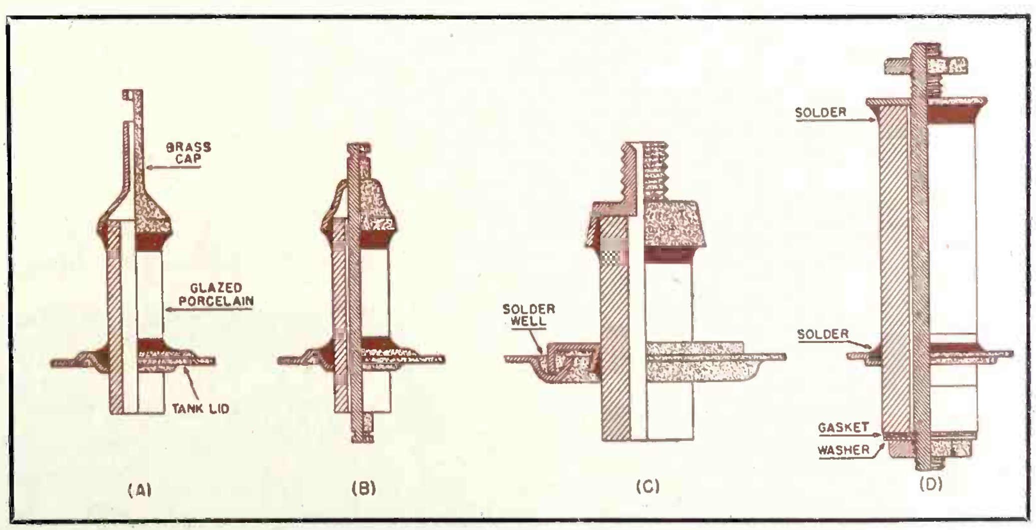


Fig. 4. Detailed construction of solder-seal ceramic and glass bushings.

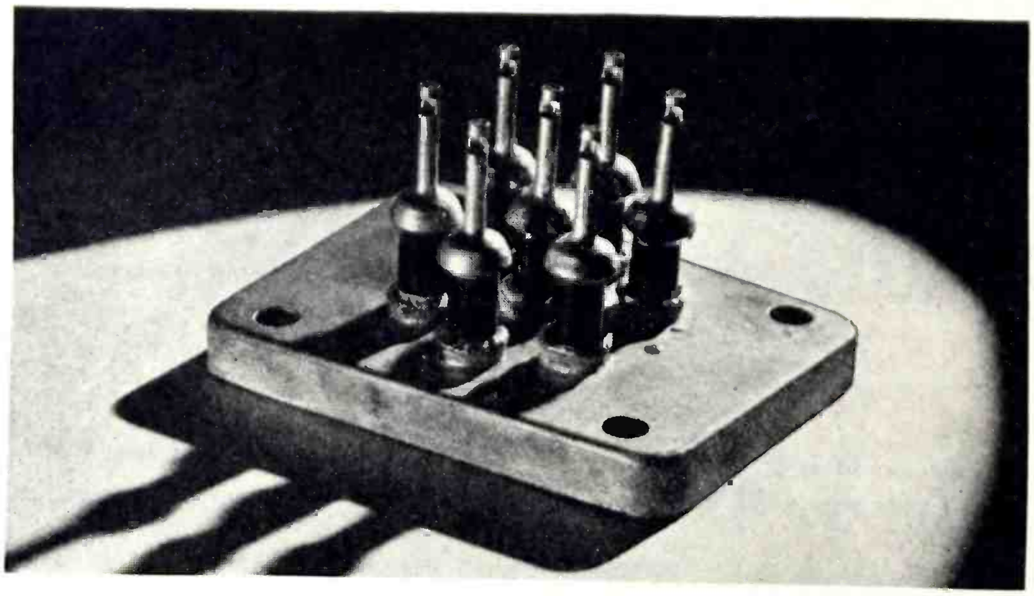


Fig. 5. Transformer cover plate assembly using solder-seal porcelain bushings.

increased adherence. The second step is cleaning the surface to remove dust, oil, dirt and any other foreign material. This can be done by such cleaning agents as carbon tetrachloride, caustic soda, or borax. The surface must be very clean to avoid interference in the adherence of the metal film.

The metallic film is formed on the specimen by bringing two chemicals together at the surface of the object. This can be accomplished either in solution in a liquid medium, or by spraying the object. The materials used in the process consist essentially of a metal salt solution and reducing agent. The reducing agent chemically reduces the metal salt to yield the pure metal, which deposits on the surface to be plated. Surfaces which are not to be plated must be masked by some means such as Scotch tape or a rubber mask. The details of two commonly used processes for applying metallic silver films are given in Table 1. Brashear's process takes, on the average, from 6 to 10 minutes for a full silver coat. Silver is deposited much more slowly by the Rochelle salt process; an hour may be required for a thick deposit to form. Other solutions than those given in the table can also be used, but these are mostly patented solutions and are not available for general use.

Copper can also be deposited in a somewhat similar manner. This is done by reducing a copper chloride solution to which have been added slight amounts of zinc chloride and gold chloride, with either Rochelle salts or cane sugar.

Chemical methods are especially applicable to depositing metallic films on surfaces such as plastics and lacquers. In such cases the chemical properties of the surface can be utilized to provide increased adherence of the metal deposit. When metallizing casein condensation products, or albuminous products, the swelling action of water makes possible its use as a roughener. On urea-formaldehyde products, the surface may be roughened by immersion in 10 per cent HCl solution. In general, improved results are obtained if the surface is primed with stannous chloride before the plating operation.

Special methods of metal plating, requiring the use of high temperatures, are available for use on glass and ceramic materials. The process can be used for any of the noble metals, which are reduced by heating.

In applying a metal coating to a glass surface, the glass is first coated with an oily solution of one of the metallic salts, and then subjected to a high temperature. The high temperature causes the oil to burn away, and the salt is reduced, leaving a smooth film of metal on the surface of the glass. Further heating to the softening point of the glass causes the metal to be partially dissolved into the surface of the glass, forming a very strongly adherent bond between the glass and the metal. The detailed process for plating a film of platinum on a glass surface is given in Table 2. Other solutions for gold, silver, and iridium are also available commercially.

In one process for metallizing ceramic materials such as porcelain, the first step is to paint gold and platinum in colloidal form in varnish on the surface of the porcelain. The painted

(*Continued on page* 36)

TABLE I

Details of processes for chemically depositing a metallic silver film.

Brashear Process

Silvering Solution	Reducer
(a) 300 cc water, 20 g. $AgNO_3$ (b) NH_4OH Ammonia (conc.) (c) 100 cc water, 14 g. KOH (d) 30 cc water, 2 g. $AgNO_3$	(A) 1 liter water 90 g. table sugar 4 cc HNO_3 (conc.) 175 cc alcohol Age for 2 weeks or a month.
1. Pour ammonia into solution (a) until a dark brown precipitate of silver oxide forms and begins to clear. 2. Add ammonia drop by drop until solution just clears. (Disregard small specks.) Stir well between drops near the end. 3. Add solution (d) drop by drop until the solution is a distinct straw color. This is to avoid excess ammonia. 4. (CAUTION. From here on use goggles, since there is danger of an explosion.) Add all of the solution (c) slowly and stir constantly. 5. Add ammonia, a dropper-full at a time and finally a drop at a time, until the solution just clears. 6. Add solution (d) drop by drop until there is a thin straw-colored or brownish precipitate. (Disregard small specks.) 7. Filter through cotton.	(B) 120 cc water 11 g. table sugar 4.8 cc HNO_3 (conc.) Boil and cool. Ready for use. (C) 120 cc water 7.8 g. dextrose Ready for use.

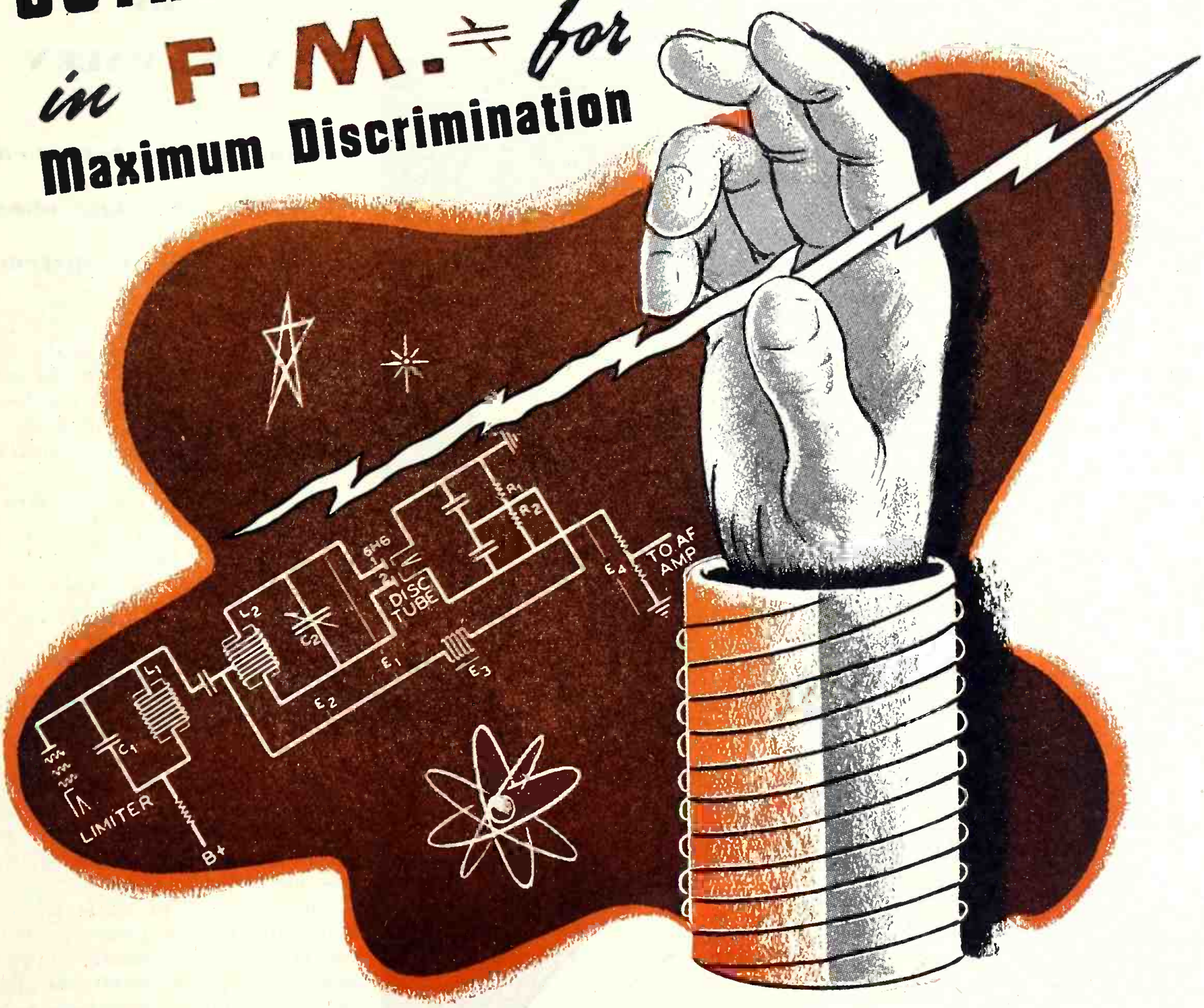
Add 120 cc of reducer (A), (B) or (C) to silvering solution and pour immediately over the objects to be plated.

Rochelle Salt Process

Silvering Solution	Reducer
(a) 300 cc water, 5 g. $AgNO_3$ (b) NH_4OH Ammonia (conc.)	1. Form solution of: 500 cc water 1 g. $AgNO_3$ 2. Bring to boil and add: 0.83 g. Rochelle salt (dissolved in a little water.) 3. Continue boiling until a gray precipitate is formed. 4. Filter while hot, and dilute to 500 cc. (Solution may be stored for a month if protected from light.)
1. Pour ammonia into solution (a) until dark brown precipitate of silver oxide forms and begins to clear. 2. Add ammonia drop by drop until solution just clears, stirring well between drops near the end. 3. Add dilute solution of $AgNO_3$ drop by drop until the solution is a distinct straw color. 4. Filter and dilute with water to 500 cc. (Solution may be stored for a month if protected from light.)	

Mix silvering solution and reducer in equal volumes and pour immediately into vessel containing the objects to be plated.

GUTHMAN *Discriminator* COILS in F. M. for Maximum Discrimination



FREQUENCY MODULATION receivers require linear discrimination against undesirable signals. Guthman engineers have developed precise **DISCRIMINATOR COILS** to discriminate equally on both sides of the resonance curve, providing maximum discrimination.

GUTHMAN *Leader in Inductronics*

DO YOUR BEST . . . INVEST IN WAR BONDS!

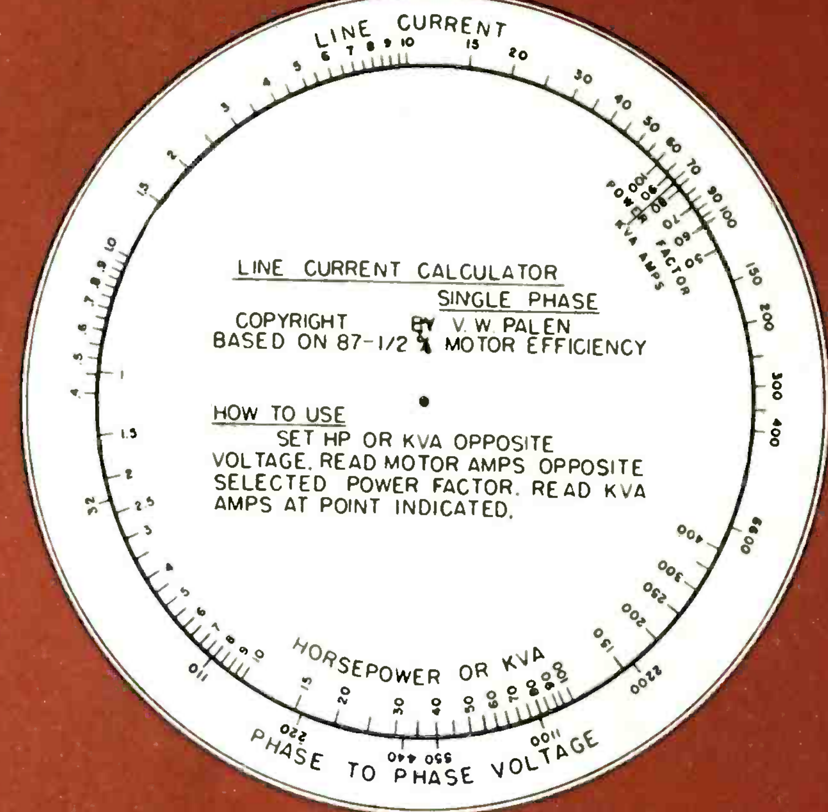
EDWIN I. GUTHMAN & CO. INC.
15 SOUTH THROOP STREET · CHICAGO
PRECISION MANUFACTURERS AND ENGINEERS OF RADIO AND ELECTRICAL EQUIPMENT

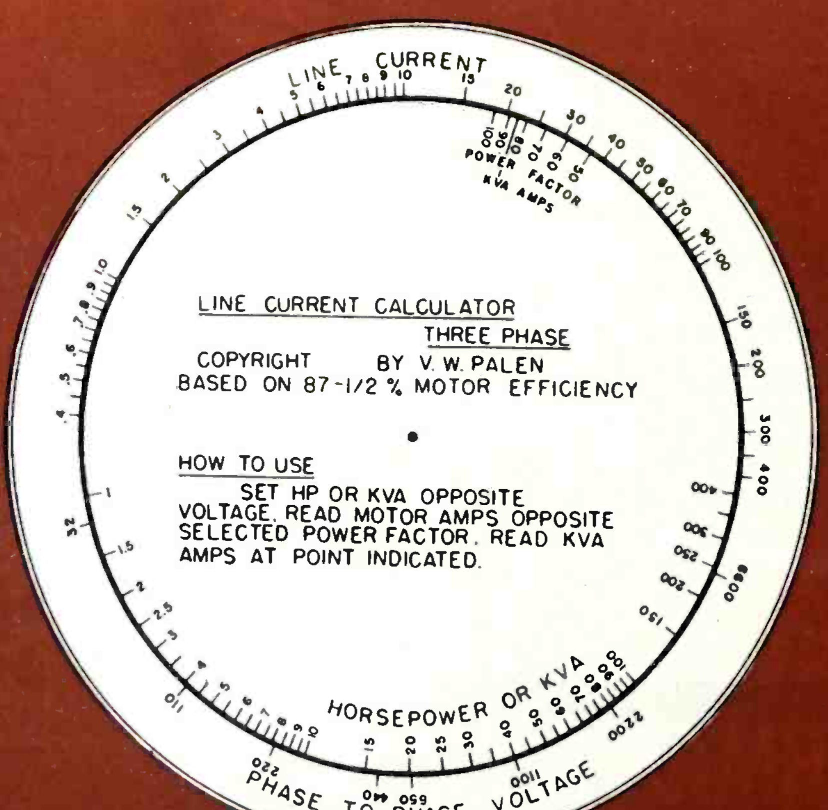
Power Line Current Calculator

By

V. W. PALEN

A power line current calculator for single phase and three phase systems.





PLANT engineers and electricians will find this Line Current Calculator useful for quickly determining amperes that will flow in motor and transformer circuits.

The single phase unit solves the equations:

$$I = \frac{H_p \times 746}{E \times PF \times Eff.}$$

(for motor current)

$$I = \frac{Kva \times 1000}{E}$$

(for transformer current)

where: E = voltage between line wires
PF = power factor
$Eff.$ = efficiency—87.5% assumed

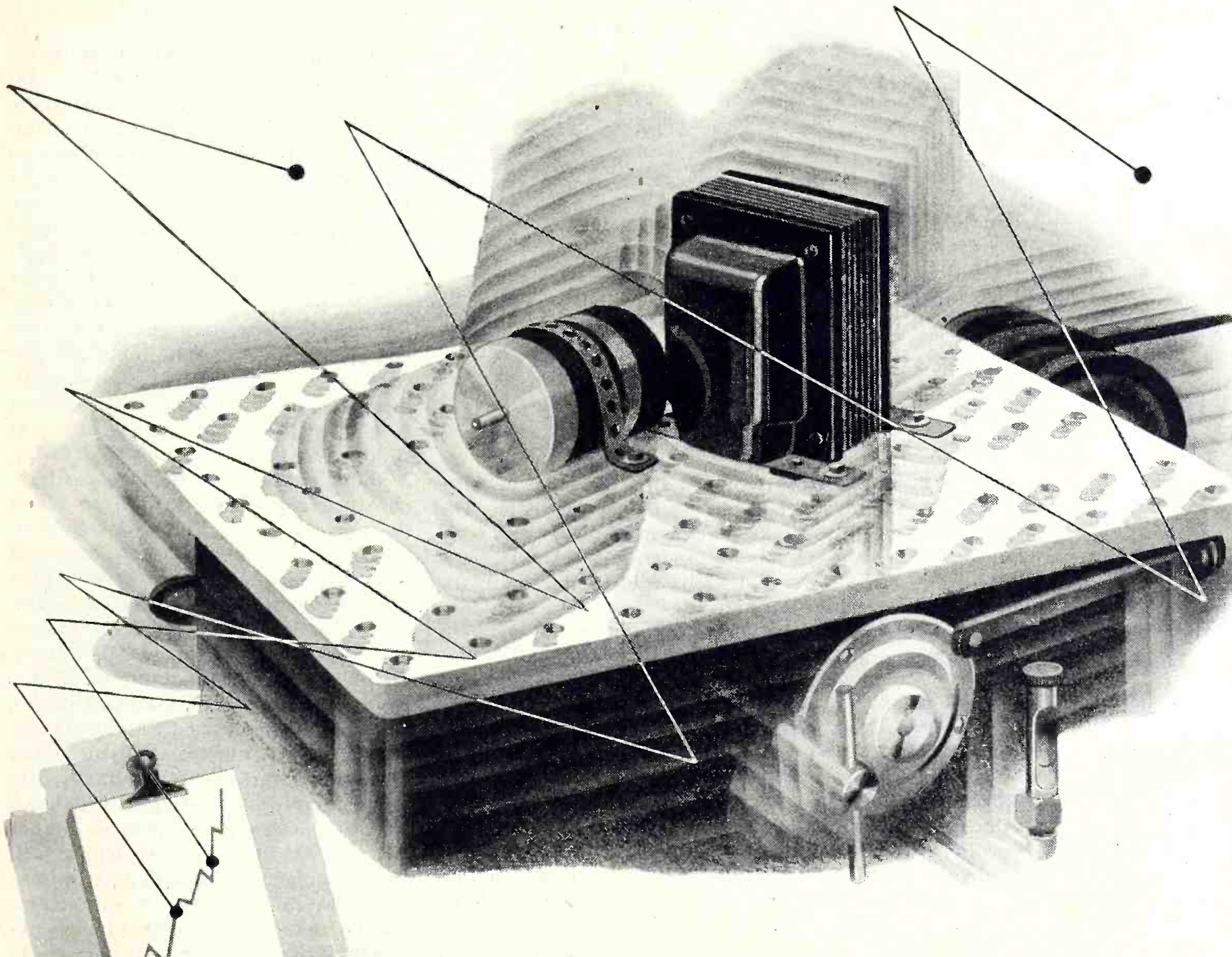
Three phase equations solved by the three phase unit are the same as above except that the denominator of the fraction includes radical 3.

Suppose a 5 h.p. single phase 220 volt motor is to be installed. Set the dial accordingly, assuming 80 per cent power factor; opposite 80 read approximately 24 amps. Now suppose a 15 kva. three phase 440 volt transformer is to be installed. Set the dial properly; opposite kva. amps. read approximately 20 amps. With the line current thus determined, proper wire size can be selected to carry the load.

Several voltages that are seldom used around plants are included for the convenience of those who might have occasion to utilize them.

Assembly

Cut along the inner and outer circles to make two rings and two discs. Mount these pieces on separate pieces of cardboard using rubber cement. Punch the center holes carefully. Insert brass bolts (with washers) to hold the parts together. Add nuts to the bolts and tighten. The discs should turn easily yet hold their setting. A drop of solder on the nuts makes the assemblies permanent.



Personals

R. J. BIELE has been appointed assistant engineer of the Receiver Division of the General Electric Company's Electronics Dept. He will be located at the company's Bridgeport plant. Mr. Biele joined General Electric in 1935 after graduating from the University of Utah with an electrical engineering degree. His work had been in the receiver division exclusively. He is an associate member of the A.I.E.E. and I.R.E.

JOHN F. DRYER, JR. has joined the staff of Amperex Electronic Products as an electronics engineer. He will devote himself to the development of power and control tubes for use in industrial applications. Mr. Dryer's most recent position was with Fairchild Engine and Airplane Company where he helped to develop a high frequency heating unit used in fabricating wooden parts and for thermosetting of glues.

G. KEITH FUNSTON, former director of purchases at Sylvania Electric Products Co., was elected president of Trinity College in Hartford, Conn. This 33-year-old business man has been granted a leave of absence from the college to serve as a Lt. Cmdr. in the Navy. He graduated from Trinity College in 1932 where he was a Phi Beta Kappa, and from Harvard Business School. He is now on duty in Washington, D. C.

WALTER F. KEAN will be in charge of the new field engineering and allocation service now being offered to the FM and Standard Broadcasting industry by Andrew Company of Chicago. Mr. Kean comes to Andrew from the Western Electric Company where he was in charge of testing radio and radar projects. He is an associate member of the A.I.E.E. and I.R.E. Broadcast executives are welcome to use his services.

RICARDO MUNIZ has joined the Espey Mfg. Co. as director of engineering. Until recently Mr. Muniz was chief engineer of Radio Navigational Instrument Corporation. He has authored several technical books as well as numerous articles on radio and television circuits. He taught radar and directed classes in radio design and development at Hunter College, New York. Mr. Muniz speaks Spanish and French fluently.

DR. ELLIS R. OTT has resigned as associate professor of mathematics at the University of Buffalo to accept the position of assistant to the Director of Engineering of the National Union Radio Corporation. Dr. Ott will devote his time to statistical quality control problems at National. He is the author of several mathematical texts as well as numerous articles which have appeared in leading technical journals.

Receiver Design

(*Continued from page 21*)

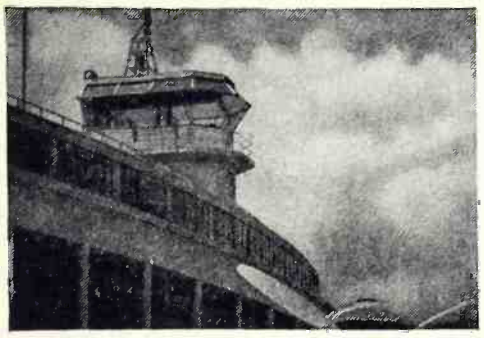
well known. Any component in the oscillator circuit whose capacitive, inductive, or resistive characteristic changes even slightly with heat or humidity, contributes to drift. When all normal precautions, including use of air dielectric trimmer capacitors, are taken, the principal remaining causes of drift are the oscillator tube itself and the oscillator coil. Materials having the least dimensional change with temperature or humidity must be chosen for the coil. The tube will contribute the most drift in a good oscillator circuit. The drift will amount to about 0.05% in frequency or about 23 kc at an initial frequency of 45 Mc. A shunt capacitor with negative temperature coefficient is used to offset the normal drift. Figure 1 shows an example of rather considerable drift which is adequately corrected with a 32 $\mu\mu$f thermal compensating capacitor.

The next consideration is the limiter and discriminator stages. An FM receiver is essentially similar to an AM receiver through the r.f. and i.f. stages. Not only is the desired FM signal amplified but all electrical disturbances of an AM character as well. Nearly all the amplitude variations which appear as noise may be removed by addition of a limiter stage which will pass frequency variations but present a "saturated" condition to voltage amplitude changes. This condition is obtained with a sharp cut-off pentode in a grid bias circuit with the plate and screen voltages approximately 2 and 20 volts respectively. Under these conditions an FM signal of 2 or more volts applied to the grid will cause plate current saturation and hence be relatively unresponsive to the grid voltage variations. When the applied FM voltage is less than the limiting value, the limiter acts as an amplifier for AM, and the noise will likely be greater than the signal.

A single limiter cannot suppress noise of the random or sinusoidal type and impulse or shock noise with equal effectiveness owing to the great difference in wave shape. If the time-constant of the grid capacitor and grid leak combination is correct for the average random noise, it is too high to follow pulses of short duration. The grid capacitor must charge and discharge with the rise and fall of noise voltage, in order not to alter the steady-state condition of the plate current. The choice of a low time-constant for a single limiter not only is unsatisfactory for random noise, but the sensitivity of the stage is reduced because of the low value of series ca-

(*Continued on page 45*)

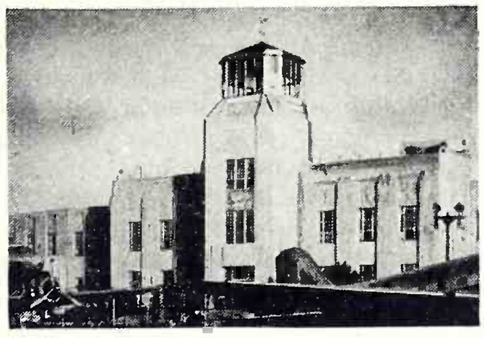
Towers that Talk!



American Airlines Photo

WASHINGTON NATIONAL AIRPORT

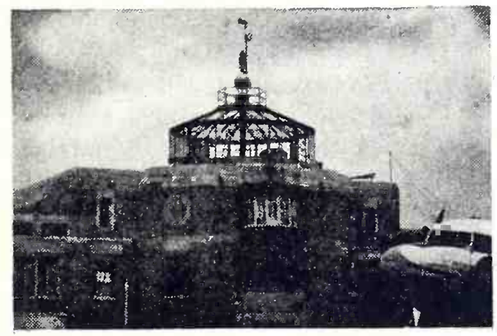
The nation's own, at the Capital City— Operated by CAA.



Delta Airlines Photo

NEW ORLEANS AIRPORT

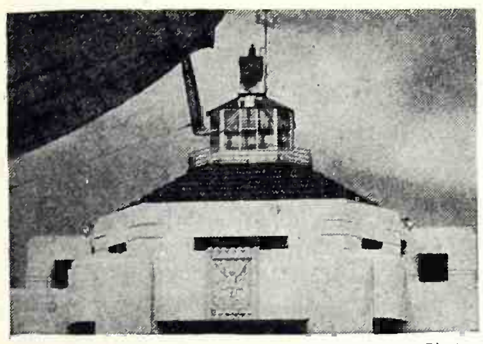
Modern airport terminal at the Crescent City—an architectural gem.



American Airlines Photo

LOUISVILLE'S BOWMAN FIELD

Pride of the Blue Grass State.



Braniff Airways Photo

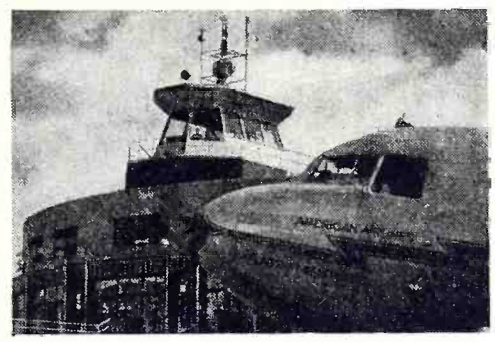
HOUSTON MUNICIPAL AIRPORT

Gateway to Mexico and Central America.

Delta Air Lines Photo

ATLANTA MUNICIPAL AIRPORT

Serving the metropolis of Southeastern U. S.



American Airlines Photo

LA GUARDIA AIRPORT, NEW YORK

One of the world's largest and busiest airports.

Sentinels of the Sky • • •

the control towers of the nation's airports that stand guard night and day. Each safe arrival and departure at these busy terminals rests on the vigilance of their skilled staffs and the reliability of their radio equipment. Each must function with never failing dependability—in peace as in war.

Radio Receptor airport traffic control radio equipment, examples of which are to be found throughout the nation in leading civil airports, and around the world in army airfields, is noted for its rugged construction and reliability in operation.

Specify **Radio Receptor** radio equipment for your airport and you may rest assured that your equipment will be equal to the best.

It is not too early to plan for that postwar airport for your municipality. Let **Radio Receptor** aid you. Send for our Airport Radio Questionnaire — no obligation.

Highways of the Air—a review of fact and opinion on the importance of radio in aviation —sent on request to those interested in airport design, construction and operation.

COOPERATION OF ARCHITECTS, CONSULTANTS AND CONTRACTORS INVITED

ARMY E NAVY

RADIO RECEPTOR CO., INC. 251 WEST 19th STREET NEW YORK, 11 N. Y.

Engineers and Manufacturers of Airway and Airport Radio Equipment • Communications Equipment • Industrial Electronics • Electronic Heating Equipment

SINCE 1922 IN RADIO AND ELECTRONICS

Industrial Review

Field Coil Taping

A NEW machine, which tapes field coils for dynamotors automatically, has been developed by the Carter Motor Company to increase and speed up production.

Prior to the introduction of this machine, the worker taped the coils by hand, winding through the center of the closed coil and stopping to tighten the material by hand.

The taping machine runs a tape through a closed coil continuously until the coil is entirely covered, and

tightens it far beyond the strength of human hands.

The moving bobbin first winds half the number of turns on the coil, at right angles to the wire, at the same time loading itself with an equal number of turns of tape. The worker then cuts the tape and the machine proceeds to unravel its load, the material covering the balance of the coil. The worker finishes the binding by drawing the loose end under and tying it off.

This equipment is being used in the *Carter Motor Company* plant at 1608 Milwaukee Avenue, Chicago, Illinois.

* * *

Radio Masts Flown to Front

AMONG the first planes to arrive as the Air Forces take over an air field captured by ground troops, is one carrying a complete ground-to-plane radio outfit including a sectional antenna mast of tubular plywood.

This mast is used for both a receiving and transmitting antenna installation and is available in 50 and 75 foot lengths. The fifty foot model comprises four sections of tubular plywood, each ten feet and ten inches long, plus a top section of four feet, eight inches. The tubes are four inches in diameter and have a wall ⅜ of an inch thick.

A crew of three men can install this antenna mast in 30 minutes. Two types of anchors are provided, one for solid ground and the other for loose soil.

Two miles of plywood sections, or enough for 150 masts of 75 feet, can be loaded in a single trailer-truck. The units are shipped in three packages, mast sections in one bundle, weighing 152 pounds, the guys and hardware in a box weighing 121 pounds and the spare parts are transported in a box weighing 45 pounds.

Post war use of this type of antenna mast for emergency radio services is suggested by the results now being achieved by the Armed Forces with this equipment.

* * *

R.F. Bulk Reducer

THE production of the vitally needed drug, penicillin, has been speeded by the introduction of a new r.f. bulk-reducing unit developed by Dr. George H. Brown of RCA.

Under old methods, the process of reducing the purified penicillin solution required 24 hours to complete. By means of the r.f. bulk reducer, this same process now consumes 30 minutes.

Experimental work was conducted with the cooperation of E. R. Squibb and Sons who furnished the penicillin with which tests were run. The experimental period started at the Squibb plant on May 5th, when the equipment was installed, and more than 1,000 tests were conducted to determine the effectiveness of the electronic system of bulk reducing. From these tests, the Squibb Company scientists have determined four main advantages of this process in addition to the obvious advantage of time saving. These advantages include, reduction in operating costs, reduction in maintenance costs through the elimination of complicated freezing apparatus, less chance of shutdowns due to refrigeration and mechanical difficulties, and reduction in floor space requirements.

After the penicillin is produced by the mold either by surface or submerged fermentation in containers holding several thousand gallons, the penicillin-containing broth is separated from the mold by filtration and the crude penicillin extracted from the broth with an organic solvent. It is then given an elaborate series of chemical treatments which remove most of the impurities and reduce the bulk by about 600 times. The final bulk reducing for the purpose of increasing the potency from 40,000 units per cubic centimeter to 100,000 units per cubic centimeter is achieved by means of r.f. heating. The application of r.f. heat does not harm the drug during the brief period of its exposure to 50 degrees F. at reduced pressure.

Production of this unit has started at the *Radio Corporation of America* plant at Princeton, New Jersey, and the bulk reducer will soon be available for the manufacture of penicillin in the 18 plants producing the life-giving drug.

* * *

Studio Installation

A NOVEL installation of fluorescent lighting in a New York studio devoted exclusively to recordings, where any electrical interference is objectionable, has been made by Sylvania Electric Products for World Broadcasting System, 711 Fifth Avenue.

The ballasts of the lamps were removed from the fixtures and mounted in ventilated metal boxes above the ceiling's soundproofing. This mounting not only eliminated the slight heat generated by the ballasts, but also removed all traces of hum that sometimes accompanies the operation of a fluorescent installation.

Twenty-four lighting fixtures are used, each equipped with two 100-watt

fluorescent lamps. The fixtures are mounted on the 22 foot high ceiling, four abreast in six rows parallel to the length of the 76 foot studio. The former lighting system which produced 12 foot-candles of illumination at a level two feet above the floor used 7½ kilowatts. The present system provides better than 35 foot-candles at the same level with a power consumption of 5½ kilowatts.

(*Continued on page 37*)

For Your Present and Post-War Production

40TH ANNIVERSARY
1904-1944

This year Lenz celebrates its 40th year of service to the communications industry.

Lenz Dial Light Sockets have always been known for their superior mechanical qualities and electrical characteristics.

Now these sockets are still further improved, with even greater mechanical strength. A stronger, tougher plastic shell is attached to the bracket with a new type of construction that provides a virtually unbreakable bond between shell and bracket. Its excellent electrical characteristics are maintained.

Consider these Lenz Dial Sockets for your present and post war production. Write for sample today.

LENZ

In Business *Since 1904*

LENZ ELECTRIC MANUFACTURING CO.

1751 N. WESTERN AVE. CHICAGO 47, ILLINOIS

ELECTRIC CORDS, WIRES AND CABLES

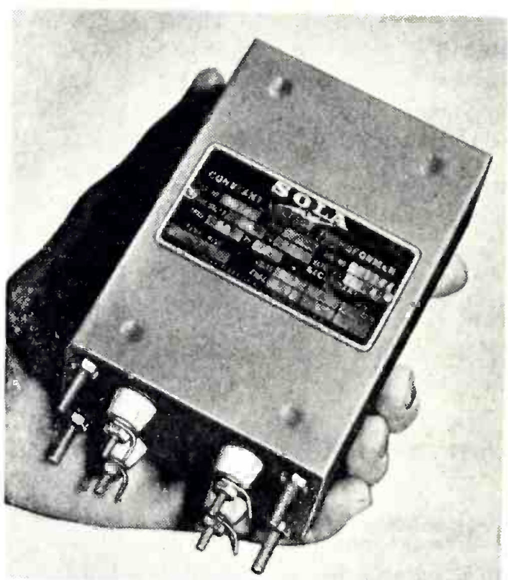
NEW PRODUCTS

TRANSFORMERS

Due to the increased demand for built-in automatic voltage regulation of filament supplies in Army and Navy electronic equipment, the Sola Electric Company has developed a constant voltage transformer to fill this need.

The unit is a compact, hermetically sealed transformer which is designed for chassis mounting. Rated at 6.3 volts, 17 va. output, it will maintain that value within ±1% regardless of line voltage variations as great as ±12 to 15%.

This transformer is of special value for the stabilization of E-C oscillator



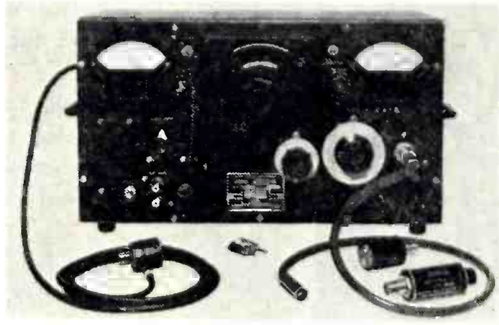
circuits. Electronic equipment, in which this transformer is a built-in component, does not require filament voltmeters or manual controls.

A new manual, Bulletin 2CV-102, is being prepared to describe various types and designs of constant voltage transformers. Copies may be secured by writing direct to *Sola Electric Company,* 2525 Clybourn Avenue, Chicago, 14, Illinois.

UHF SIGNAL GENERATORS

The Federal Manufacturing and Engineering Corporation has developed a new laboratory type UHF signal generator which is capable of producing a range from 7.6 to 330 megacycles, with a frequency calibration accurate to plus or minus 2%. Voltage output is controlled by an accurately calibrated attenuator network which allows control from 1 microvolt to 20,000 microvolts.

The output is arranged so that an internal source of modulation at a frequency of 1000 cycles may be used, or



by the use of an incorporated switching arrangement, an external source of modulation may be used between 30 cycles and 20,000 cycles, adjustable from 0 to 60%, as indicated by a direct-reading modulation meter.

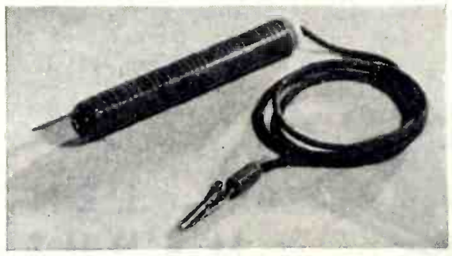
A stabilized power supply incorporated in the unit provides operation at either 115 or 230 volts a.c., 40 to 60 cycles, single phase. This power supply insures an absolute minimum of frequency change due to power line fluctuations.

These signal generators are available on priority from the *Federal Manufacturing and Engineering Corporation,* 211 Steuben Street, Brooklyn, 6, New York.

CONTINUITY TESTER

A self contained continuity tester is being offered by Walker-Jimieson, Inc., to speed routine checking of shorts and open circuits in coils, fuses, lamps, tubes, appliances and other low resistance units or assemblies whose resistance is 12 ohms or less.

An indicating bulb in the end of the tester illuminates the point of application and indicates conveniently without the need for looking at the meter, the presence of a short or open. The tester uses two self-contained penlight



batteries and a No. 222, .125 ampere, 2.2 volt lamp. The case is of plastic, ¾" x 5⅝". A lead 36" long is included.

This unit speeds up test and inspection procedures in the laboratory, on the production line or in electrical maintenance departments.

Further details and prices may be secured by writing to *Walker-Jimieson, Inc.,* 311 S. Western Avenue, Chicago, Illinois.

DOCUMENT PROTECTION

In order to protect secret documents of all types, a marking compound has been developed by the North American Philips Company which can be used to identify such documents. when used in conjunction with an industrial X-ray unit.

The documents are stamped "secret" with the marking compound. Routine investigation by plant guards consists of X-raying all brief cases and packages. The X-ray immediately picks out the document marked "secret" and its presence can be immediately determined.

Experiments have shown that secret papers hidden in a stack of literature 1½ inches thick inside of a zippered

bag can be spotted easily and clearly. The guard is able to make this survey rapidly by means of a fluoroscope.

This X-ray ink is being demonstrated in the showrooms of the *North American Philips Company* at 100 East 42nd Street, New York, or additional information will be furnished upon request to the same address.

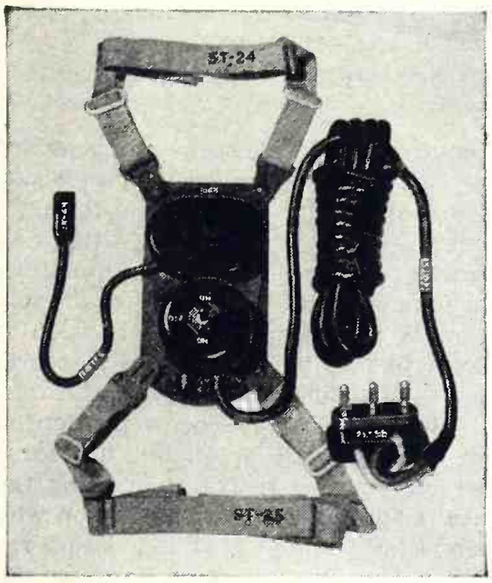
CHEST SET TD-3

A Signal Corps Chest Set TD-3 is being produced in quantity by Trav-Ler Karenola Radio and Television Corporation of Chicago.

The unit consists of a chest unit, equipped with a switch; a junction box; two cotton webbing strips; and two cords for connecting a throat or lip microphone to a transmitter.

The Chest Unit has a toggle switch which has three positions, on, off and momentarily on. The junction box is located on the chest plate directly above the toggle switch and has a molded bakelite housing.

The cord which connects to the microphone is a two-conductor stranded copper wire and has a JK-48 jack in one end. The other cord, which is plugged into the transmitter, is a



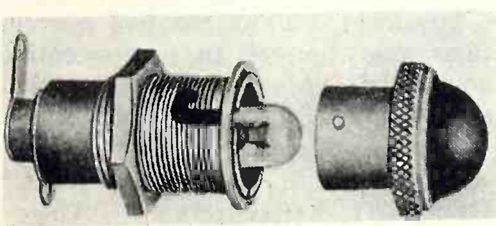
three-conductor tinsel cord with a PL-58 plug on one end.

Complete units or component parts can be furnished to manufacturers. Requests for further information should be made direct to *Trav-Ler Karenola Radio and Television Corporation,* 1036 West Van Buren Street, Chicago, Illinois.

INDICATING LAMP

A new indicating light with a bayonet type lens cap, known as the Kirkland T3-BLC Indicating Light Unit, has been announced by the H. R. Kirkland Company.

This unit is designed to be used with a T3 ¼ type single-contact bayonet lamp bulb and embodies a new design of lamp socket, free from press-fit methods of assembly and provides direct electrical connection from the



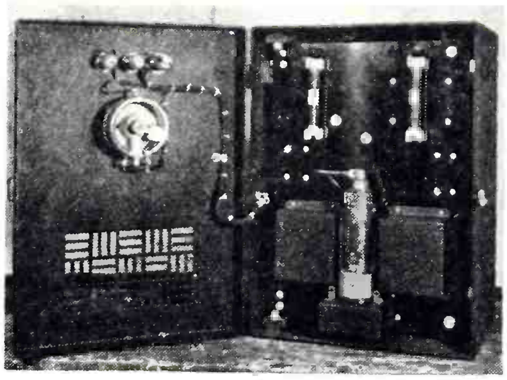
shell and the center contact pin to the terminal spades.

Further information may be obtained direct from the manufacturer by writing Dept. RE-7, *The H. R. Kirkland Company,* Morristown, New Jersey.

WELDING TIMER

A new welding timer with heat control for timing intervals of one-half cycle or less in applications where small objects of high conductivity are to be welded has been announced by Westinghouse.

The timer is furnished as a separate control for use with existing small bench welders and also in combination with a small welding transformer. Only one central tube is used, this thyratron serving the dual purpose of rectifying alternating current to charge a firing capacitor and also firing the small ignitron power tube. Heat con-



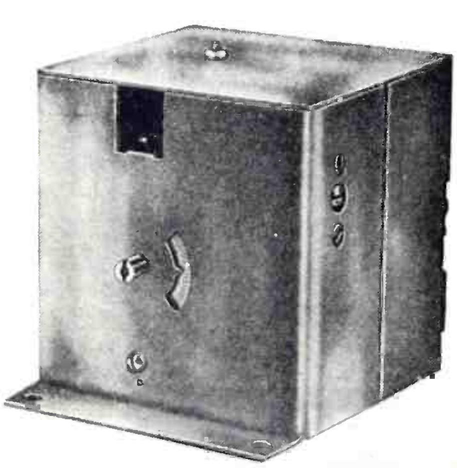
trol is accomplished by a phase shift method, the adjustment dial for which is mounted on the cabinet door.

Further information about this timer, which is rated at 230/460 volts, 50/60 cycles, may be secured from Department 7-N-20, *Westinghouse Electric and Mfg. Company,* East Pittsburgh, Pa.

COMPACT TIMER

A new impulse-initiated timer recently introduced by Struthers-Dunn, Inc., is 71.8% smaller by volume than previous conventional units used for similar applications. This new timer has the further advantages of rugged, shock-proof construction, easily accessible contacts, and a dustproof cover.

This timer is known as the Type PSEH-1 and is furnished in both a.c. and d.c. types. Contact operation occurs at the end of a delay interval after power has been applied, or after receipt of a momentary impulse from a push-button, limit switch or other



source. The adjustable timing range is 20 to 1 and the mechanism is imme-

(*Continued on page* 41)

Television

22% Want Television

TELEVISION home receivers head the list of products which the American family expects to buy as soon as peacetime manufacturing resumes, if the experience of the Franklin Square National Bank can be used as a criterion.

This bank has instituted a savings plan whereby their depositors can save for special postwar purchases in accounts earmarked for that purpose. Twenty-two percent of their depositors saving under this plan have designated television receivers, priced by the bank at $400.00, as the purpose of their savings. Contrasted to this percentage are thirteen percent for automobiles, twelve percent for electric washers, twelve percent for refrigerators, while others are saving for home furnishings, ranges, sewing machines and helicopters.

Mr. Arthur T. Roth, vice-president of the bank, has urged other banks to follow this plan for two reasons, first, to drain off excess inflationary capital and, second, to provide a backlog for the postwar reestablishment of civilian goods industries. He pointed out that if the public has the money for various types of household equipment available, the resumption of consumer goods manufacture can begin at once on the basis of orders placed or ready to be placed.

The entire program during which these and other statements were made regarding the postwar market of goods, was telecast to New York area televiewers.

* * *

Burrows on Television

R. E. BURROWS of the General Electric Electronics Department predicted in a recent address that "commercial television will develop gradually with the coming of peace, and will not take the country by storm the day the war is over."

Mr. Burrows feels that progress will be comparatively rapid in the several cities where television broadcasting facilities exist now, especially if television receivers at popular prices are made available to hundreds of thousands of homes.

However, after the war, starting from the date the government authorizes production of transmitters, it will require somewhere between a year and a year and a half to produce television transmitters for other points throughout the country. Some television networks may be developed within three or four years after transmitter production is resumed. Color television is from five to ten years away, according to Mr. Burrows.

"Success of television won't depend on novelty alone or on fine or coarse screens, but on restraint in using the new medium. There is no reason why television couldn't permit existing radio noises to continue, limiting the visual show to relatively brief periods each day. Both types of programs are controlled by the same industry. It has already given us all the quantity we can use, there should be some daring executives willing to concentrate on quality for a change," Mr. Burrows pointed out.

* * *

National Conventions

THE two national political conventions, held at the Chicago Stadium were covered by RKO Television Corporation for the National Broadcasting Company.

The proceedings of both conventions were recorded on special television films which were flown daily from Chicago to New York and telecast to the television receivers in New York, Philadelphia and Schenectady through the facilities of WNBT, WPTZ and WRGB.

The local color of the two conventions was covered in preconvention photographs in addition to the actual proceedings of the conventions.

* * *

DuMont Appoints

TED COLLINS, producer of many of the top programs on the air, has been named Program Consultant of the DuMont television station WABD, according to the announcement made by Leonard F. Cramer, vice-president of Allen B. DuMont Laboratories. Inc.

Mr. Collins is familiar with the various aspects of programming telecasts and his services will be available to advertisers who use the DuMont station. He has already worked out several new ideas which he hopes to present in the new WABD studios.

Crystal Manufacture

(Continued from page 6)

processing operations than the pressure-type. On the other hand, once the supporting wires have been soldered to the crystal plate, they remain fixed throughout subsequent operations, thus simplifying final frequency adjustments.

Beginning with an etched plate of predetermined orientation and dimensions, the first step in the fabrication of a wire-supported unit is to apply a silver deposit, in the form of small spots, to the nodal points on both sides of the crystal. To these spots the fine lead wires will later be attached. While in use, the liquid silver is placed in a fixture and constantly shaken. Throughout the spotting operation, agitation of the silver is interrupted only long enough for the operator to fill a shallow paste well; this well contains sufficient silver for spotting 10 crystals, after which it must be filled.

Application of the silver paste to the surfaces of the crystal is accomplished by means of a spotting mandrel, which is wetted with paste, then lowered in a fixture until it touches one surface of the crystal. The plate is then turned over, and the operation is repeated. Spotted plates are then laid in groups of approximately 100 on a nichrome screen and are placed on a 750° F. hot plate for a brief period, after which they are laid in pyrex petri dishes and fired for 20 minutes at 980° ± 10° F. in a 3000 watt electric furnace. Each fired spot is held to dimensions of .045-.015 inches in diameter, and between .0002 and .002 inches in thickness.

After cooling to room temperature, the crystals are plated with silver in an evaporation process machine developed by the Bell Telephone Laboratories. The heating element in this unit is molybdenum wire .020 inches in diameter wound into a close spiral on a mandrel, and then stretched to form a wavy wire with 24½ wave wells per 4 inches of length. Pure silver wire .010 inches in diameter, cleaned in trichlorethylene and cut into ½ and 11/32 inch lengths, is used for plating. These lengths of wire are bent into hairpin shape and clamped to the heating element.

In plating crystals, general cleanliness must prevail, and no dust or lint should be allowed to settle on the surfaces of the crystals. The spotted crystals are placed flat and with edges together on the plating tray, inserted into the plating machine, and the pressure is reduced to 2×10^{-5} mm. of mercury, equivalent to about one one-hundred millionth of an atmosphere. When this pressure is reached, 5 amperes of current are applied to the heating element, and increased at regular intervals up to and including 14 amperes. The current is shut off, and crystals are allowed to cool for 20 minutes before air is admitted to the chamber.

The crystals are then turned over on the plating tray, and the process is repeated. After plating, the weight of the coating on the crystal surfaces is 3.0 minimum to 5.0 maximum M.S.I. (milligrams per square inch) of silver.

With this step in the process completed, the plating is removed from the edges of the crystals by holding the plates in rubber-faced tweezers and stroking the edges lightly with emery paper. After edging, the resistance of the plates must be greater than 30 megohms, as measured in a resistance test set. As an aid in the subsequent soldering operation, the silver spots are then carefully burnished on a hardened, ground steel plate.

The soldering of fine wires to the electrode surfaces of the crystals is often described as the "heart" of the process of manufacturing wire-mounted units. The wire used is an 8 per cent tin bronze with a minimum tensile strength of 180,000 pounds per square inch, and to facilitate soldering the wire is given an electro-tinned finish of 6 M.S.I. The solder is used in the form of a thin ribbon.

The soldering machine itself has been specially designed for this particular operation. Wire is fed into the machine from a spool, through the head of a movable arm; the head contains a wire guide and small clamp for holding the wire. A crystal is placed in the holding jaws of the machine, which are thermostatically controlled at 210° F., and closing of the jaws accurately positions the crystal. The head holding the wire is then placed in a locating station on the solder punch. Depressing the handle of the solder punch indexes the ribbon of solder, perforates a small pellet of solder and impales it on the end of the connecting wire.

The head, bearing the wire and the small impaled pellet, is then moved to the flux station, where the pellet and a portion of the wire above it are dipped in flux. Moving the head to the soldering station, where pellet and wire are placed carefully on the spot of the crystal, the operator then releases an air valve which forces a hot air blast upon the junction of the pellet and the spot. The temperature of the air blast is so adjusted that the solder is melted, and the attachment completed, in a matter of a few seconds. The wire clamp is released, and the wire-holding head is raised against a stop; the wire is clamped again, and is then cut by exerting pressure on a scissors detail. The crystal plate is then turned over, and operations are repeated on the other surface.

During this minute process, the operator is aided by a fixed binocular microscope. It has been found in the Hawthorne Works shop that the operator must develop a certain soldering technique, and that slight changes in operations are necessary from time to time because of variations in silver "spots," solder, flux and wire. A well-made solder joint will withstand a pull-test of 700 to 1,000 grams.

In preparation for actually mounting the crystals, tempered piano wire springs are soldered to the terminal pins of the base assembly under a magnifying glass. Each spring is adjusted, and a pellet of solder is soldered to the spring about ⅛ inch from the free end, and is dipped in flux. Together with the base assembly, the crystal with connecting wires attached is then place in a fixture, tilted at a 45° angle. The solder pellet is melted with an iron, and is rolled along the spring to the intersection of the connecting wire, where the soldering is completed.

The crystal units are sprayed with hot trichlorethyne. They are next placed in a transmitter circuit, and while stabilizing the transmitter, are calibrated to frequency. This operation is performed by removing quartz from one edge of the plate by hand-lapping with emery paper. The units are again washed, baked for four hours at 70° C., and sealed. After an aging period of four two-hour cycles of heating to 70° C., and cooling, they are ready for final inspection.

It should be emphasized, of course, that the entire process of manufacturing quartz oscillator plates is still undergoing development, and that many present-day methods soon may be regarded as obsolete. Meanwhile, the entire industry is faced with the fact that highest quality quartz is no longer as plentiful as it once was. Originally, manufacturing procedures at Hawthorne Works were set up to handle stones approximately three pounds in weight, but over a two year period crystals have become smaller and smaller. Rocks with natural prism and apex faces, fairly common at first, now are less plentiful.

In fact, at the present time the Hawthorne Works shop is successfully manufacturing crystal units from raw material that formerly would have been considered "junk."

As previously stated, the use of X-ray diffraction in the manufacturing process has been extremely helpful in establishing mass production methods. Also, advantages have been gained from improvement in blades, wheels, and from more extensive utilization of diamonds rather than lapping. Commercial equipment, replacing stop-gap devices, is more readily available.

Output that would be sufficient to meet military needs has been the sole objective in the industry. However, as the volume of production reaches a point of stability in relation to military requirements, crystal engineers will find that they have more time for perfecting present processes, and for developing new ones. It may be expected that in the future the crystal industry will benefit from constantly improving techniques.

Metal Plating

(*Continued from page* 24)

porcelains are then fired in electric furnaces at closely controlled temperatures. The metallic compound becomes a high-luster, permanent, integral part of the glaze on the porcelain. Any other metal can then be electroplated onto this metal coating.

For electronic applications it is usually most convenient to apply a coating of 60-40 tin solder to the metal film. This is done either by a dipping operation or a soldering iron, depending upon the size of the surface to be tinned. A surface which has been tinned in this manner has the soldering characteristics of solid brass or copper.

One of the most important applications of this method of plating metal films on glass and ceramics is that when the coating of solder is applied it affords a simple and convenient method of making a vacuum-tight seal between metal and dielectric. This method of solder-sealing to ceramics has many important applications in electronic design. For instance, it considerably simplifies the problem of designing hermetically sealed transformers, capacitors, and coaxial cable assemblies. A photograph of a bushing of the type used in transformer construction is shown in Fig. 2. The detailed construction of this and two other types of bushings in common use for this purpose is shown in (A), (B)

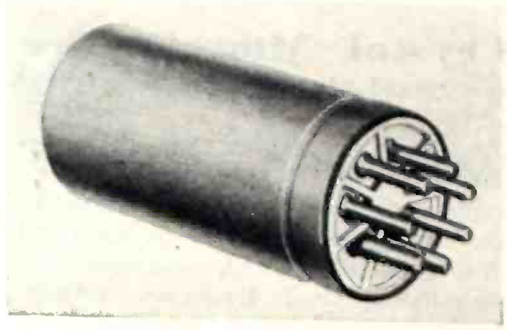


Fig. 6. Vibrator assembly with cermaic disc.

and (C) of Fig. 4. In practice, the bushing is set into the metal cover which has been perforated and prepared for soldering, and soldered along the lower band of metal. This furnishes an air-tight seal. The terminal for the lead can be either of the hollow type, permitting the lead wire to be drawn through and soldered at the top after assembly of the case and cover plate, or of the solid stud type to which the lead wire must be soldered before the cover plate is secured to the case. A complete transformer cover plate assembly using solder-seal ceramic bushings is shown in Fig. 5.

Glass bushings which have been metal plated and tinned have also been found extremely useful in the design and construction of hermetically sealed assemblies. The construction of a glass bushing which has been used for sealed transformer cases is shown diagrammatically in Fig. 4 (D). Soldered glass to metal seals may also have an important effect on the design of high vacuum devices. Solder-sealing will probably not become of very great importance in vacuum tube construction because of the inability of the solder to withstand the high temperatures at which vacuum tubes are customarily operated; however, they may be of great value in the design of such devices as vacuum condensers, which are not operated at elevated temperatures.

There are a large number of other practical applications of metallized glass and ceramics. Fig. 7 shows a gas-sealed coaxial cable assembly. Metal plating on ceramic and glass coil forms presents a very convenient terminal to which to solder the ends

TABLE II

Detailed procedure for depositing platinum film on glass.

(a) 100 cc of 10% H_2PtCl_6 solution
(b) Absolute alcohol
(c) 6 cc oil of lavender (keep ice-cold)
(d) Burgundy pitch

1. Evaporate solution (a) to dryness.
2. Dissolve in minimum quantity of absolute alcohol.
3. Add alcohol solution slowly to (c).
4. Add Burgundy pitch to give mixture consistency so that it will remain uniform when it is applied.
5. Heat glass slowly until oil burns away and salt is reduced, leaving a deposit of platinum.
6. Continue to heat to softening point of the glass, to form the deposit in an adherent compact film.

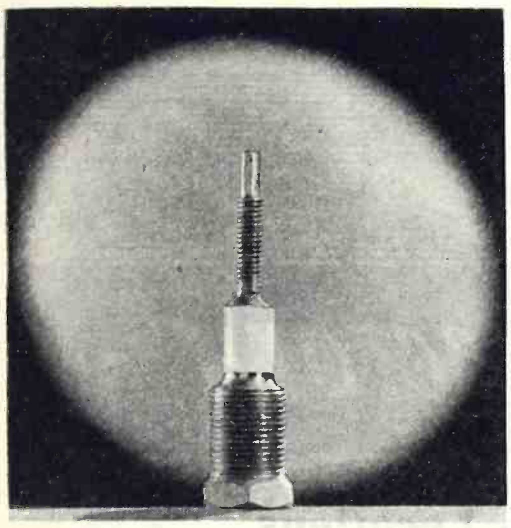


Fig. 7. Gas-sealed coaxial cable assembly.

of the coil. In Fig. 6 is shown a photograph of a vibrator assembly in which the ceramic insulating disc has been platinized and solder-sealed. This assembly has passed vibration, high altitude, and heat cycle tests successfully.

In designing any equipment which makes use of the techniques of metal plating on dielectrics, the relative merits of the different methods are of considerable interest.

One of the most important considerations is the adherence of the metal coating to the dielectric surface. When vacuum and chemical methods are used, great care must be taken in cleaning and preparing the surface, in order to obtain sufficiently good adherence. Even when the surface has been prepared properly, the bonding of the deposit is often a very serious problem and may not be very satisfactory unless there is also mechanical bonding due to the contours of the object that is being plated. The best results are obtained when the metal film completely covers the dielectric, or is continuous and of sufficient thickness and uniformity to hold its shape mechanically. The adherence of metal films which have been fired onto glass or ceramic surfaces is much better. On porcelains, after heat treating, the metallic film is a permanent, integral part of the glazing. On glass surfaces the metal dissolves partially into the surface of the glass to form a permanent seal which cannot be separated without breaking the glass.

As a laboratory procedure, there is very little to choose among the three different methods for convenience in performing the process. A minimum amount of auxiliary apparatus is required for performing the chemical plating process, but the vacuum apparatus and heating equipment required for the other two processes are usually found in a reasonably well-equipped laboratory. All three processes can be performed by any competent research laboratory technician.

Chemical deposition methods are particularly well suited to manufacturing processes where it is necessary to plate large quantities of objects at low cost. This can be done either by individually spraying large pieces, or by tumbling small pieces in bulk. The plating processes are quite rapid, and can be performed very conveniently. If any large quantity of ceramic or glass objects is to be metallized, special heating equipment may be required. However, this is not too great a disadvantage since there are a number of manufacturers who specialize in plating glass and ceramic and are prepared to supply ready made assemblies in a large variety of different forms and shapes.

Industrial Review

(*Continued from page* 30)

This same type of installation may be effectively installed in broadcast studios and the *Sylvania Electric Products Company* of Emporium, Pennsylvania, will welcome inquiries from broadcast studio executives and engineers.

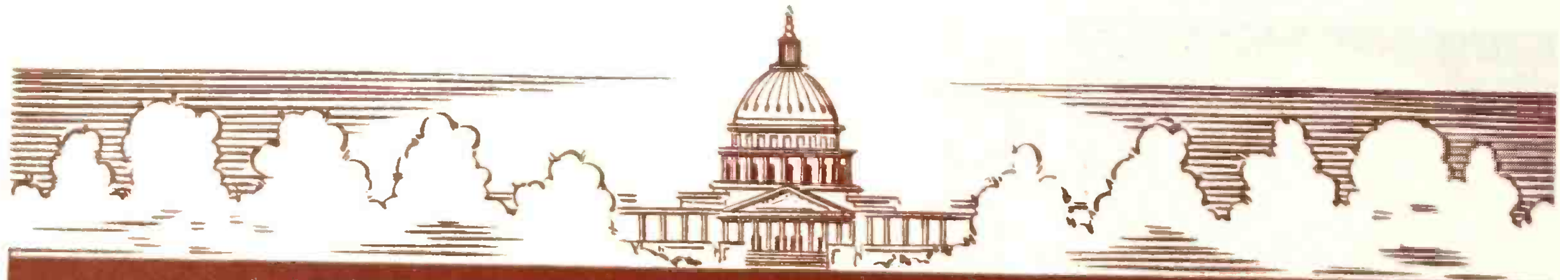
* * *

Goodrich Rivnuts

A ONE piece, combination rivet and nut plate, known as a rivnut, is now being used to waterproof radio sets. The rivnut, which is manufactured by the B. F. Goodrich Company, is used to attach carrying straps to the radio sets. Heretofore, water seeping in at this point of the radio manufacture precluded true waterproof and submersionproof construction.

While rivnuts have been used for years for attaching de-icers to airplanes, this is the first instance in which this product has been used in the radio industry. Rivnuts can be inserted and locked into place by a bulge or head produced by a special tool, while working entirely from one side. They are threaded inside to serve as a nut plate. Not only can they be fixed in place where one side of the work is impossible or difficult of access, but a new spline type of rivnut has been developed which can be locked into a block of wood or plastic. A hole is drilled into the wood or plastic, the rivnut pounded into it and "headed" with a special tool.

Details may be obtained by writing the *Industrial Products Division, B. F. Goodrich Company,* Akron, Ohio.



★★★★ Washington Directory ★★★★

Government Agency Personnel . . . Locations

O.E.M., 101 Indiana Ave., NW, REpublic 7500
Wayne Coy, Liaison Officer, Rm. 252 State Dept. Bldg., Ext. 5181

W.P.B., Social Security Bldg., REpublic 7500

Donald M. Nelson, Chairman, Rm. 5055, Ext. 2113
Bruce Catton, Div. of Inf., Rm. 5525A, Ext. 5242

Radio and Radar Division

R. C. Ellis, Director, Rm. 1023, Ext. 2566
H. P. Rockwell, Components, Ext. 75075
Kenneth A. Hathaway, Resistors, Ext. 71278
Robert McCurdy, Test Equipment, Ext. 71827
Howard V. Kitchen, Relays and Microphones, Ext. 73544
Charles Burmaster, Operations Unit, Ext. 76083
F. C. Bash, Vacuum Tubes, Ext. 73149
L. J. Chatten, Products and Facilities, Ext. 71946
Morris L. Lewis, Electronic Tubes, Ext. 74831
P. M. Deeley, Capacitors, Ext. 75043

WAR DEPARTMENT, The Pentagon, REpublic 6700

Henry L. Stimson, Secty. of War, Rm. 3E880, Ext. 3211
Col. H. S. Wright, Aide, Rm. 3E880, Ext. 3214
Lt. Gen. Wm. Knudsen, Production, Rm. 3E606, Ext. 71361
Robt. P. Patterson, Undersecretary, Rm. 3E714, Ext. 2254
John J. McCloy, Asst. Secty., Rm. 4E886, Ext. 2385
Robt. A. Lovett, Asst. Secty., (Air), Rm. 3E967, Ext. 3718
Gen. George C. Marshall, Chief of Staff, Rm. 3E921, Ext. 2077
Lt. Gen. J. T. McNarney, Deputy Chief, Rm. 3E936, Ext. 4371
Major Gen. M. G. White, Asst. Chief (G-1), Rm. 2E928, Ext. 2851
Major Gen. Clayton Bissell, Asst. Chief, (G-2), Rm. 2E800, Ext. 72577
Major Gen. T. T. Handy, Asst. Chief (Operations), Rm. 3E808, Ext. 2904

Bureau of Public Relations

Maj. Gen. Alexander D. Surles, Director, Rm. 2E878, Ext. 2716
Col. Stanley J. Grogan, Deputy Dir., Rm. 2E872, Ext. 5135
Lt. Col. Robt. E. Kintner, Exec. Officer, Rm. 2E868, Ext. 74200
Col. Ralph F. Gow, Chief (Ind. Serv.) Rm. 2E867, Ext. 2513
Lt. Col. Douglas Parmentier, Acting Chief (News Div.), Rm. 2E865, X3494
Col. Albert Warner, Intelligence Div., Rm. 2E873, Ext. 6358

Army Air Forces

Gen. Henry H. Arnold, Commanding Gen., Rm. 3E1009, Ext. 2766
Col. Fred M. Dean, Ex. Officer, Rm. 3E1014, Ext. 2964

Army Ground Forces

Lt. Gen. Lesley J. McNair, Commanding Gen., Rm. 26, War College, Ext. 281
Brig. Gen. James G. Christiansen, Chief of Staff, Rm. 26, Ext. 281
Col. William J. Mitchell, Deputy Chief of Staff, Rm. 28, Ext. 286

Army Service Forces

Lt. Gen. Brehon Somervell, Commanding Gen., Rm. 3E672, Ext. 4102
Maj. Gen. W. D. Styer, Chief of Staff, Rm. 3E664, Ext. 71814

Office of the Chief Signal Officer

Maj. Gen. Harry C. Ingles, Chief Signal Officer, Rm. 3E200, Ext. 6604
Maj. Gen. Roger B. Colton, Chief, Eng. & Tech. Serv., Rm. 3E348, Ext. 5986
Maj. Gen. W. H. Harrison, Procurement, Rm. 2E260, Ext. 6101
Brig. Gen. F. E. Stoner, Communications, Rm. 4E250, Ext. 3096

NAVY DEPARTMENT, Navy Building, REpublic 7400

James Forrestal, Secretary of the Navy.
Capt. John W. Roper, USN, Aide to the Secty., Rm. 2046, Ext. 3115
Mr. Charles F. Detmar, Jr., Special Asst. to Secty., Rm. 2046, Ext. 3115
Mr. Eugene S. Duffield, Special Asst. to Secty., Rm. 2046, Ext. 3115
Ralph A. Bard, Undersecretary of Navy
Comdr. Piper, Aide to Undersecretary, Rm. 2054, Ext. 3234
Artemus L. Gates, Asst. Secty. of the Navy for Air
Capt. B. W. Wright, USN, Aide to Asst. to Secty. of the Navy for Air
Comdr. M. P. Aldrich, USNR, Spec. Asst. to Asst. Secty. of the Navy for Air, Rm. 2072, Ext. 61308
Mr. Harvey C. Emery, Spec. Asst. to Asst. Secty. of the Navy for Air, Rm. 2912, Ext. 2930
Comdr. E. C. Bench, USNR, Spec. Asst. to Asst. Secty. of the Navy for Air, Rm. 2072, Ext. 4591
Lt. Comdr. J. A. Gifford, Spec. Asst. to Asst. Secty. of the Navy for Air, Rm. 2072, Ext. 61308

Executive Office of Secretary of Navy

Adm. A. J. Hepburn (Ret.), Chairman General Board, Rm. 2072, Ext. 4591
R. Adm. J. A. Furer, Coordinator of Research & Devices, Rm. 0149, Ext. 4050
Capt. Stuart Farrar Smith, Inventions, Rm. 0139, Ext. 2547

Office of Procurement and Material

V. Adm. Samuel M. Robinson, Chief, Rm. 2010, Ext. 2207
Joseph W. Powell, Deputy Chief, Rm. 2014, Ext. 3331
Information, Ext. 3473
R. Adm. James M. Irish, Planning & Statistics, Rm. 2000, Ext. 3486
Capt. A. J. Wellings, Inspection, Rm. 2247, Ext. 5256

Bureau of Naval Personnel

Vice Adm. Randall, Chief of Naval Personnel
R. Adm. Louis E. Denfeld, Asst., Rm. 2070, Ext. 7243
Lt. Comdr. Charles A. Appleby, USNR, Aide to Chief, Rm. 2072, Ext. 7101
Information, Rm. 2018, Ext. 7171

Bureau of Ordnance

R. Adm. G. F. Hussey, Jr., Chief
R. Adm. Willard A. Kitts, III, Asst. Chief, Rm. 0301, Ext. 2005
Capt. R. W. Holsinger, Production, Rm. 0024, Ext. 3271
Capt. C. L. Tyler, USN, Research, Rm. 0447, Ext. 3343

Bureau of Aeronautics

R. Adm. D. C. Ramsey, Chief
R. Adm. Lawrence B. Richardson, Asst., Rm. 2902, Ext. 2022
Lt. Goodman, Editorial Research, Rm. 4828, Ext. 3570

Bureau of Ships

R. Adm. Edward L. Cochrane, Chief
R. Adm. E. W. Mills, Asst. Chief, Rm. 1804, Ext. 3391
R. Adm. A. H. Van Keuren, Research, TRinidad 2424, Ext. 100
R. Adm. J. W. Waller, R. N., Maintenance & Supply representative, REpublic 7955, Ext. 36 or 37

HEADQUARTERS, U. S. MARINE CORPS, REpublic 7400

Lt. Gen. A. Vandergrift, Commandant
Brig.-Gen. R. L. Denig, Public Relations, Rm. 1028, Ext. 7386

HEADQUARTERS, U. S. COAST GUARD, REpublic 7400

V. Adm. Russel R. Waesche, Commandant
R. Adm. L. T. Chalker, Asst., Rm. 7002, Ext. 4310
Capt. E. Reed-Hill, Public Relations, Rm. 8202, Ext. 4316
R. Adm. H. F. Johnson, Engineer in Chief, Rm. 5202, Ext. 4316

W.M.C., Social Security Bldg., EXecutive 4660

Paul V. McNutt, Chairman, Rm. 5554, Ext. 2301

Bureau of Selective Service

Maj. Gen. Lewis B. Hershey, Director, REpublic 5500, Ext. 1

FCC, New Post Office Bldg., EXecutive 3620

James Lawrence Fly, Chairman
T. J. Slowie, Secretary
Charles R. Denny, General Counsel
Rosel Hyde, Assistant General Counsel
George P. Adair, Chief Engineer

OFFICE OF RESEARCH, 1530 P Street N.W.

Dr. Vannevar Bush, Director, Rm. 201, Ext. 5308
Carroll Wilson, Asst., Rm. 204, Ext. 71794
Dr. Irvin Stewart, Secty., Rm. 206A, Ext. 4226

National Defense Research Committee

Dr. J. B. Conant, Chairman, Rm. 317, Ext. 6263
Dr. R. C. Tolman, V.-chairman, 2101 Constitution N.W., EXecutive 8100
F. L. Hovde, Exec. Asst., Rm. 301, Ext. 4205
Paul Scherer, Special Asst., Library, Ext. 73383

U. S. PATENT OFFICE, Dept. of Comm. Bldg.

Conway P. Coe, Commissioner of Patents
Leslie Frazer, First Asst. Commissioner

Sound on Video

(*Continued from page* 17)

and reception purposes of both sight and sound. In the picture reproduction section these increments or impulses saturate a fluorescent material to produce visible light. This fluorescent material, in turn, renders a delay or carryover of the light due to its decay period. However, the aural reproduction impulses are derived from the photoelectric effect of the target plate and are passed through an audio amplifier which in turn, due to its infinite impedance and negligible loading effect, produces a facsimile of the original sound emanation. "Sound on Video" produces a picture of sound for transmission purposes and upon reception reproduces this picture for reconversion back into sound.

Target Plate

Since the target plate, which in reality is a modified form of photoelectric tube, is the nucleus of the "Sound on Video" receiver system, the design and working principle of this should be covered in a little more detail.

Reference has been made to the phenomena of the logarithmic decay characteristic of phosphorescent substances when excited by light or electronic bombardment, and through this is achieved the conversion of light, which in "Sound on Video" is created by the electronic stream bombarding the modified photo-electric tube, to restore electrical impulses for audio reproduction.

Original oscilloscope photographs of "Sound on Video" waveforms and integration waveforms are shown in Figs. 5 and 6.

Fig. 3 shows the construction of the target plate employed in this system. This tube, or cell, is very similar to the conventional vacuum type photoelectric tube, with the exception that it is mounted inside the cathode-ray tube used for picture reproduction. However, the modified differences are that this cell is externally coated with a short-persistence fluorescent substance and is exhausted independently from the cathode-ray tube within which it is mounted.

This procedure, which actually is mounting a tube within a tube for different working purposes, is not entirely new to the industry, as it is actually being used by the Radio Corporation of America in their present electron microscope, without any cross interference. Another parallel is the present dual purpose radio tubes. Although all elements are constructed in one envelope, yet each element is capable of carrying out a separate function independent of the other.

Fig. 4 clearly illustrates the decay characteristics of fluorescent material with relative brightness plotted as a function of time in seconds. Upon close observation of this graph one can readily see how the "Sound on Video" waveform analysis is derived from the one depicted in Fig. 4(A).

Mention has been made of the short pulses created by the horizontal sweep employed in television for audio image restoration, and the presence of these pulses has given rise to doubt as to the feasibility of this system. However, if a vacuum photoelectric tube is subjected to intermittent pulses of light, the response of the cell is independent of the frequency of these pulses. This statement is confirmed by L. R. Koller.[2] He has further stated that the response of a photoelectric surface to a light depends upon the total flux or total amount of light falling upon the surface and not on its intensity. The response from a given quantity of light is the same whether it is concentrated

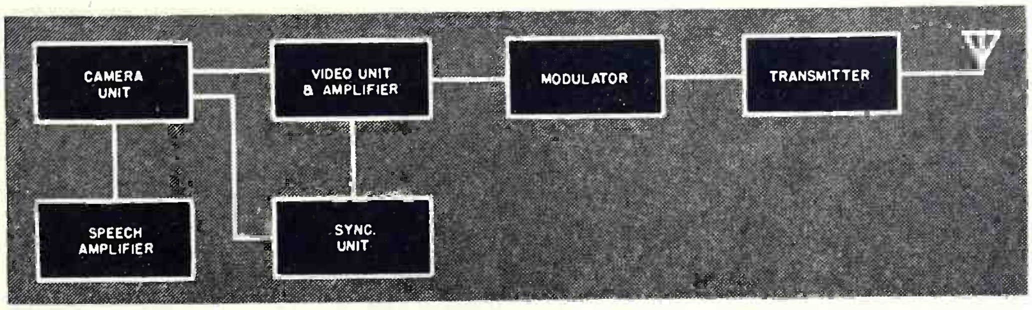
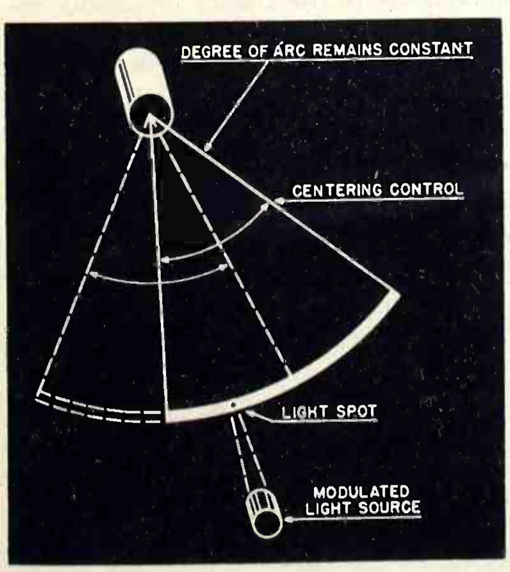


Fig. 14. Block diagram of "Sound on Video" television system.

Fig. 13. Operation of sound iconoscope.



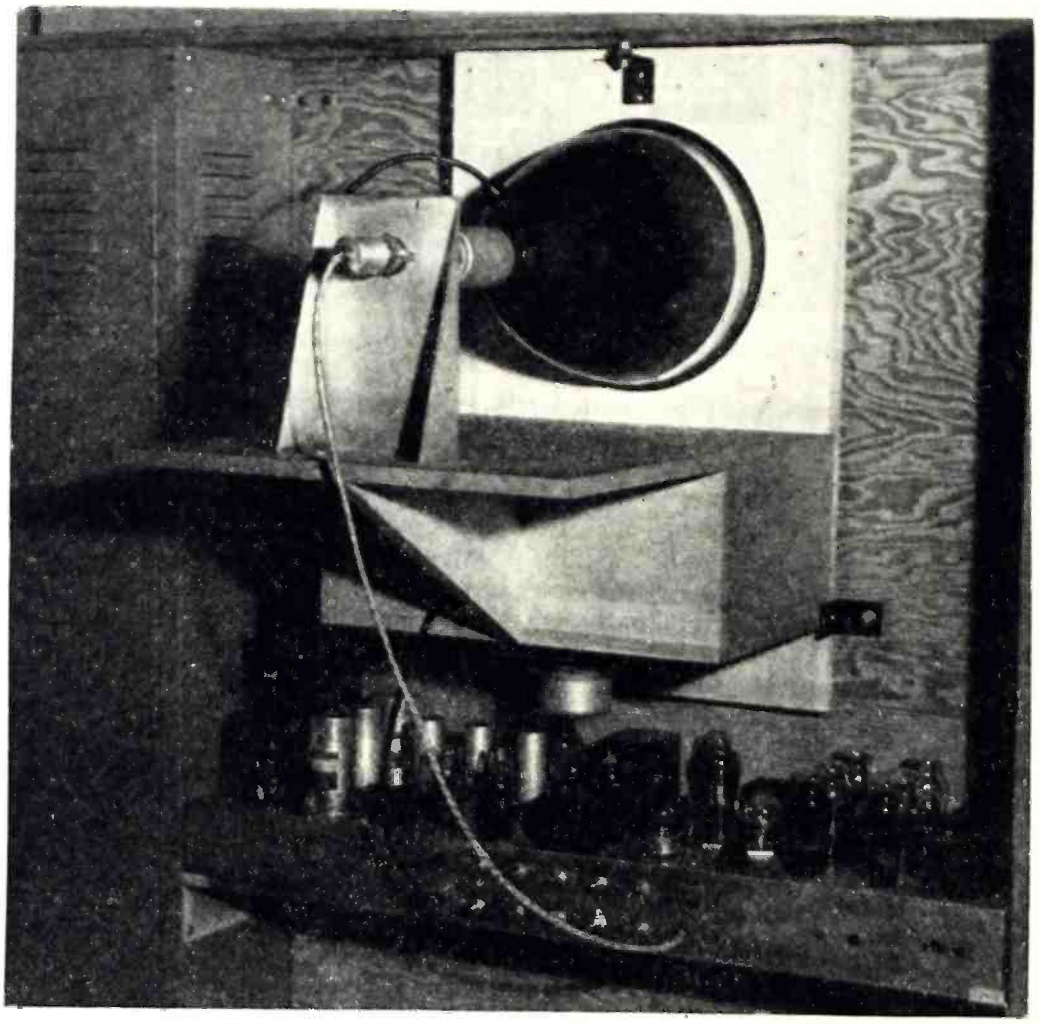


Fig. 15. Rear view of "Sound on Video" unit, showing kinescope and associated supplies.

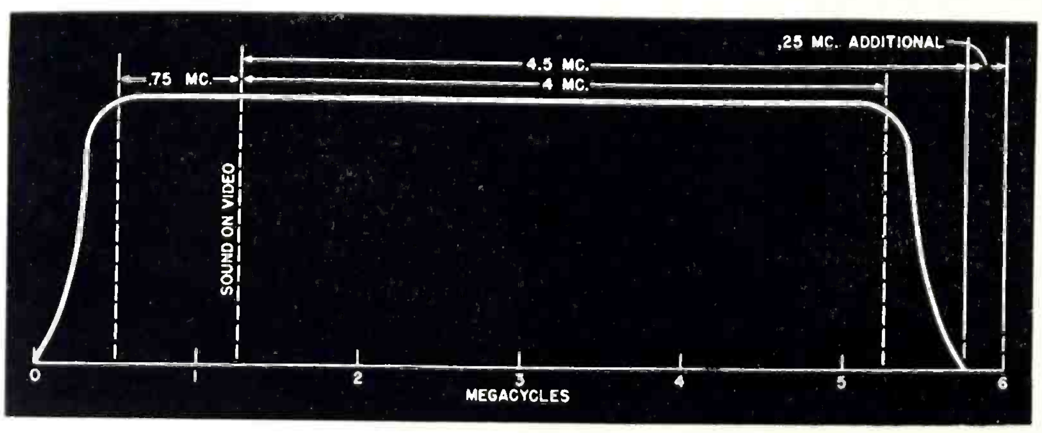
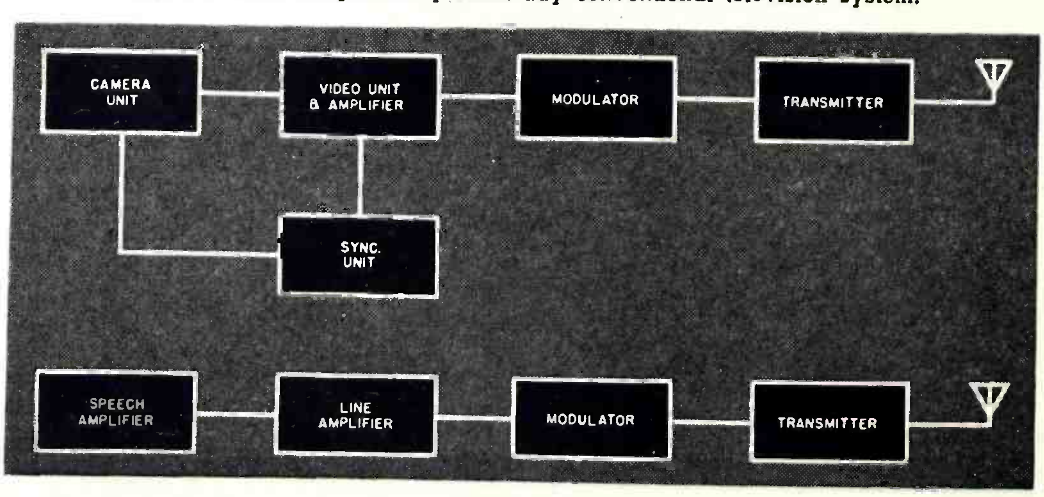


Fig. 16. The various components that go to make up the 6 megacycle television channel.

☆ ☆

Fig. 17. Block diagram of present day conventional television system.



on a small spot or spread out over a large area, and therefore the light definition of the sound image, of either variable area or density, need not be very sharp for conversion by the photoelectric tube. However, "Shot" noise can be created in the photoelectric cell by unmodulated light, and precautions must be taken to eliminate or reduce same, as previously outlined in this article.

A television receptor which eliminates the irksome interference arising from cross-talk due to inadequate trapping of sound in the intermediate frequency video signal circuit, through the elimination of a double intermediate frequency amplifier, as required in present reception, is now practical. This results in a reduction of cost and greatly simplified tuning procedure since there would be no further need for complicated mechanical tuning or switching devices, thereby assuring consistent resonance of the receiver to both video and audio signals, inasmuch as they are combined on a single carrier. This is impossible with present receivers as they are tuned to maximum resonance on the video carrier and depend upon broad band reception for resultant pick-up of the corresponding sound carrier.

Figs. 14 and 17 illustrate, through block diagrams, the complete "Sound on Video" system in direct comparison to the present standardized system.

In conclusion, "Sound on Video" should not be confused with the known system in which a single carrier is sound frequency modulated during horizontal blanking. This single carrier system does not depend upon increments, but wave form analysis through integration for transmission and reproduction, and as a result suffers great audio limitations inasmuch as it causes the audio wave form to be broken and consequently renders for reproduction only segments or parts of the original wave form.

The increment phenomenon employed in "Sound on Video" is directly analogous to the theory originally set forth by Max Planck, "That radiated energy is not continuous, but merely a rapid succession of spurts or bundles of quanta."

As "Sound on Video" is now a proven principle it merely becomes necessary to analyze this system in the laboratory for definite findings as to frequency characteristics, noise level, distortion and dynamic range. These analyses are now being undertaken by the inventor.

REFERENCES

1. *Goldmark, Peter, and Hendrick, Paul, Proc. I.R.E., Dec. 1939.*
2. *Koller, L. R., "Physics of Electron Tubes," P. 180.*

New Products

(*Continued from page* 34)

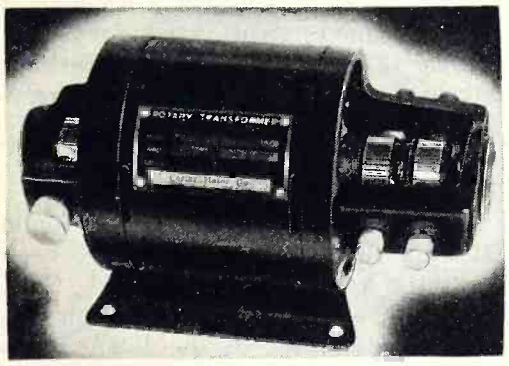
diately recycling. A built-in double-pole, double-throw auxiliary relay provides a variety of circuit arrangements common to, or isolated from the control circuit.

The timer can be supplied for a.c. operation on 110 volts, 25 or 60 cycles, 220 volts, 25 or 60 cycles, or for d.c. operation at any specified voltage from 6 to 120 volts.

Full details may be obtained from *Struthers-Dunn, Inc.*, 1321 Arch Street, Philadelphia, 7, Pennsylvania.

DYNAMOTORS

In order to provide three separate outputs simultaneously from a single generator, the Carter Motor Company has developed a multi-output genera-



tor for applications in police or aviation radio work.

The use of a single dynamotor reduces the heavy drain on storage batteries when used in mobile equipment. It is possible, with this unit, to provide 6.3 volt a.c. as well as the "B" power supply for the receiver and also provide, from the same dynamotor, the high voltage necessary for the transmitter.

Wherever space is at a premium and where a.c. and d.c. must be provided simultaneously, the Multi-Output Dynamotor may be used.

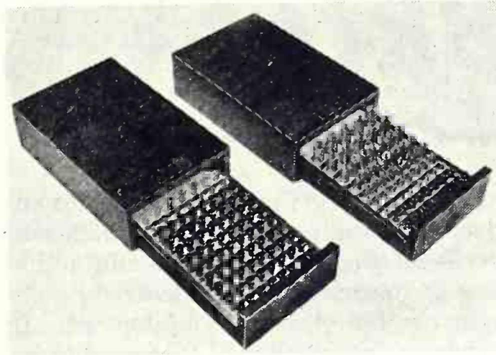
A complete brochure on this unit will be made available to engineers requesting it from the *Carter Motor Company,* 1608 Milwaukee Avenue, Chicago, Illinois.

GAGE CABINETS

Strong, compact cabinets completely equipped with Precision Pin Sets, number drill, letter drill and fractional sizes are being offered by the United Precision Products Company.

The cabinets are especially designed and fitted for their purpose. Brass strips with letter, number or fractional are permanently affixed in clear easily-read white, to identify each gage at its position. Gages are progressively stored for instant pick-up. The smaller pins are stored in glass vials with heavy plastic screw tops and felt cushions at the bottom of the vial for added protection.

Protection against moisture, corro-



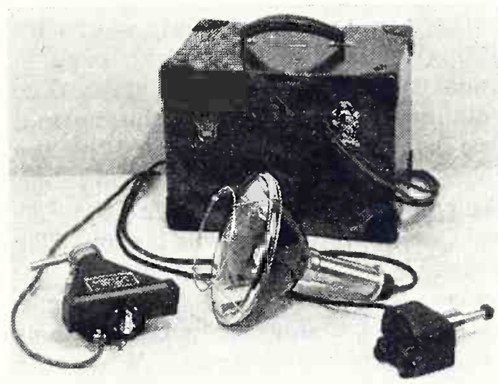
sion and dirt is provided. The cabinets are 9⅞"x15½"x4½".

Complete information may be obtained by writing direct to Dept. RE-8, *United Precision Products Company,* 3524 West Belmont Avenue, Chicago 18, Illinois.

PORTABLE BALANCER

The Davey Portable Balancing Equipment for dynamic balancing of machine parts of all sizes in their own bearings, or in bearings built for the purpose, is now being supplied with an added feature. The equipment consists of a Vibrometer, which measures vibration amplitude directly and a Stroboscope which gives the direct visual reading of the phase angle. The new feature is a remote control switch mounted on the Vibrometer which places the entire operation in the hands of a single operator, instead of adjustments being made by a second operator, as in earlier models.

Simplicity of construction and operation have been retained so that balancing may be performed by practical men and theoretical knowledge is not required to interpret the results. Two models are available for balancing electric motors, motor generators, and machine parts. These two models weigh 22 and 25 pounds each.



Details of application may be obtained from *The Vibroscope Company,* 6 East 39th St., New York, 16, New York.

NEWS BRIEFS

RUSH JOB

The International Detrola Corporation of Detroit, Michigan, was recently cited by Major General Harry C. Ingles, Chief Signal Officer, for the performance of a seemingly impossible task.

The Army required a large quantity of platter-on-a stick devices, used in mine detectors in a single day. The amount needed equalled the normal five day output of the plant. With the cooperation of management and labor, the company's expediters, and the Signal Corps, production was begun. The women workers on the production line paused only long enough to have buckets of cold water thrown over their aching wrists and arms. When the early morning deadline arrived, the train which had been backed into the plant siding was loaded and sealed and the shipment of vitally needed mine detector parts was on its way to the front.

NEW PLANTS

Four companies have announced the expansion of existing facilities to take care of present business and prepare for postwar orders.

The Audio Development Company of Minneapolis has just completed construction of a new building which houses the general and engineering offices, the experimental and design laboratory and the model shop. Floor space formerly occupied by these units will be taken over by the production department to provide a 25 percent increase in manufacturing facilities for transformers and other electronic equipment.

Negotiations have been completed by Thomas A. Edison, Inc., for the leasing of the plant formerly occupied by the U.S. Hammered Piston Ring Company at Morristown, New Jersey. This building will house the war products division of the company. 10,000 square feet of manufacturing space is now available through this move.

The Illinois Condenser Company has added another floor to its facilities at their plant at 1160 North Howe Street in Chicago. Production facilities have been enlarged and production is now 300 percent over last year at this time. The company manufactures all types of condensers for the Armed Forces.

The Mec-Rad Division of Black Industries of Cleveland, Ohio, has started the construction of a new building adjacent to the present plant which will be devoted entirely to the manufacturing of mechanical and electrical components for electronic equipment. In addition to doubling the productive capacity for h.f. antennas, the new plant will contain an enlarged laboratory, as well as testing and research facilities.

PARTS CONFERENCE

The radio and electronics parts industry will hold its annual conference at the Stevens Hotel, in Chicago on October 19-20-21. The sponsoring organizations include the Association of Electronic Parts and Equipment Manufacturers, the Sales Managers Club, and the National Electronics Distributors Conference.

Each registered manufacturer will have a conference booth for conferences only. In keeping with the wartime restrictions, there will be no displays, no literature for distribution and no exhibits in these booths. The booths will be of uniform size and will furnish facilities for the personnel of various companies to get together to discuss distribution and sales information.

The general chairman of the conference is Mr. H. W. Clough of the Belden Manufacturing Company. Publicity is in charge of Charles Golenpaul.

SPORTS BROADCASTS

A possible postwar use of one essential item of war equipment was demonstrated at the Victory National Open golf tournament when scorers and sport writers used the U.S. Signal Corps Handie-Talkie to chart the progress of the tournament.

This equipment which is manufactured by the Motorola Radio Division of Galvin Mfg. Co., was used by observers stationed on greens throughout the course to flash scores back to the club house as each competing foursome holed out. This enabled the press and spectators to follow the progress of the tournament stroke by stroke and to tell instantly where each of the competing golfers stood in the scoring.

The manufacturers foresee postwar applications of the Handie-Talkie to communication facilities for police and other law enforcement groups, relief and rescue parties at disasters, sports events, firemen and railroad repair crews. The Company's entire output of this transmitter-receiver is going to the Armed Forces at the present time.

WESTINGHOUSE ORDERS

Production demands for new types of weapons developed by Westinghouse in cooperation with the Armed Forces were largely responsible for the increase in company orders received during the first five months of this year. The increase is 6 percent over the same period in 1943.

Orders received by the plant up to May 31st totalled $384,769,328 as compared to the 1943 orders of $360,674,274 for the same period. The Company's production for the first five months of this year was 21 percent ahead of the same period last year.

This year's record rate of production was attained despite the fact that nearly 21,000 experienced Westinghouse employees are in the armed services.

RMA DIRECTORS

Two new directors of the Radio Manufacturers Association have been recently announced. Mr. S. I. Cole, president of Aerovox Corporation was named a director of the RMA Parts Division for a two-year term beginning in 1944 and Frederick R. Lack, vice-president of the Radio Division of Western Electric was elected a director of the association for a similar term.

Both men have been prominent in RMA affairs for the past several years.

BEACHHEAD TRANSMISSION

The first material to be transmitted direct from the beachhead in Normandy to the United States was carried over the facilities of Press Wireless, Inc.

This transmission was made possible by the presence of a 400 watt mobile transmitter of the company's own design and manufacture. Messages were transmitted at the rate of 350 words and more a minute. The transmitter is equipped with a low-hung doubler antenna and a diesel driven power unit. Reception was effected at the Baldwin, Long Island, terminal of the company by one of the company receivers. The first dispatch filed at the beachhead at 5:50 A.M. EWT was delivered in a New York newspaper office in less than 21 minutes.

During the first two weeks of operation, the mobile unit transmitted 200,000 words of press material. The outfit is being operated under authority of the war theater command and the Signal Corps. Other and larger units will be put into operation.

RADIOMEN ELECTED

Two men in the radio industry have been elected to important posts in the American Management Association according to the announcement of W. L. Batt, Chairman of the Board.

Mr. Don G. Mitchell, vice-president in charge of sales for Sylvania Electric Products, has been named to the post of vice-president in charge of marketing in the AMA.

C. S. Craigmile, vice-president of the Belden Manufacturing Company, was named director of the association.

The AMA is an organization of executives from all industries who exchange constructive criticism and suggestions in the various fields of management, personnel and industrial relations, marketing, finance and other managerial problems.

END-TO-END COMMUNICATION

End-to-end radio communication is being used by the Seaboard Air Line Railway Company on the run between Richmond, Virginia, and Miami, Florida.

The trains are equipped with Bendix very high frequency multi-channel radios, consisting of a transmitter, receiver and power unit in a single compact case.

Loud speakers are used to notify the called party and conversation proceeds over regular telephone type transmitters which carry the "press-to-talk" feature.

Mr. J. R. DePriest, Superintendent of Telegraph and Signals for the company reports that this equipment is speeding the dispatching of messages from the conductor to the engineer and eliminating unnecessary operating delays.

APCO CONFERENCE

The 11th annual national conference of the Associated Police Communications Officers will be held at the Commodore Perry Hotel, in Toledo, Ohio, September 18, 19, and 20th.

Some of the important problems to be discussed at this conference include, frequency allocation, inter-city communications, interference and manpower. Representatives of the FCC will take active part in the deliberations.

Equipment from leading manufacturers in the communications field will be displayed and representatives will explain and describe postwar police communications equipment.

RADIO CHIEF OF WPB

Frederick A. O'Leary of Belmont, Mass., has been made chief of the radio and radar section of the War Production Board New England Division. He succeeds Michael Scott who has been commissioned in the U.S. Navy.

O'Leary who has been a WPB employee for 16 months, was formerly associated with Raytheon Manufacturing Company and the Eastern Company.

The division which Mr. O'Leary heads is responsible for assisting New England military electronic equipment manufacturers with production, scheduling, procurement, manpower and prioritv problems.

TWO-WAY RADIO FOR CABS

Two-way taxicab radio is to be installed in Cleveland in the Yellow and Zone Cabs at the end of the war by the General Electric Company. The proposed installation is being worked out by GE's Electronics Department and the Cab Research Bureau, Inc.

Radio equipped cabs would be available in emergencies growing out of accidents, fire, crime and other disasters. Contact could be made with any cab instantly at any place in the city. Advantages of this system include the elimination of unattended call boxes and the reduction of dead mileage with its resulting conservation of gasoline, rubber and the extended life of the cab.

Present plans call for one main transmitter for the downtown area and two others to cover the rest of Greater Cleveland. Each transmitter would have four channels, with 100 cabs assigned to each channel.

NEW COMPANY FORMED

The organization of Grayhill, with general offices at 1 North Pulaski Road, Chicago, and manufacturing facilities at La Grange, Illinois, has just been announced.

The company, which takes its name from Mr. Ralph M. Hill and Mr. Gordon E. Gray, will manufacture mechanical and electrical switching devices for use by the electrical, electronic, and aircraft industry. The company is now in production on snap-action and rotary switches of original design.

Mr. W. S. Lewis has assumed the post of chief mechanical engineer and general manager, while Arnold Wassell is in charge of the plastic design engineering and production.

VIDEO FOR ADVERTISERS

Department store executives heard Irwin A. Shane, director of the Television Workshop predict that television will play a very important part in postwar department store advertising. It is Shane's contention that television will sell merchandise as no other advertising medium in the past. Merchandisers must make plans now for the inclusion of this type of advertising in their postwar budgets and by training personnel to present television programs which will sell merchandise.

Besides the normal station facilities which will make telecasts available to the entire television audience in any metropolitan area, stores will have "jeep" television.

in the first limiter can be used to control a positive bias on the second limiter grid by applying the voltage drop across a resistor in the first limiter grid to the grid of an extra tube and applying a portion of the positive plate voltage to the second limiter grid. In operation, a signal of predetermined magnitude will bias the "squelch" tube to plate current cut-off, thereby removing the disabling positive voltage from the grid of the second limiter.

A simple and effective method of inter-station noise suppression is applicable to a single as well as a double limiter, and no extra parts or circuits are required. It consists only in operating the limiter screen grid at a higher voltage than is customary. The best constants are a no-signal screen voltage of about 51 volts from a well regulated source such as a tap on the bleeder resistor, and 2.2 volts on the plate through a dropping resistor. With these conditions the limiter is entirely unresponsive to voltages under 0.75 volts applied to the grid. This value is just above that created by inherent receiver noise and hence entirely quiet operation between stations is attained. The sensitivity of the receiver, rated on the basis of a 20 db signal to noise ratio, and a 2 volt limiter grid signal, is not impaired. With a signal grid voltage of 1 volt or more, the limiter functions normally. The action is much like a trigger and the effect is demonstrated when tuning in a station. While a normal limiter would permit an appreciable interval of noise rise as resonance is approached, the interval is extremely short with the limiter described here because of the narrowed range of noise voltage response.

A tuning indicator, or "eye," is essential for satisfactory operation of an FM receiver, because three peaks of audio response are heard when tuning, only the center one being free of noise and distortion. This is characteristic of a discriminator, hence the need for accurately locating the center point with visual means. Exact adjustment to the midpoint of the discriminator is desirable to insure undistorted response and to balance out ignition and other noise types not entirely removed by the limiter. Several accurate methods of indication con-

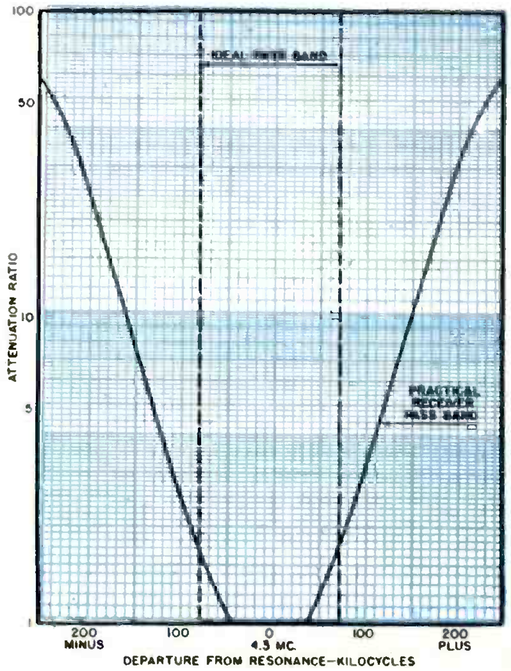


Fig. 6. Ideal and practical selectivity characteristics for FM broadcast receivers.

trolled by the discriminator are available[3] but the simplest type, controlled by limiter grid current, proves adequate on carefully aligned receivers. This is a 6U5 type indicator tube which responds to the amplitude of the received signal. A small amount of AVC in the i.f. amplifier is required to insure a sharp indication with strong signals.

Extended fidelity or the transmission and reception of the higher audio frequencies and overtones necessary to the full appreciation of good music is one of the outstanding characteristics of FM. Standard broadcast stations on AM are only 10 kc apart in the spectrum and audio modulation frequencies above 5,000 cycles per second give side-bands which extend into the adjacent channel and produce interference. The means for obtaining high fidelity reproduction on the regular broadcast band is a serious design problem, while high fidelity in an FM receiver is simple, limited only by the design of the audio amplifier and speaker system. The pre-emphasis inserted at the transmitter in order to give a more favorable signal-to-noise ratio is compensated with a shunt capacitor of about .002 μf and series resistor of about 68,000 ohms at the output of the discriminator in the receiver.

In conclusion, the following improvements are recommended for post-war receivers:

1. The normal drift of the FM oscillator should be reduced as much as possible.
2. Alignment procedure should be as simple as possible, and should allow peaking by a meter reading rather than by an oscilloscope.
3. A better limiter circuit and a simple combination FM discriminator and detector should be developed.
4. Push buttons should be provided for FM as well as AM.
5. Dial calibration in production receivers should not deviate more than $\pm$¼ channel from exact tune.
6. Inter-station noise should be suppressed.
7. More efficient built-in antennas should be installed.
8. A tuning indicator should be employed.
9. A better selection of components and better quality control in production will insure more uniform performance in the field.

Thus, the improvement of postwar FM receivers and the consequent increase in public acceptance rests squarely on the engineer. His ability to solve some of the more troublesome problems existing today in FM reception is of utmost importance if this improved method of radio reception is to be universally utilized and enjoyed.

REFERENCES

1. *Armstrong, Edwin H., "A Method of Reducing Disturbances in Radio Signaling by a System of Frequency Modulation," Proc. I.R.E., May, 1936.*

2. *Roder, Hans, "Theory of Discriminator Circuit for Automatic Frequency Control," Proc. I.R.E., May, 1938.*

3. *Rogers, J. A., "Tuning Indicators and Circuits for Frequency-Modulation Receivers," Proc. I.R.E., March, 1943.*

PHOTO CREDITS

Pages

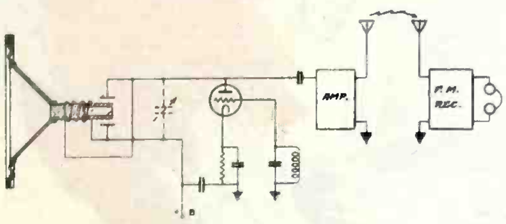
11	General Electric
13	Victor J. Andrew Co.
23, 24, 36	Westinghouse

INDEX OF ADVERTISERS

PATENTS

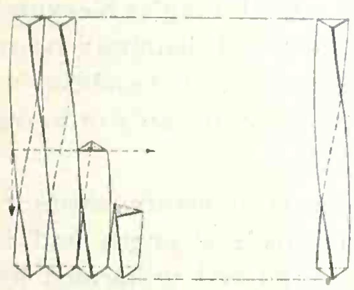
FREQUENCY MODULATION

A device for varying the frequency of an oscillator, wherein variable inductance and capacity elements are actuated by sound waves, and thus alter the oscillator frequency, producing frequency modulation. D. M. Kaltenbacher, assigned to Radio Corporation of America. Filed May 29, 1942, issued July 11, 1944. No. 2,353,162.



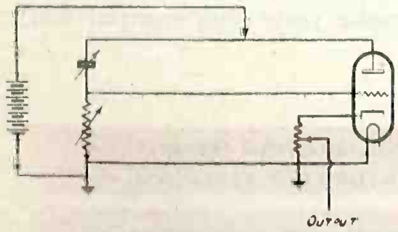
TELEVISION SCREEN

A viewing screen scanned by a beam of light for television reception comprising an equilateral prism having similar warped lateral surfaces each being of a material which liberates light of a different color from the others when scanned by said beam. Otto H. Schade, assigned to R.C.A. Filed March 24, 1942, issued June 13, 1944. No. 2,351,294.



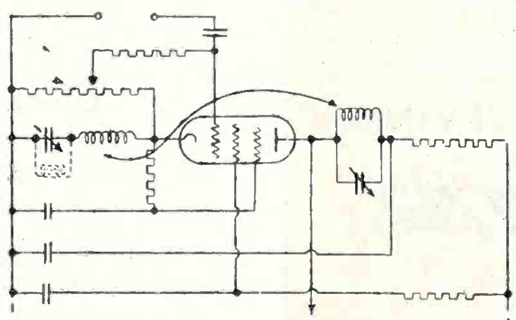
QUENCHED OSCILLATOR

A quenched oscillation generator comprising a condenser connected from grid to plate of the oscillator tube by means of a parallel line circuit, a grid resistor connected from grid to cathode by means including at least a portion of one conductor of the parallel line circuit, and a source of current connected directly across the series condenser and grid resistor by a pair of leads, one of the leads being connected to the anode conductor midway between anode and condenser. The whole circuit arrangement and parameters have such adjustments and values that the circuit generates uhf oscillations and also generates and applies to the grid a voltage pulse at a frequency lower than the uhf oscillations, this voltage serving to periodically quench the device as an oscillation generator. Thomas Dixon Parkin, assigned to Radio Corporation of America. Filed October 28, 1942, issued July 11, 1944. No. 2,353,493.



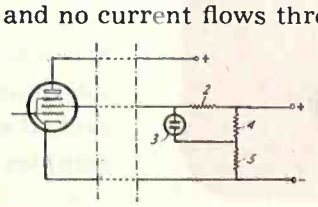
SELECTIVITY APPARATUS

An electronic tube circuit arrangement comprising a cathode, an anode, and at least one grid, a counter-coupling channel and a series resonant circuit arranged in said cathode supply lead, and screening means surrounding the inductance of said series resonant circuit and connected to said cathode. Ladislas de Kramolin, vested in the Alien Property Custodian. Filed December 22, 1937, issued June 6, 1944. No. 2,351,934.



TUBE FAULT INDICATOR

The grid-cathode circuit of the tube is used as one leg of a balanced bridge network connected across the d.c. supply source. The other legs of the bridge are formed by the resistors 2, 4, and 5. Three is an indicating device, such as a neon tube. As long as the tube operates satisfactorily, the bridge is balanced, and no current flows through 3.



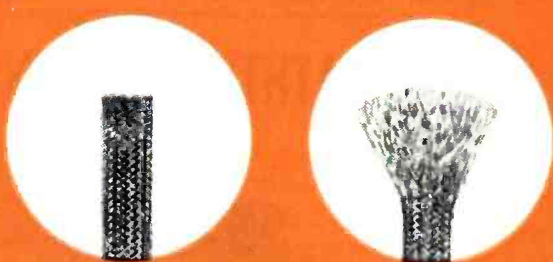
If a fault appears in the tube, the bridge will be unbalanced, and the indicator will show a flow of current. Hans Joachim Frundt and Wilhelm Schonfeld, Berlin, Germany; vested in the Alien Property Custodian. Filed November 13, 1940, issued March 28, 1944. No. 2,345,042.

NO FRAYED ENDS
NO FRAYED NERVES

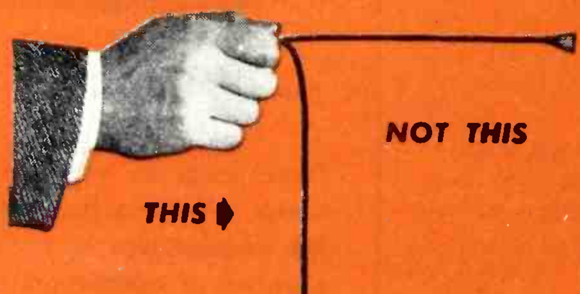
WHEN YOU USE BH FIBERGLAS SLEEVING!

BH EXTRA FLEXIBLE FIBERGLAS SLEEVING

2 WAYS BETTER



NON-FRAYING



NON-STIFFENING

Here's an Insulation that Handles Easier, Cuts Cleaner and Saves Time

IF you're exasperated by ordinary sleeving that frays on the ends, works stiffly and doesn't hold up in use . . . then you'll certainly want the low-down on BH *Extra Flexible* Fiberglas Sleeving! For this is a really *flexible* and definitely *non-fraying* sleeving—built around the excellent insulating qualities of Fiberglas by an *exclusive* BH process.

Fiberglas, you know, is moisture-resistant, high in dielectric and tensile strength and is shunned by fungus growths and unharmed by most chemicals. "Punishment" tests prove that BH *Extra Flexible* Fiberglas Sleeving has even more advantages. It is *permanently* non-fraying and non-stiffening. It won't burn because both yarns *and* impregnation are non-inflammable. And it lasts indefinitely without cracking or rotting.

Assembly and repair men say BH *Extra Flexible* Fiberglas Sleeving is a pleasure to handle and a sure bet for long life in the most severe service. So why tolerate a less efficient sleeving any longer? BH is available in all standard colors and all sizes from No. 20 to ⅝", inclusive. Write for samples today and make your own comparison!

BH PRODUCTS

NON-BURNING IMPREGNATED MAGNETO TUBING • NON-BURNING FLEXIBLE VARNISHED TUBING • SATURATED AND NON-SATURATED SLEEVING

BENTLEY, HARRIS MANUFACTURING CO.

Dept. R Conshohocken, Penna.