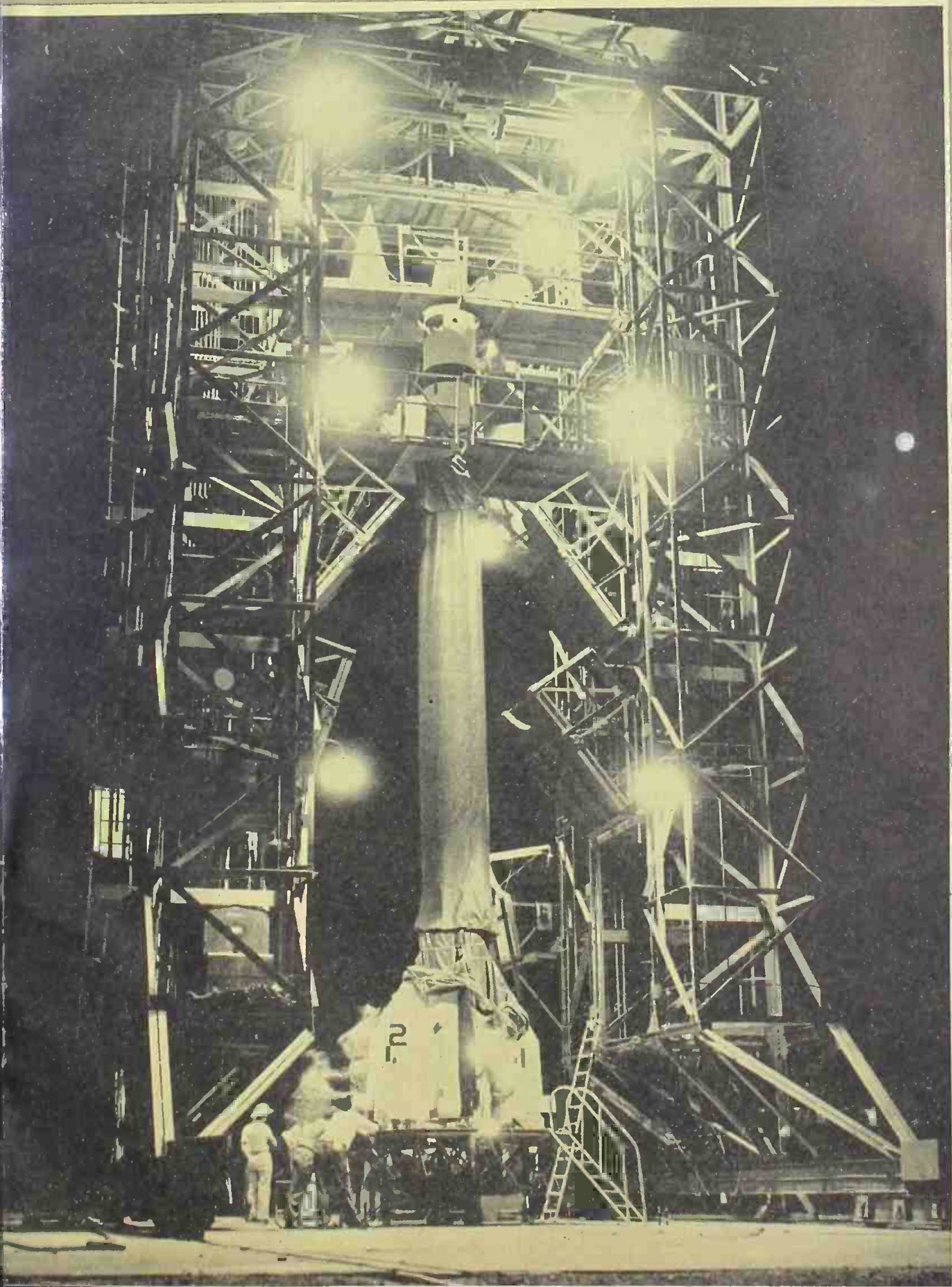
NOVEMBER, 1949

RADIO & TELEVISION NEWS

RADIO-ELECTRONIC Engineering



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NOVEMBER, 1949

DEPARTMENTS

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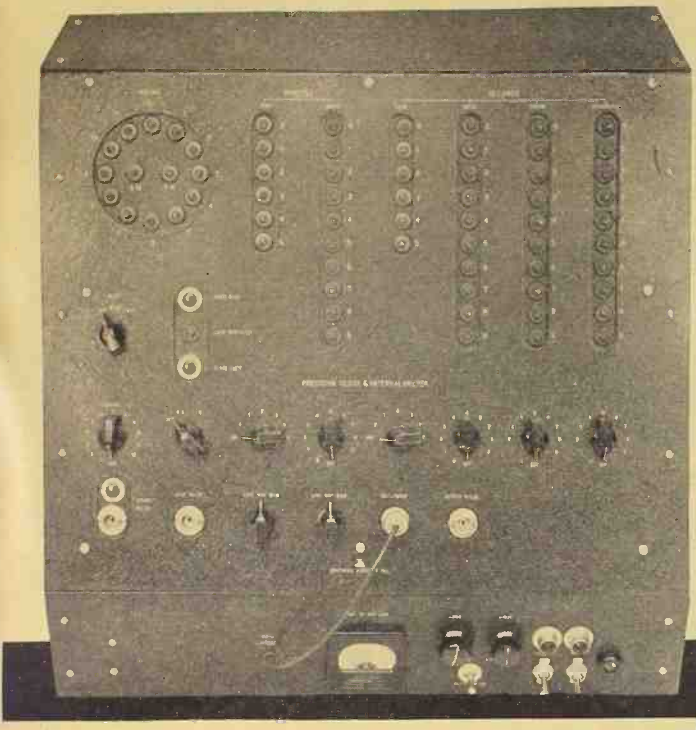
COVER PHOTO—By Acme

Preparations are under way to fire the Navy's giant Viking rocket at White Sands Proving Ground, N. M. A protective sleeve covers a portion of the target. The rocket contains a great deal of electronic telemetering equipment for reporting data back to the earth during flight.

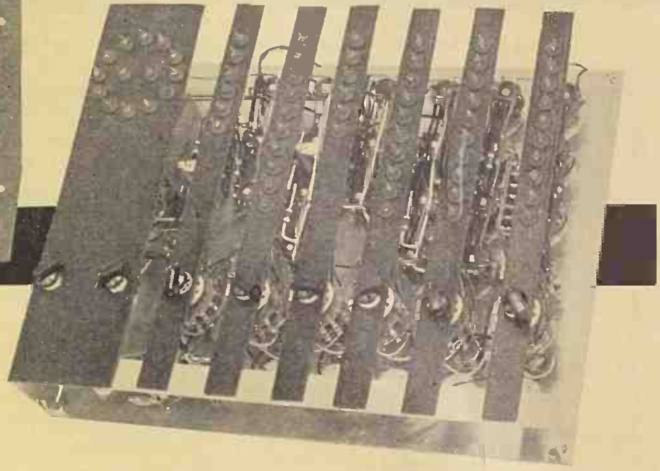
DIRECT READING TIMER and CLOCK

By A. E. WOLFE, Jr.
and F. G. STEELE
Northrop Aircraft, Inc.

Design and construction of a highly accurate intervalometer for 1/100 sec. to 24 hr. timing.



Front panel view of the clock and intervalometer.



Interior view of the precision clock.

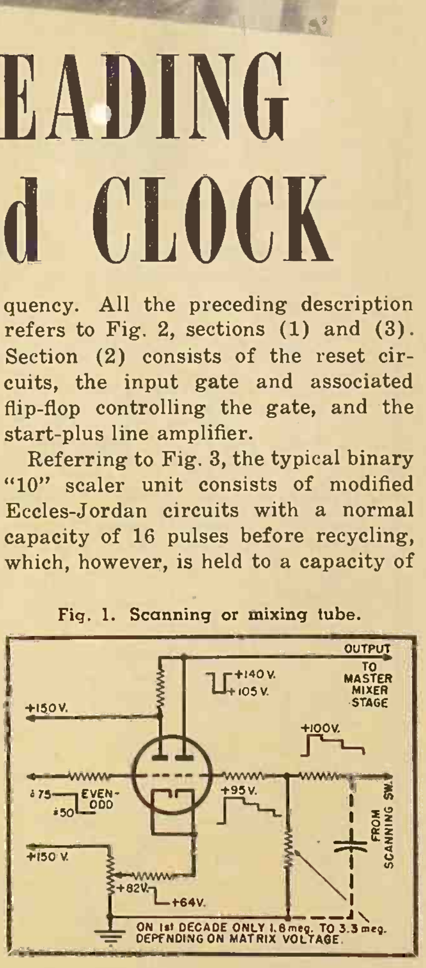
CONSIDERABLE interest has been shown lately in "Atomic" or electronic clocks. Engineers at *Northrop Aircraft* needed an extremely accurate clock, one which would start or stop at a previously determined time and which would record accurately to 1/100 second an interval between two operations. Their answer to the problem is the *Northrop* intervalometer.

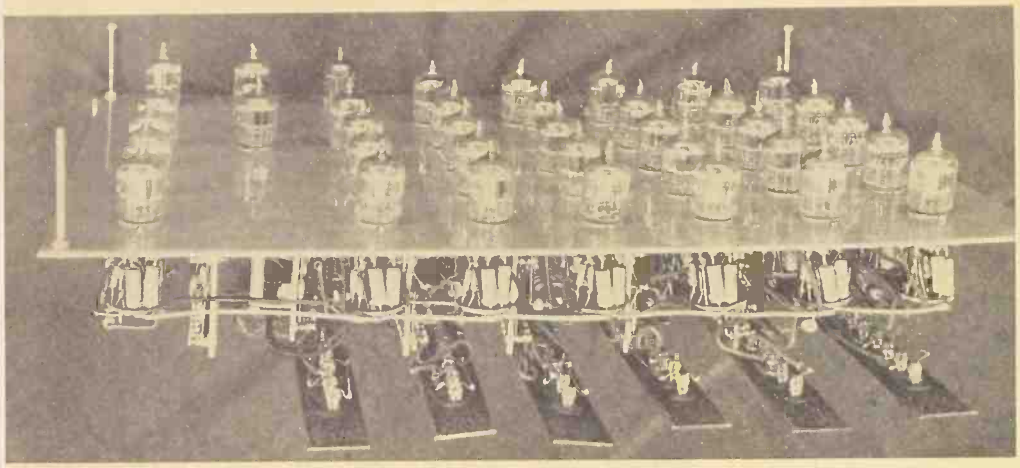
The intervalometer is used in conjunction with a frequency standard consisting of a temperature controlled 102.4 kc. quartz crystal oscillator and several frequency dividers. The reason 102.4 kc. was selected is that this is an even power of two and therefore simple scale of two dividing circuits could be used. It was believed that these scale of two dividing circuits would be more reliable than other types of circuits. The frequency divider consists of 10 double triode tubes and provides the input pulse rate to the clock of 100 pulses per second.

As shown in the picture, the "face" of the clock consists of six vertical rows of neon bulbs reading from right to left 1/100 sec., 1/10 sec., sec., 10 sec., min. and 10 min., and also a circular display of twelve neon bulbs corresponding to the hours. In the center of this circle are two neon tubes indicating AM and PM. Reading from the right, each of the first three rows of 10 bulbs is connected to a 10-position scaler unit. Each 10-position unit consists of four double triodes connected in a special feedback circuit (Fig. 3), the output of each scaler unit being fed to the succeeding unit. The output of the third scaler unit, which represents seconds, is fed to a six-position counter consisting of three double triodes. This scaler unit represents tens of seconds and feeds the minute unit. This is another scaler unit feeding a second six-position counter representing tens of minutes. This counter in turn feeds the hour counter which feeds the AM-PM indicator, a single flip-flop. Below each of the above mentioned scaler units is a multi-position switch which scans each unit and detects the number it contains. The outputs of all the switches are mixed, and the output of the mixer detects the total number contained in the clock. Depending on how the clock is used, this number could represent either a time interval or some absolute time. The unit below the face of the clock proper consists of a power supply and a built-in 100 cycle pulse source which can be substituted for the frequency standard if accuracy desired is not greater than variations in line frequency. All the preceding description refers to Fig. 2, sections (1) and (3). Section (2) consists of the reset circuits, the input gate and associated flip-flop controlling the gate, and the start-plus line amplifier.

Referring to Fig. 3, the typical binary "10" scaler unit consists of modified Eccles-Jordan circuits with a normal capacity of 16 pulses before recycling, which, however, is held to a capacity of

Fig. 1. Scanning or mixing tube.





Interior view of the precision clock and intervalometer.

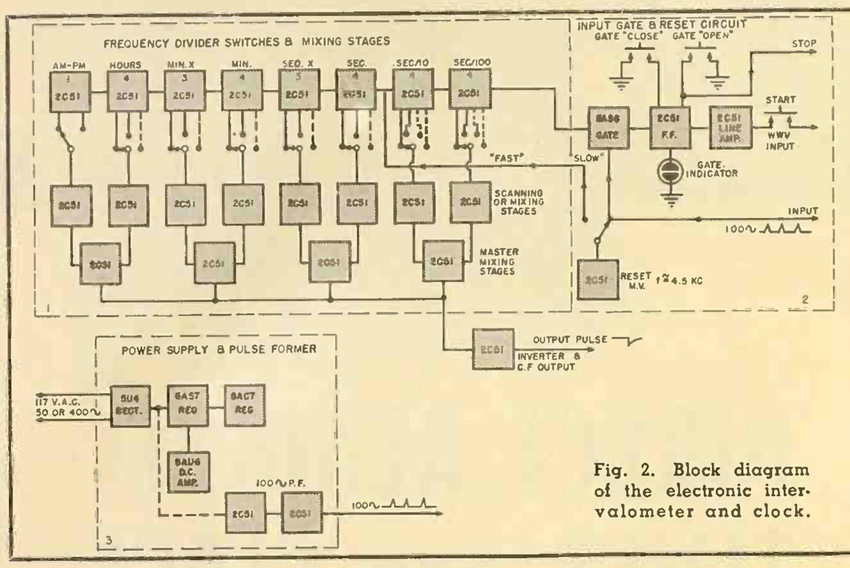


Fig. 2. Block diagram of the electronic intervalometer and clock.

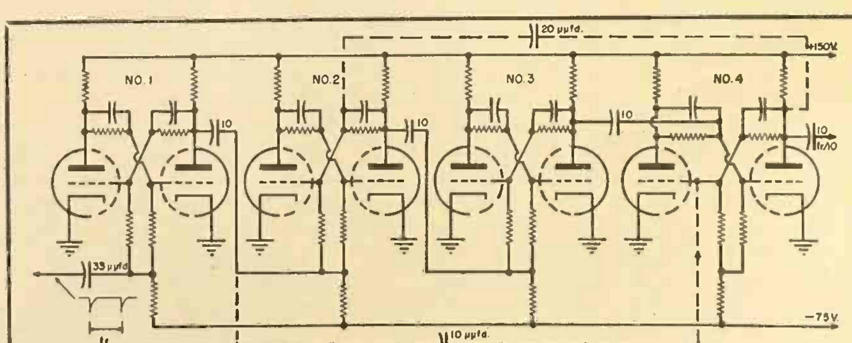
10 by utilizing two feedback paths. The other types of scaler units utilize the same principle to reduce their normal capacity of eight pulses to a capacity of six pulses. Referring to the block diagram, it will be seen that four units with a capacity of 10 are used, i.e., sec./100, sec./10, sec. and min. Two scaler units with a capacity of six, i.e., sec. x 10 and min. x 10, are used, as well as one unit with a capacity for the hours. This latter unit is made up of a counter of six preceded by a flip-flop. The development of a matrix to scan the four tubes (Fig. 3) through their 10 positions is as follows: First, if a stage be in the 01 condition, let that = 0, and if a stage be in the 10 condition, let this = 1 in the following table (Fig. 4).

The actual connections of the matrix appear at the right-hand side of the table. In the section immediately below the counting stages, junctions indicate 510,000 ohm resistors. Junctions below that indicate NE-2 bulbs. Referring to Fig. 4, the table shows five combinations of the last three stages which, when combined with the even-odd configuration of the first stage, gives us 10 possible outputs.

A short description of the operation of the matrix follows. Referring to Fig. 4B, the NE-2 bulb will only light when side *b* is high and side *a* is low. Side *b* is high only when all flip-flop plates connected to it are high.

Considering the counter with 0 pulses (10 configuration using the abbreviated sequence), each stage is therefore in the 0 condition, which means that all left-hand plates are high. As previously explained, an NE-2 bulb will only light when one side is high and the other side is low. Therefore, since the left-hand plates in all stages are high, we must use the right-hand plate in stage 1 and left-hand plates in stages 2, 3, and 4 to light the (0) bulb. If we feed one pulse into the counter, the first stage is the only one to be affected going from the 0 to the 1 condition, i.e., the left-hand plate is now low. Therefore, now to light the (1) bulb, we use the same "high" connection, but for the "low" side of (1) we use the left-hand plate of stage 1. Consider now the counter when we feed another pulse into it. From the table we see that both the first and second stages are affected, the first stage going back to the 0 condition and the second stage going to the 1 condition. The even branch from stage 1 now becomes low. In a similar manner, all subsequent positions up to 9 are carried out and the 10th pulse returns the system to zero.

It has been shown that the neon bulbs indicate the number of pulses fed into the counter. Associated with each scaler unit is a 2 deck wafer switch (see Fig. 8) connected as shown to the NE-2 bulbs. The rotors of these switches, therefore, will be able to detect when a given number appears in the counter. These rotors are con-



PULSE	NO. 1	NO. 2	NO. 3	NO. 4
0	01	01	01	01
1	10	01	01	01
2	01 —(CARRY)→	10	01	01
3	10	10	01	01
4	01 →	01 →	10	01
5	10	01	10	01
6	01 →	10	10	01
7	10	10	10	01
8	01 →	01 →	01 →	10
9	10	01	01	10
0	01 →	10 (OVERRIDDEN) 01	01	01 →

Fig. 3. Typical binary "10". Stage in "01" means left hand section plate high, right hand low: carry from 0 to 1 only.

nected to the scanning or mixing stages.

Briefly, a mixing stage consists of a double triode d.c. amplifier connected as shown in Fig. 1. An input is applied to each grid of the double triode and coincidence is detected in the plate circuit. The wave shapes are as shown in Fig. 1, and the 100,000 ohm pot in the cathode circuit is used to detect only the most positive part of the wave on grid 2. Eight of these scanning or mixing stages are used, i.e., one to each scaler unit. Coincidence of all the outputs of all the scanning or mixing stages is detected in the master mixing stages. These consist of four double triode tubes with a common plate load resistance and separate inputs on each of the eight grids which are derived from the eight outputs of the eight scanning or mixing stages. There is an output from the master mixing stages when and only when inputs to all eight grids are present (Fig. 5).

The output from the master mixing stages is fed into the inverter and cathode follower output stage (Fig. 6). This consists of a 2C51 double triode. The input to the inverter stage is a rectangular wave of about 100 v. amplitude and .01 seconds (10,000 μs.) width. This wave is differentiated in the input circuit to the inverter, and only the leading edge is used. The output of the inverter is a negative going pulse approximately 50 μs. wide and approximately 100 v. in height. This is fed into the cathode follower and this negative going pulse appears on the output jack.

Input Gate and Reset Circuits

The input gate is a 6AS6 tube controlled by a flip-flop (Fig. 7). The 100 cycle timing pulses are applied to G_1 and the controlled voltage for the gate which is derived from the flip-flop is applied to G_3. The gated output appears in the plate circuit. The clock was designed to be started by WWV time pulses and therefore a pulse shaping amplifier was included. This pulse shaping amplifier merely develops a series of five sharp pulses from the five 1000 cycle sine waves which make up a WWV one-second pulse. In addition to the electronic means of controlling the gate, two push buttons are associated with the flip-flop allowing manual operation of the gate if desired. An NE-2 bulb connected to the proper plate of the flip-flop serves as a gate indicator showing either open or closed condition.

To set the clock at any given time, the reset circuits as shown in section (2) of the block diagram are used. These consist merely of a two-position switch and a free running multivibrator running at approximately 4.5 kc. In the "fast" position, the differentiated output of the multivibrator is fed directly

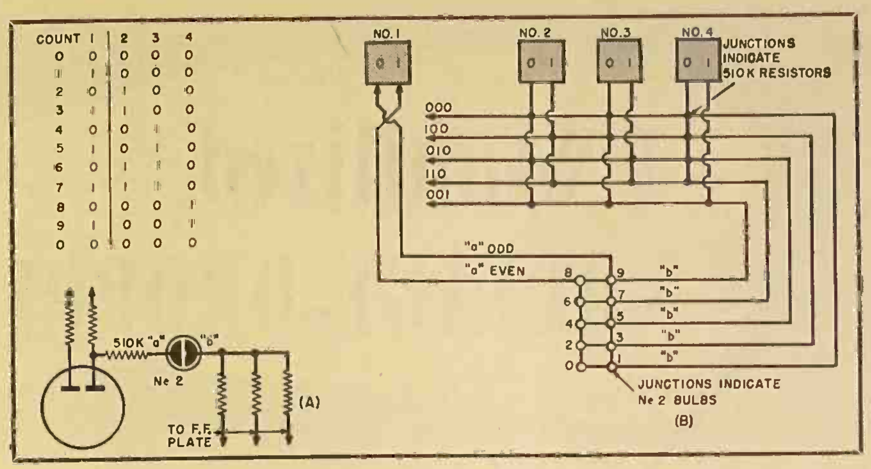


Fig. 4. (A) Matrix development for typical binary "10". A given bulb will light when even-odd bus is low on one side of bulb and high on other side. (B) Detail of (A). Bulb lights only when all F.F. plates on side "6" are high and "a" is low.

to the one-second scaler unit bypassing the input gate and the first two scaler units, i.e., the sec./100 and the sec./10 units. This is done to quickly cycle the last three scaler units to their approximate final position. When this has been accomplished, the reset multivibrator is set to slow, the output from the inverter and cathode follower unit is connected to the stop jack, and the 6AS6 gate is manually set open. As soon as the required number, as determined by the positions of the various switches, is present in the clock, a pulse appears at the output of the cathode follower which triggers the flip-flop controlling the input gate, thus closing the gate. The reset multivibrator is now turned off, the 100 cycle input is connected, and the clock is now set. The entire reset operation takes on the average 30 to 45 seconds.

In operation over an extended period, the only maintenance required has been the replacing of two type 2C51 tubes and the readjustment of one of the scanning or mixing tube cathode biases.

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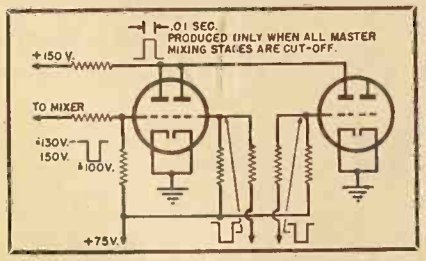


Fig. 5. Master mixing stages.

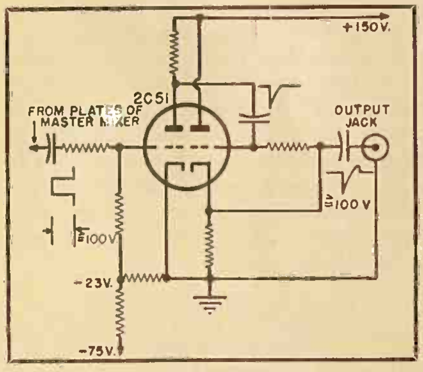
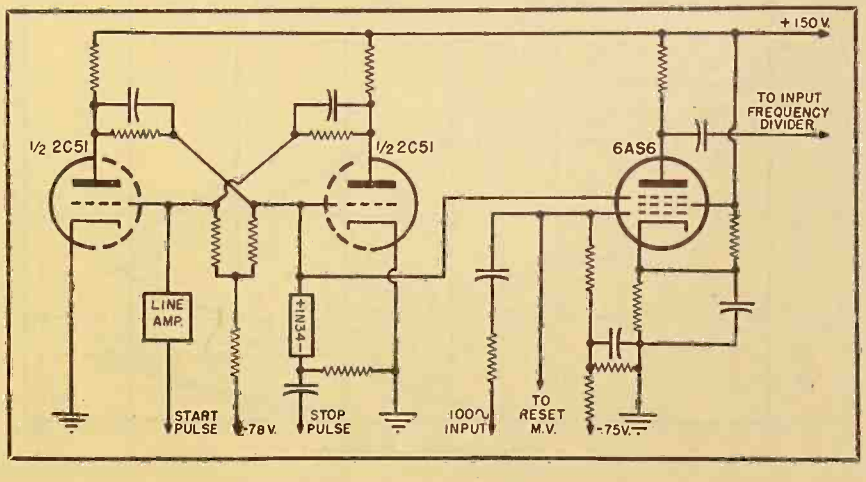


Fig. 6. Inverter and cathode follower for output pulse.

Fig. 7. Input gate driven from flip-flop.



A Stabilized VOLTAGE-DROPPING Element

By SYDNEY E. SMITH
Engineering and Industrial Experiment Station, University of Florida

A cathode follower may be used to provide an adjustable stabilized d.c. voltage with small bleeder current.

MANY electronic circuits require a variable current from a source of good voltage regulation. Often, the voltage required is lower than the power supply output voltage and is derived from a conventional voltage divider. It can easily be shown by means of Thevenin's Theorem that the voltage regulation of this type of circuit is inversely proportional to the bleeder current. When good regulation must be provided and the load current varies over a wide range, the necessary bleeder current may be an unduly large percentage of the total current load on the supply. Such a design is inefficient, both in first cost and in operation.

In cases of this kind, the cathode follower may often be used to advantage as a voltage dropping and stabilizing device requiring negligible bleeder current. In addition, the circuit may provide a considerable amount of filtering of a.c. ripple voltage which may be present on the output of the power supply, and a low impedance to signal components of load current.

Circuit Analysis

The circuit of the cathode follower employed as a voltage stabilizer is indicated in Fig. 2. The purpose of the capacitor C is twofold: to prevent any a.c. ripple present on the power supply voltage, E_{bb}, from appearing on the reference voltage E, and to maintain the grid at the a.c. potential of the low side of the load. The operation of the tube is then such as to provide considerable filtering of a.c. ripple and a low output impedance to a.c. components of load current. The d.c. output voltage E_b will be the difference between the drop across R_2 and the bias required by the tube at the value of load current and plate voltage $(E_{bb} - E_b)$ which obtains.

$$E_b = E - E_c \quad . \quad . \quad . \quad (1)$$

Since it is generally desirable to operate the tube without grid current, the required grid bias, E_c, will be a negative quantity and the load voltage will be greater than E.

Assuming that the supply voltage E_{bb} does not vary, the regulation of the load voltage will be determined by the variation in grid voltage required by the stabilizer with varying load current.

$$\text{Regulation } (\%) = \frac{\Delta E_c}{E_b} \times 100 \quad . \quad . \quad (2)$$

ΔE_c is the variation in required grid voltage and E_b is the full load output voltage.

The degree of power supply ripple filtering provided by the stabilizer may be obtained by reference to the equivalent circuit of Fig. 3A. From this circuit, it follows that

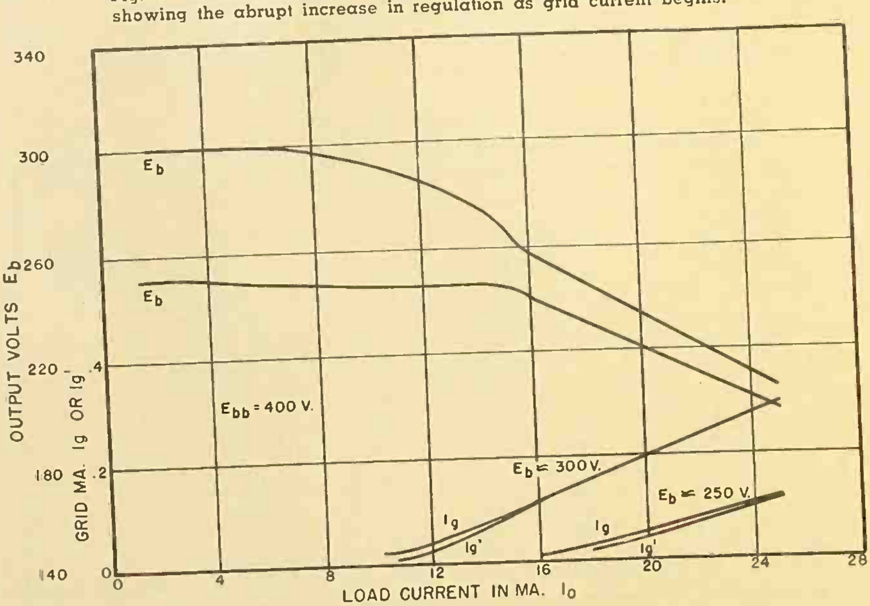
$$e_r = (e_{rr} - \mu e_r)\frac{R_L}{R_L + R_p} \quad . \quad . \quad . \quad (3)$$

Solving explicitly for e_r and dividing by e_{rr} to obtain the ripple attenuation ratio:

$$\frac{e_r}{e_{rr}} = \frac{1}{(\mu + 1) + \frac{R_p}{R_L}} \quad . \quad . \quad . \quad (4)$$

The stabilizer impedance to a.c. components of load current may be derived from the equivalent circuit of Fig. 3B in which the load has been replaced by a constant current generator driving i_L through the parallel resistors R_p and R_L. The tube has been replaced in the usual manner by a

Fig. 1. Voltage regulation characteristic of the circuit of Fig. 2, showing the abrupt increase in regulation as grid current begins.



constant current generator driving the current $-e_s g_m$ through the paralleled resistors. The signal frequency voltage appearing across the load is then:

$$e_s = (i_L - e_s g_m) \frac{R_L R_p}{R_L + R_p} \quad . \quad . \quad . \quad (5)$$

from which the output impedance of the stabilizer is:

$$R_o = \frac{e_s}{i_L} = \frac{R_o R_L}{(1+\mu)\ (R_p + R_L)} \quad . \quad . \quad (6)$$

or, when $\mu >> 1$:

$$R_o = \frac{1}{g_m} \times \frac{R_L}{R_p + R_L} \quad . \quad . \quad . \quad . \quad (6a)$$

Eqts. (6) and (6a) will be recognized as the usual ones for the output impedance of the cathode follower. In many applications, the fact that the output impedance is independent of frequency may be an added advantage of the circuit.

Since in the usual case the stabilizer will operate without grid current, the reference voltage divider may be of high resistance, requiring but one milliampere or less of bleeder current. The capacitor C should be chosen so that its reactance at the power supply ripple frequency, or at the lowest frequency of the signal load current, will be small compared with the magnitude of R_1 (or, more accurately, small compared with $(R_1R_2)/(R_1+R_2)$).

Practical Circuit Operation

The results of measurements performed upon a laboratory circuit employing a type 6J5 tube are indicated in Figs. 1, 4 and 5.

It will be observed that in both cases of Fig. 1 the output voltage drops slowly until grid current begins to flow, then falls sharply. In each case, the variation in the output voltage up to the point at which grid current begins agrees well with the value of grid voltage at plate current cutoff for the plate voltage $(E_{bb} - E_b)$ applied to the cathode follower. These curves indicate that for good voltage regulation the cathode follower should be operated between the limits of E_c = cutoff and E_c = zero as the load current varies from zero to its maximum value. Over this range, the output voltage will vary by the difference in grid voltage, and no grid current will flow.

The grid current curve I_g' was obtained with no ripple voltage applied to the circuit, while I_g was obtained with a ripple of 10 volts r.m.s. superimposed upon the 400 volt supply (3.54% ripple). As should be expected, the grid current curves indicate that the presence of ripple voltage upon the power supply output reduces the maximum d.c. load current which may be supplied without grid current.

Fig. 4 shows the variation in output ripple voltage with d.c. load current. At 300 volts output, the ripple attenuation ratio was of the order of 0.07, or about 22 db. to the grid current point, while for the 250 volts case, corresponding values were 0.06 and 24 db.

It must be observed that the a.c. output impedance curves of Fig. 5 are somewhat sketchy due to the limited capacity of the a.c. load current generator employed. They are included here, however, to indicate certain limitations in operation of the circuit. It will be observed that the output impedance is lowest at moderate values of direct current and small values of alternating current. The increase in impedance at low values of direct current is in agreement with Eqt. (6) since the transconductance of the tube falls off at low values of plate current. The increase in output impedance with a.c. load current is due to either of two factors:

(1) With increasing a.c. load current the path of operation of the tube extends over a greater portion of the characteristic curve. Since the plate current-transconductance characteristic of the tube is not linear, the transconductance averaged over the path of operation is less than that at the d.c. operating point.

(2) When the sum of the d.c. and the peak a.c. currents is greater than the value for which E_c of the stabilizer must be zero, the grid draws current, thus reducing the load voltage on the signal peaks. Again, the average value of the output impedance over the signal cycle is effectively increased.

The above discussion indicates that the maximum a.c. load current may be supplied when the d.c. load current is equal to one-half of the maximum d.c. current which the circuit can supply without grid current, in the absence of an a.c. load current. The maximum value of the peak load current is then equal to the d.c. load current, but the output impedance to the alternating

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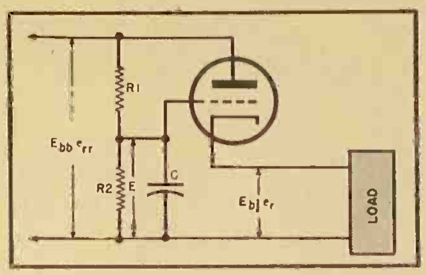


Fig. 2. Circuit diagram of the cathode follower voltage stabilizer.

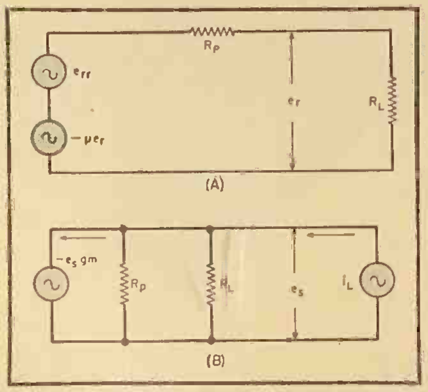
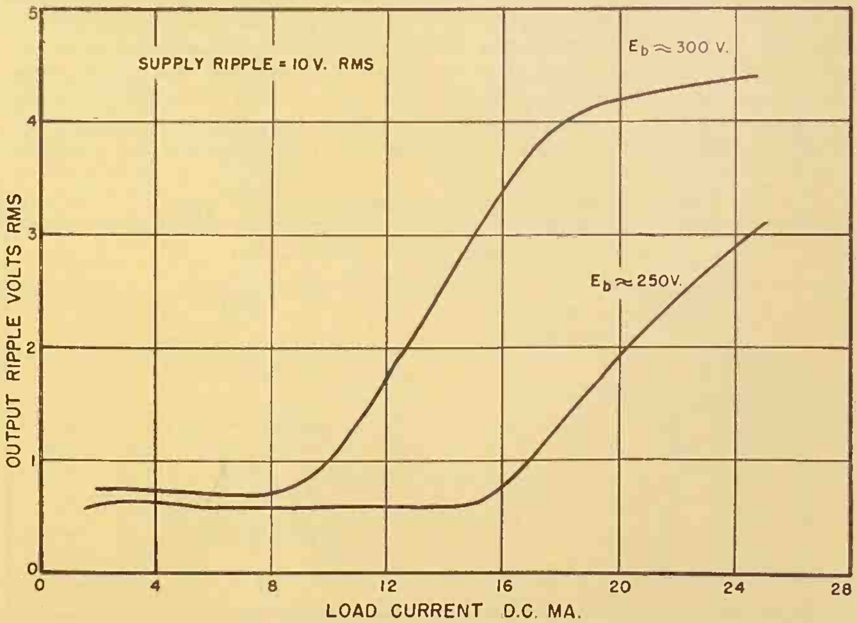
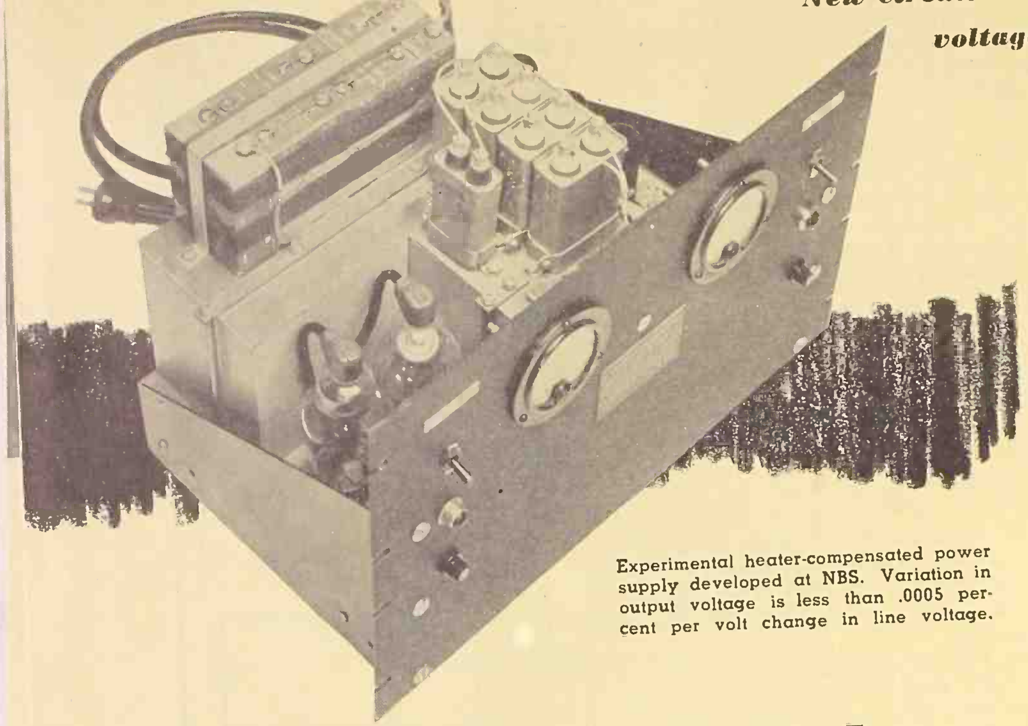


Fig. 3. (A) Circuit equivalent of Fig. 2 for ripple frequency components of power supply voltage, e_{rr}. (B) Circuit equivalent of Fig. 2 for a.c. components of load current.

Fig. 4. Power supply ripple filtering characteristic of the stabilizer.



New circuit developed at NBS uses heater-voltage fluctuations to compensate for line-voltage fluctuations.



Experimental heater-compensated power supply developed at NBS. Variation in output voltage is less than .0005 percent per volt change in line voltage.

Heater-Compensated POWER SUPPLY

A NEW method of compensating for line-voltage changes in stabilized direct-current power supplies has been developed by Robert C. Ellenwood and Howard E. Sorrows at the National Bureau of Standards. In the new circuit arrangement, heater-voltage fluctuations are used to compensate for the line-voltage fluctuations. This compensation thereby increases the stability of the output voltage. This method can be applied to power supplies employing degenerative voltage stabilizers in which d.c. amplifiers compare the output voltage against a fixed reference voltage. When the output voltage changes, the resulting voltage difference between the output and the reference potential is amplified by the amplifier so that the resistance of a control tube is altered in such a way as to restore the output voltage to its original value. The stability of such power supplies without heater compensation is adequate for many purposes, but for very precise measurements where greater stability is required, the new heater-compensated power supply fills a definite need. Heater compensation can be used to good advantage in power supplies for such constant-current devices as direct-current amplifiers and microwave oscillators.

In order to analyze the effect of heater compensation, measurements were made on a typical stabilized power supply (350 volts, ¼ ampere). The experimental heater-compensated power supply constructed at the National Bureau of Standards employs a type 6SJ7 pentode as the amplifier. Other tubes of the same general type have also been used with satisfactory results. Small portable dry batteries are used as a reference voltage. The reference voltage was made nearly equal to the output voltage so that the full change in output voltage is applied to the control grid of the amplifier tube. The batteries are placed in series with the amplifier grid lead in such a way that no current is drawn. This results in a very stable reference voltage and lengthens the service life of the batteries. The control function is performed by several 6L6's connected in parallel. Six tubes can carry a load current of 250 milliamperes and present an internal impedance of only 2 ohms. The output voltage was found to be influenced by small changes in the heater voltage of the amplifier tube, but independent of the heater voltage of the control tube(s). A change in temperature of the amplifier cathode produces a corresponding change in the velocity of the emitted electrons and consequently in the magnitude of the amplifier plate current. The amount of compensation from heater voltage action is a function of the amplifier screen-grid voltage, and the degree of control by the cathode over the plate current is greatest at low screen potentials. The correct screen voltage for maximum stability must be determined experimentally.

When a change occurs in the heater voltage, the change in the amplifier plate current produces a proportiona[l] change in the voltage across the gri[d] resistor of the control tube. This effec[t] produces an additional compensatio[n] for line-voltage changes. For a constan[t] heater voltage, an increase in line vol[t]age of ten volts results in an increas[e] in output voltage of about 0.1 vol[t]. With the line voltage to the stabilize[r] held constant and the potential of th[e] screen grid of the stabilizer set at 12 volts, an increase of ten volts in th[e] primary voltage of the heater tran[s]former results in a 0.1 volt decrea[se] in output voltage. With the high-vo[l]tage and heater transformers connect[ed]

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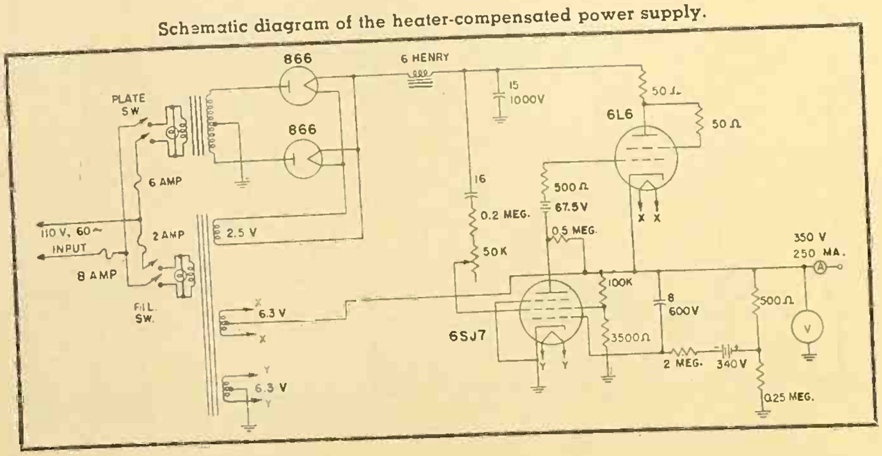
Schematic diagram of the heater-compensated power supply.



Adjustment of QUADRATURE NETWORKS

By SIDNEY WALD
Bendix Radio Div., Bendix Aviation Corp.

Design of a precision 90° phase shifting network which may be built from noncritical components.

MANY occasions arise in the electronics laboratory when it is necessary to set up a phase-splitter circuit to give a 90 degree phase shift of one of the input voltages.

Normally this is accomplished either by attempting to install precision circuit values in the apparatus or else by using non-precision parts and adjusting the components of the network until a circle is obtained on an oscilloscope. The first method is costly and not justified in low-cost equipment while the second method is too inaccurate since it is not possible to say with certainty that the achieved pattern is perfectly circular.

This article points out how an oscilloscope may become a useful device for precision checking of quadrature networks. The concept depends on the fact that a zero or 180 degree shift between vertical and horizontal plates may be recognized with good accuracy because the pattern closes to a straight line. With a good scope, phase deviations of the order of ½ degree may be detected in the deviation of the straight line display.

If we were to introduce a precise 90 degree phase shift between the circuit to be adjusted to quadrature conditions and the scope, the resulting pattern would be an inclined straight line when the adjustment is correct. Fig. 1A shows a typical application of this technique. The requirement which is difficult to fulfill is the accurate 90 degree fixed phase shifter particularly because of the common ground found in most circuits.

Many circuits have been proposed to give a 90 degree phase shift but unfortunately many are four terminal devices and require a transformer when a common ground is desired. Figs. 1B and C show well known 90 degree phase shifters.

The simplest and usually most desirable configuration for a phase shifter is the *RC* arrangement of Figs. 1D and 1E. The highest usable phase shift obtainable from either of these circuits depends upon the amplitude attenuation which may be tolerated, being .707 at 45 degrees and approaching zero output at 90 degrees.

Ordinarily it is undesirable to simply cascade such circuits to obtain greater phase shift than is possible with one because of the loading effect of successive circuits on the previous ones. For example, two 60 degree networks in cascade give an over-all shift which is considerably less than 120 degrees.

A special case arises when two 45 degree networks are cascaded, when the loading effect of the second circuit on the first vanishes. A simple analytical proof is given here to substantiate this statement.

Referring to Fig. 1F:

$$e_1 = I_1 (R - jX) - I_2 R \quad (1)$$

$$o = -I_1 R + I_2 (2R - jX) \quad (2)$$

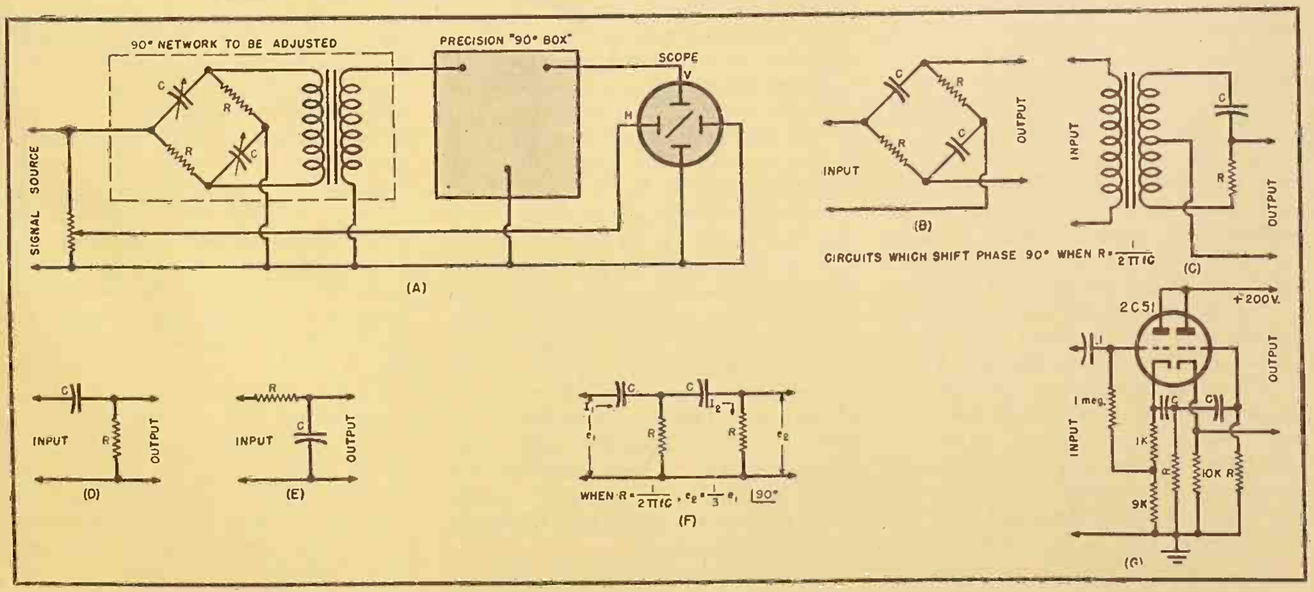
$$e_2 = I_2 R \quad (3)$$

Let $X = R$ and substitute (3) in (1):

$$e_1 = I_1 R (1 - j) - e_2 \quad (4)$$

(Continued on page 31)

Fig. 1. (A) Typical quadrature network adjustment. C or R is varied until pattern is a straight line. (B) and (C) Circuits for shifting phase 90°. (D) and (E) Simplest R-C phase shifting arrangements. (F) 90° network. (G) A precision 90° box. R = 1/2πfC for 90° between input and output.



FIELD INTENSITY SURVEY of an FM Station

Rear view of car with trunk cover removed, showing how the antenna is mounted.

By HAROLD REED
Chief Engineer, Station WOL

One method of making a field intensity survey of an FM station to meet the FCC requirements.

FIELD intensity contours of an FM broadcast station are to be determined in accordance with the methods prescribed in the "Standards Of Good Engineering Practice Concerning FM Broadcast Stations" of the Federal Communications Commission. These Standards state that FM broadcast stations shall determine the extent of their 1 millivolt per meter and 50 microvolt per meter contours. It is further stated that although some service is provided by tropospheric wave, the service area is considered to be only that served by the ground wave. The extent of the service is determined by the point at which the ground wave is no longer of sufficient intensity to provide satisfactory broadcast service.

The field intensity considered necessary for service in city business or factory areas is 1 millivolt per meter median field intensity and in rural areas 50 microvolt per meter median field intensity. A median field intensity of 3 to 5 millivolts per meter should be placed over the principal city to be served and for class B stations, a median field intensity of 1 millivolt per meter should be placed over the business district of cities of 10,000 or greater within the metropolitan district served. A field intensity of 5 millivolts per meter should be provided over the main service area of a class B station.

This paper presents a discussion of the procedure employed in conducting a field intensity survey, in accordance with the FCC Standards, of a class B FM station with effective radiated power of 20 kilowatts. The transmitter power output was 8.4 kilowatts. Transmission line efficiency was 79%. The antenna had a power gain of 3 with a height of 410 feet above average terrain.

Measurements to determine the service area of an FM broadcast station must be made with mobile equipment of a field intensity meter of proper frequency range and calibrated against recognized standards, a source of power for this instrument, an antenna designed for the frequency of the signal to be measured, a graphic instrument more popularly known as a recorder, a mobile recording assembly for driving the recorder from the speedometer shaft of the field survey car, and miscellaneous accessories for both the measuring apparatus and the recorder. This collection of equipment when properly installed and operated provides for the required continuous mobile recording of the field intensity of the FM transmitter in accordance with the FCC regulations.

Several installation problems were encountered in the process of setting up this equipment, foremost of which was in the mounting of the antenna on the car. The most convenient vehicle would be a light truck, or preferably a station wagon because of its all wooden body construction. These means of transportation were unavailable to the writer at the time this field survey was undertaken. It was therefore necessary to employ a passenger vehicle which in this case was a 1941 Chevrolet business coupe.

The FCC Standards specify that the receiving antenna be of a non-directional type and of the same polarization as the transmitting antenna. It was found that a completely satisfactory non-directional type of antenna for this work was unavailable. Experimental antennas have been constructed for this purpose and several were found to be fairly successful but none to the writer's knowledge proved to be entirely satisfactory. The greatest handicap of the non-directional antenna in the conducting of these tests is the weak signal pickup it provides as the end of any given transmitter radial is approached. Permission to employ a dipole antenna was obtained from the Federal Communications Commission. This, of course had to be continuously properly orientec with respect to the transmitter as the field car moved outward from the trans mitter site in order to insure maxi mum signal pickup at all times ir the receiving antenna. This rotationa provision further complicated matters considering that it was necessary t make the installation on a privatel owned car with as little mutilation a possible.

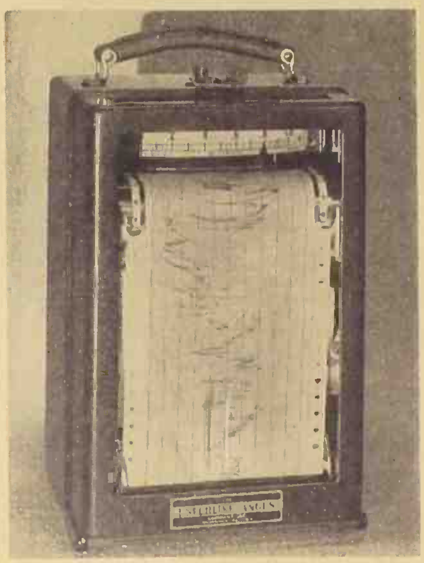
At first the logical support appeare to be the front or rear bumper of th car. However, it was decided the sir gle support at the bottom of the antenn mast was not sufficient for the 10 fo pole and further the coupling drive fo orientation could not be easily effecte Either side of the vehicle where th car radio whip antenna is usual mounted did not seem to offer ar greater possibilities and presented further disadvantage by allowing o half of the dipole to protrude outwa from the car body with the hazard striking high trucks, busses, trees, a other obstacles encountered in trav

Cutting a hole through the roof of the car was out of the question.

The trunk in the rear proved to be the answer. The lid of the trunk was easily and quickly removed, being held by 4 screws in the hinges and 4 screws in the arms that hold the lid open. This particular car contained a substantial shelf in the trunk compartment upon which a gear box with a 20 to 1 ratio, purchased for a few dollars from a war surplus distributor, was mounted. A short length of 1¼ inch pipe was screwed into a coupling which was welded to the gear box, and a further support for this pipe was attached to the under side of the top of the trunk compartment.

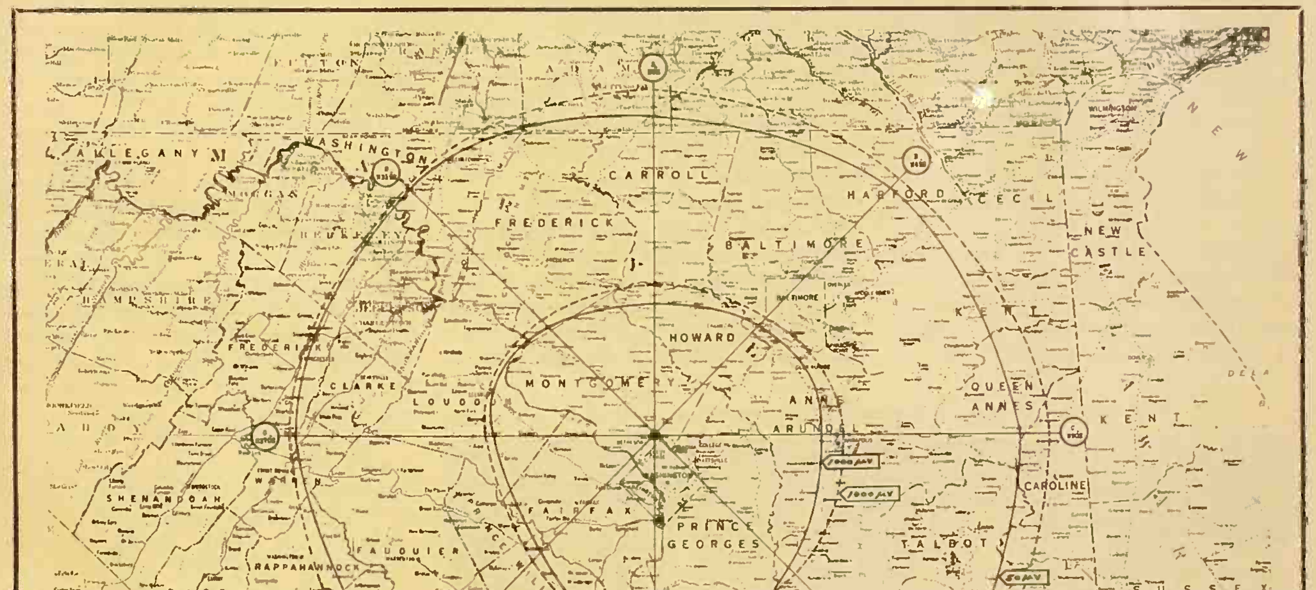
The dipole antenna which is supplied with the field strength meter includes 2 poles with a tee coupling to obtain either horizontal or vertical polarization. Using these 2 poles and coupling resulted in a height above ground of slightly less than the 10 feet the writer wished to achieve, so a longer pole was purchased from a local hardware store and substituted for the lower section. This 2 section mast could then be slipped into the short section of 1¼ inch pipe on the gear box. A 1½ inch long machine screw was inserted through the pipe and pole and a nut attached. This screw protruded far enough through the pipe to attach thereto a direction indicator which was made from a piece of copper tubing with a nut soldered to one end and the other end flattened to form a pointer which was painted white so it could be clearly seen through the rear window. The antenna must necessarily be easily and quickly removed because of low hanging tree branches and wires which may be encountered. In this case it was only necessary to loosen the thumb screw on the tee coupling and drop the upper half of the mast. The antenna arrangement may be seen in the photographs. The gear box is in the wooden housing on the trunk shelf.

A flexible shaft such as used for sanding discs, grinding wheels, etc. was connected to the gear box by means of the chuck on this shaft. The motor end of the shaft was fastened inside the car and a pulley was attached to which was bolted a handle for turning the antenna. The coaxial cable for the antenna goes through a hole, along with the flexible shaft, at the front part of the trunk compartment to the field meter inside the car. This arrangement resulted in a smoothly operating setup and the gear box held the antenna steady in any direction. It is necessary, of course, to adjust the length of the dipole for the frequency of the station. This may be calculated, or it may be ascertained from a curve supplied with the equipment. Also one of the poles



Esterline-Angus recorder of the type used to record field intensity along the various radials.

Contour map of Washington, D. C. and vicinity showing measured and computed field intensities for Station WOL-FM.



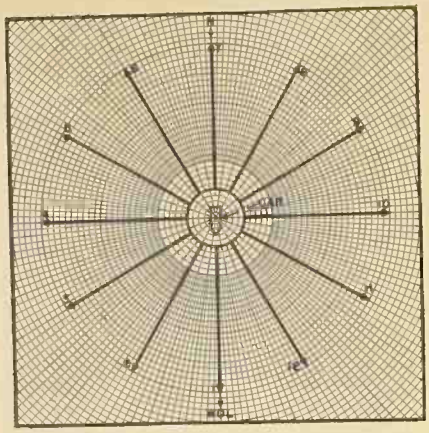


Fig. 1. Radials which were followed in making field intensity measurements.

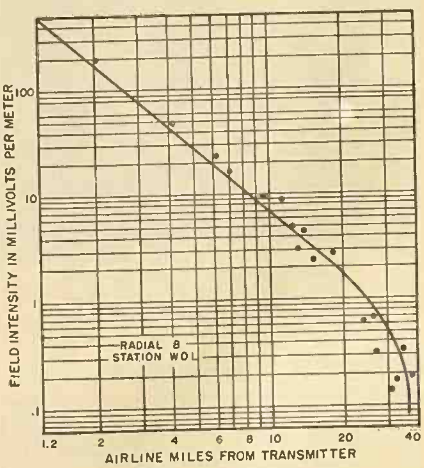


Fig. 2. Field intensity along radial B (Fig. 1) from Station WOL.

furnished has a scale engraved on it which is directly calibrated in megacycles.

Complete installation or removal of all equipment could be effected by the two engineers making the survey in just 15 minutes, including the removal or replacement of the trunk lid and license plate which was attached by two bolts with winged nuts to two small angle brackets placed on the car gravel plate.

The field intensity meter employed for these measurements was an *RCA* type WX-1A model made by the *Clarke Instrument Corp.* This equipment is furnished complete with two adjustable dipole antennas, a two section antenna mast with tee coupling for horizontal or vertical polarization, an adjustable tripod, coaxial antenna cable, and battery cable. Each half of the dipole may be folded parallel with the mast for easy adjustment and for transportation when not in use. The instrument contains a built-in vibrator power supply, permitting the use of a 6-volt storage battery as the power source. Output jacks are provided for direct connection to a standard 5 milliampere or 1 milliampere type graphic recorder. It also contains a built-in loudspeaker and audio amplifier for monitoring either AM or FM signals while measurements are being made. The frequency range of the meter is from 50 to 220 megacycles.

An *Esterline-Angus* graphic recording instrument was employed to continuously record the intensity of the transmitter output signal as the field car traveled away from the station. This instrument was a model A.W. d.c. milliammeter which is a 0-1 milliampere recorder. It contains a spring powered chart drive; however, for this work it is more satisfactory to operate the recorder from the speedometer drive shaft of the car. A photograph of the recorder with a section of the chart of Radial A of this survey on the instrument is presented through the courtesy of the *Esterline-Angus Co.* A model 110 mobile recording assembly, manufactured by the *Clarke Instrument Corp.* and distributed by *RCA* was used to drive the recorder. This assembly consists of a recorder drive, tee coupling box, and the required drive shafts.

To install this assembly the drive shaft is removed from the speedometer of the car and attached to the tee coupling box which was mounted on the fire wall of the car under the dash board. One of the drive shafts supplied connects from the tee box to the speedometer and the other one goes from the tee to the recorder drive which is mounted on the case of the graphic instrument. When this apparatus is properly installed it provides the necessary drive for the recorder chart and the chart speed with this assembly is 4 inches per mile. The recorder drive can be disengaged from the recorder by turning a knob on the side of the case. This is convenient when it is found necessary to back track on a radial run or when backing the car.

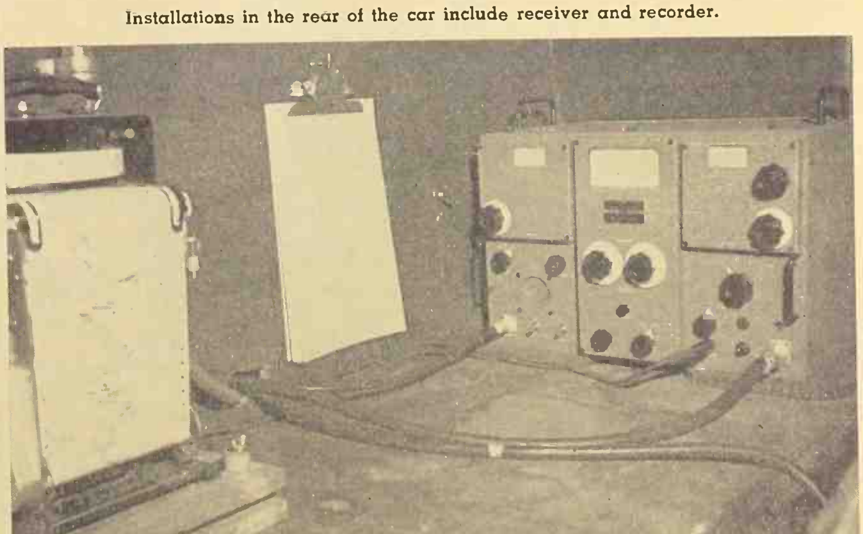
Sponge rubber pads were used in mounting the field meter and recorder between the car seats and wall of the trunk compartment. The flexible shaft for orienting the antenna was fastened to this wall. Winged nuts were used to secure all equipment for rapid installation and removal. There was enough room for an engineer to sit on an automobile cushion and operate the equipment and keep the log. This installation in the car interior is shown in the photographs, which together with the pictures of the antenna installation were taken by the author.

After all equipment was satisfactorily assembled in the car and several test runs made, it was necessary to correct the calibration of the field intensity meter due to the presence of the car body. The simplest procedure in determining the correction factor is to modify the antenna constant (K) given in the data sheets supplied by the manufacturer and which must be applied to the field intensity as read directly from the meter.

This instrument is supplied with frequency factor curves for each attenuator setting of the field meter. The result is based on the antenna being in free space as far as the dipole radiation resistance is concerned, and this K factor corrects for transmission line loss, r.f. attenuator setting, and frequency characteristic of the calibrating oscillator voltmeter.

To find the modified K constant required the field car was driven to a farm about 10 miles from the transmitter site. There on a level open field, over 500 feet from the nearest overhead wires, trees, buildings, and other obstructions, a compass rose was laid out by driving twelve wooden stakes into the ground in a circle, the stakes being 30 degrees apart. The car was then

Installations in the rear of the car include receiver and recorder.



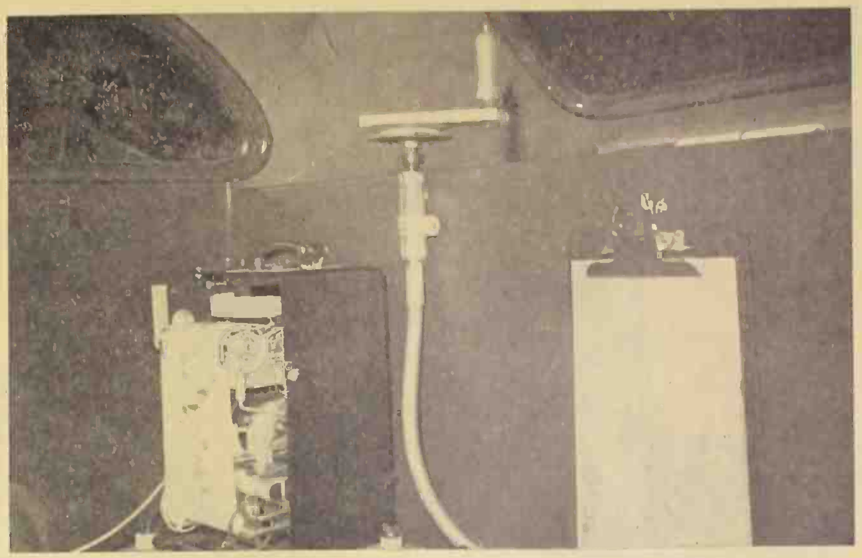
placed in the center of this circle and successively faced toward each stake and the field intensity reading for each of these positions carefully recorded. The dipole was in each instance properly oriented with respect to the transmitter while the car was rotated through the 360 degrees of the rose. It was carefully observed that each reading was taken under the same conditions except for the position of the vehicle. The car doors were closed and the engineers making the tests were inside the car when each reading was taken.

All apparatus was then removed from the car and set up on the ground with the antenna mounted on its tripod, 10 feet above ground and positioned in the center of the compass rose. The car was moved over 500 feet distant from the measuring location to prevent inaccurate measurement due to the car body. With the dipole oriented toward the transmitter the true field intensity reading was recorded.

The true field reading was found from the expression, $F = S \times K$, where F is the field intensity, S the scale reading of the meter, and K is the calibration constant for any given attenuator setting. This true field intensity was indicated as Ft. The field intensity reading for each position of the car in the compass rose was recorded as the apparent reading or Sa. Then K', the modified antenna constant, was obtained from the equation: $K' = Ft/Sa$. This ratio must be solved for each position of the car in the compass rose. The average of the K' values thus obtained is the correction factor to be applied. However, during this survey all measurements were made while following a radial in an outward direction from the transmitter site; therefore, the modified antenna constant used was the average of the K' values of positions 4, 5, 6, 7, 8, 9, and 10. See Fig. 1.

Two men were required to make the survey. One was assigned to drive the car, follow the plotted course, watch for low hanging tree branches and wires and assist with checking speedometer mileage readings. The other man operated the equipment and kept a detailed log.

Before starting each radial run the route to be traveled was carefully planned. The FCC Standards state that measurements are to be made along roads which are as close and similar as possible to the radials which were submitted with the application for construction permit. These radials which were spaced 45 degrees apart around the transmitter site were drawn on road maps. Maps obtained from the American Automobile Association for the local area were found helpful in choosing streets and roads for the first half of the trip. Onion skin paper was placed over these maps and the radials and nearest roads thereto were traced on this paper. Street names, route numbers, and towns were shown. One copy was made for the driver and one for the operator of the antenna and field equipment. In accordance with FCC Standards measurements were made to a point on each radial well beyond the contour under investigation.



Installation in rear of car showing hand crank for rotating antenna.

Accuracy of calibration of the field meter is maintained by a self-contained calibrating system. Calibration was checked at the start and several times during each radial run. The storage battery was in a fully charged condition at the beginning of each trip and the transmitter power output was held as constant as possible. The contents of the log included field intensities at frequent locations, identifying landmarks, car mileage, time of day, and comments.

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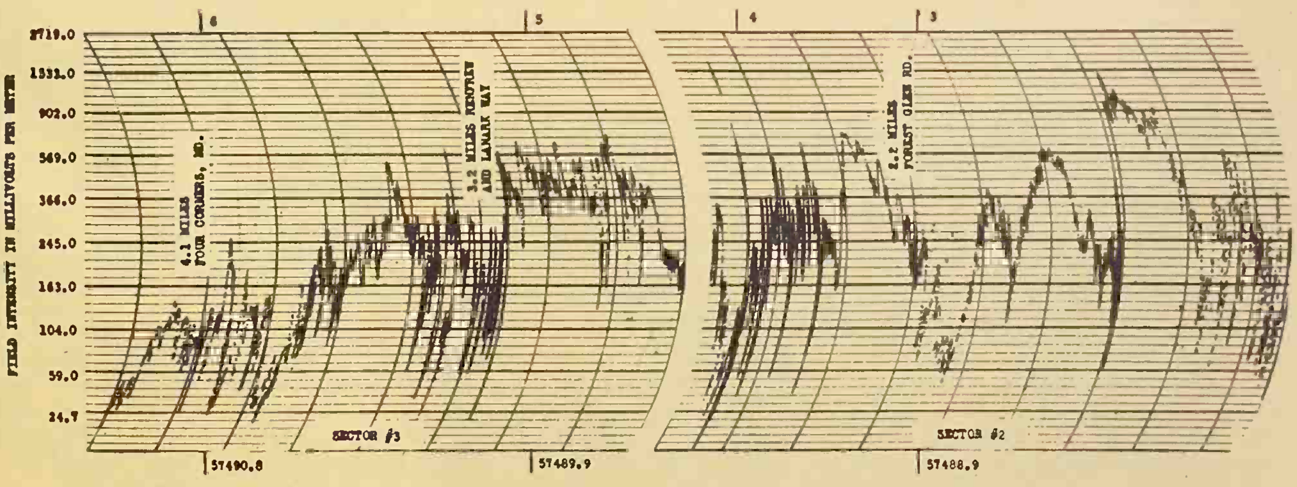
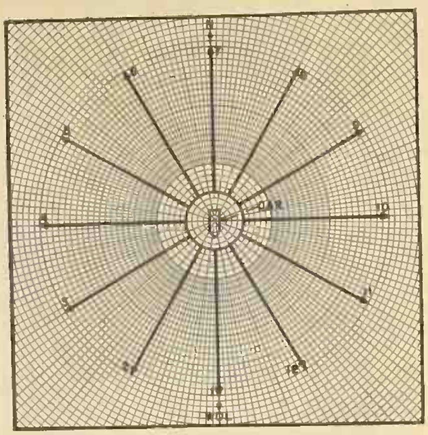
Fig. 3. Sample portion of recording of field strength along radial B (Fig. 1).





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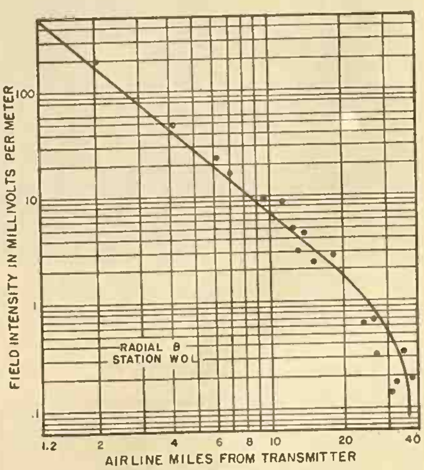

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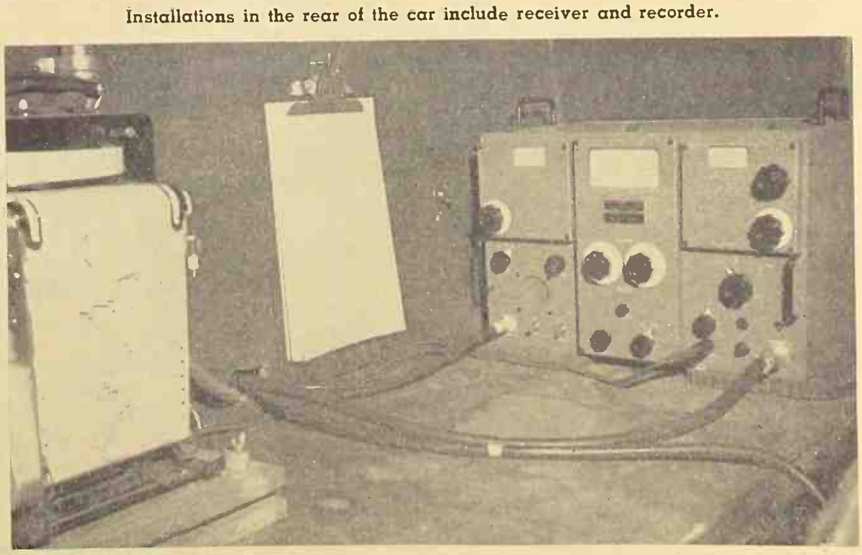

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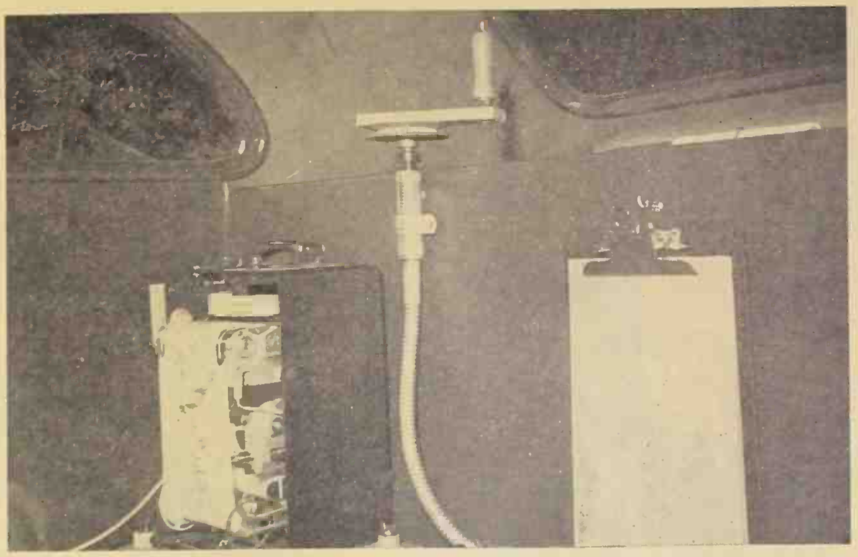

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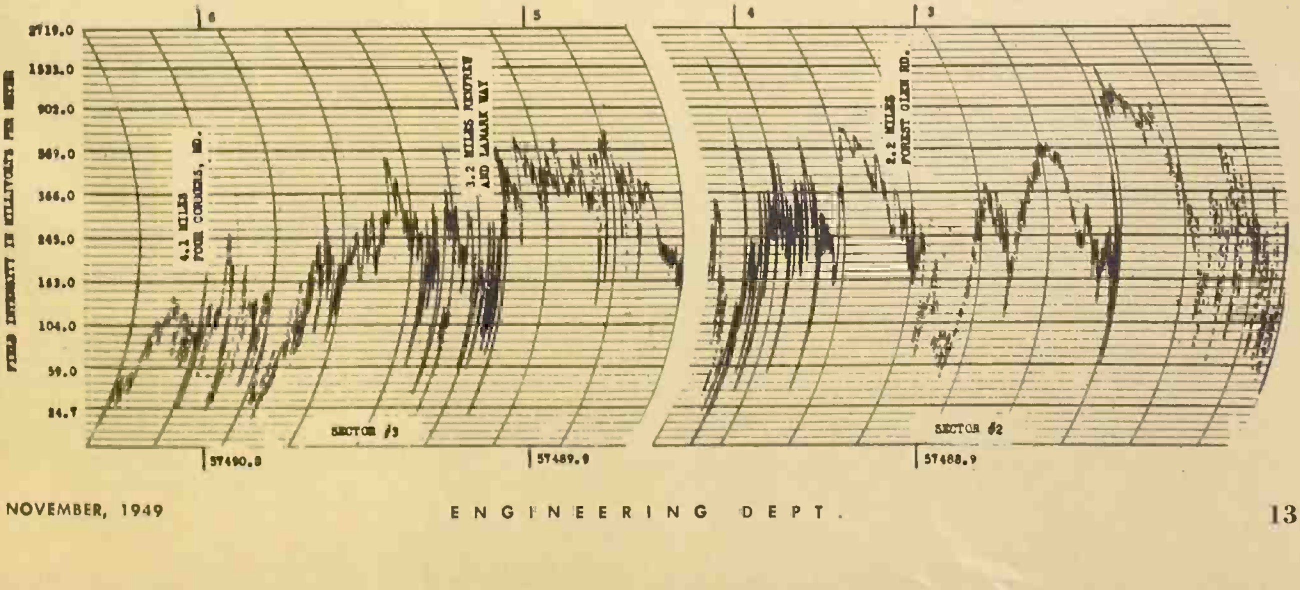
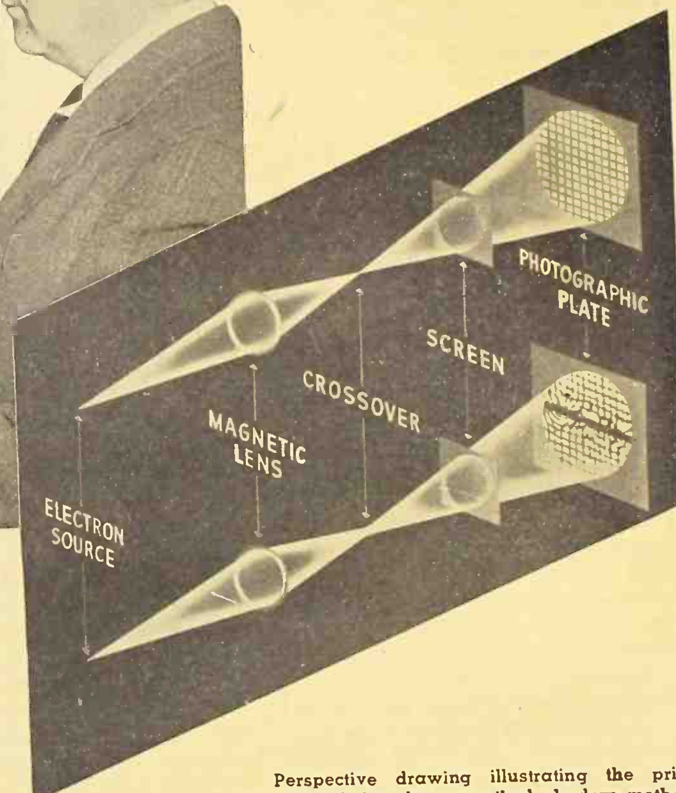
Fig. 3. Sample portion of recording of field strength along radial B (Fig. 1).



ELECTRON-OPTICAL Shadow Method

The magnetic lens system of this horizontal experimental electron microscope at the National Bureau of Standards was used to produce a visual representation of magnetic fields by means of the electron-optical shadow method. From the patterns thus obtained, field intensities may be computed. Dr. L. L. Marton of the Bureau staff, who designed the instrument, is shown at the control panel. Above and to the right of the panel the lens system ends in a circular fluorescent screen on which the electron beam converges to form an image.



Perspective drawing illustrating the principle of the electron-optical shadow method for the quantitative study of electrostatic and magnetic fields of extremely small dimensions. In this example, the new technique is used to explore the field of a ferromagnetic recording wire magnetized in evenly spaced short pulses. Above: conventional magnetic lens system. Below: the magnetic recording wire has been introduced between the electron source and the magnetic lens. From measurements of the distortion of the image, accurate values of the magnetic field intensity can be computed.

A novel method developed at NBS for detecting and measuring very small electrostatic and magnetic fields.

AS THE RESULT of a series of electron-microscope experiments at the National Bureau of Standards, Dr. L. L. Marton of the Bureau's electron physics laboratory has developed an electron-optical shadow technique[1] which provides a valuable tool for the quantitative study of electrostatic and magnetic fields of extremely small dimensions. The new method makes use of an electron lens system to produce a shadow image of a fine wire mesh placed in the path of the electron beam. From the distortion in the shadow network caused by deflection of the electrons as they pass through the field under study, accurate values of field strength are computed. Thus it is possible to investigate quantitatively fields that have not been susceptible to other methods of investigation, for example, the fringe fields from the small domains of spontaneous magnetization in ferromagnetic materials.

The new development, which is based on extensive theoretical analysis, should provide a powerful means for broadening present knowledge concerning space-charge fields, fields produced by contact potentials, patch fields in thermionic emission, charge distribution in a gaseous plasma, waveguide problems, and the basic magnetic properties of metals. Though similar in some respects to the electron-optical Schlieren method[2] previously developed at the Bureau, the shadow method is much better adapted to precise determinations of field intensity.

The principle of the shadow method was discovered in the course of a study of a recording wire magnetized in evenly spaced short pulses by means of a conventional magnetic recording head. In practice, the recording wire—or other object to be studied—is placed between an electron source and a system of electron lenses. The lens system focuses the electron beam to form an image of the wire on a fluorescent screen. By placing a wire mesh of known gage just beyond the back focus of the

1. *For more complete details see, "Electron Optical Observation of Magnetic Fields," by L. Marton and S. H. Lachenbruch, scheduled for publication in J. Research NBS 43, Oct. (1949) RP2033. See also, "Electron Optical Mapping of Electromagnetic Fields," by L. Marton and S. H. Lachenbruch, scheduled for publication in J. Ap. Phys. 20, Nov. 1949.*
2. *In the Schlieren method, a magnetic lens forms an image of a source of electrons on a small copper stop which intercepts all direct rays. If in the space between the electron source and the lens there is a variation of the index of refraction for electrons—in other words, a variation in electric or magnetic field intensity—an image of that inhomogeneity will then be produced by means of the same lens in a conjugate plane beyond the stop. Thus a dark-field image of the magnetic or electric field is obtained on a fluorescent screen or on a photographic plate. See "Electron-optical Schlieren effect," NBS Technical News Bulletin 32, 82 (1948).*

lens system, a shadow image of the mesh is superposed on the image of the wire. This shadow image is formed by projection from the virtual source provided by the reduced image of the source of electrons. The portions of the shadow network adjacent on the screen to magnetized regions of the recording wire are then found to show considerable distortion.

A complete theoretical analysis of this effect has shown that the distortion of the shadow image is due to the deflection of the electron beam by the field of the recording wire at each magnetized region. The result is a corresponding displacement of the reduced image of the electron source. This displaced image, acting as a virtual source, forms a shadow image, likewise displaced, of the network. Deflection of the beam may also change the distance of the virtual source from the wire, in which case the magnification of the displaced image is affected. Obviously, the displacement and change in size of the shadow image at any point depend on the strength of the field of the magnetized wire at a corresponding point.

Formulas have been derived by S. H. Lachenbruch of the Bureau staff which permit the calculation of consistent absolute values of field strength in magnetic or electric fields of various geometrics from experimental measurements of the position of the wire mesh, the displacement and magnification of its shadow image, and the known constants of the apparatus. The patterns obtained also provide a qualitative visual representation of minute electrostatic and magnetic fields. Although it is possible to compute field intensity from the intensity distribution of the pattern obtained by the Schlieren method, the shadow method is of far greater utility for quantitative work since the image displacement and magnification can be measured much more accurately than can the intensity distribution across the Schlieren pattern on a photographic plate.

Perhaps the greatest value of the electron-optical shadow method lies in its utility for exploring complex electric and magnetic fields of extremely small dimensions or in which a probe of size greater than the electron would disturb the field under study. In the past, calculations of the field intensity at a point have been limited to those special cases in which the geometry of the field exhibits a high degree of symmetry. The shadow technique now provides data for accurate calculation of the absolute value of the intensity in the neighborhood of a specimen of any size or shape without altering or disturbing the field.

The method is thus well adapted to investigation of the fundamental nature of ferromagnetism. Experiments now under way at the National Bureau of Standards include a study of the behavior of the fringe fields of the ferromagnetic domains; in this work a single crystal of cobalt having very large magnetic domains is being used. An extension to ferroelectric materials is also contemplated for the purpose of checking the domain theory of these substances; of particular interest will be a study of the polarization of barium titanate and other high-dielectric materials which are now being widely used in the production of small-sized capacitors for radio, radar, and television.

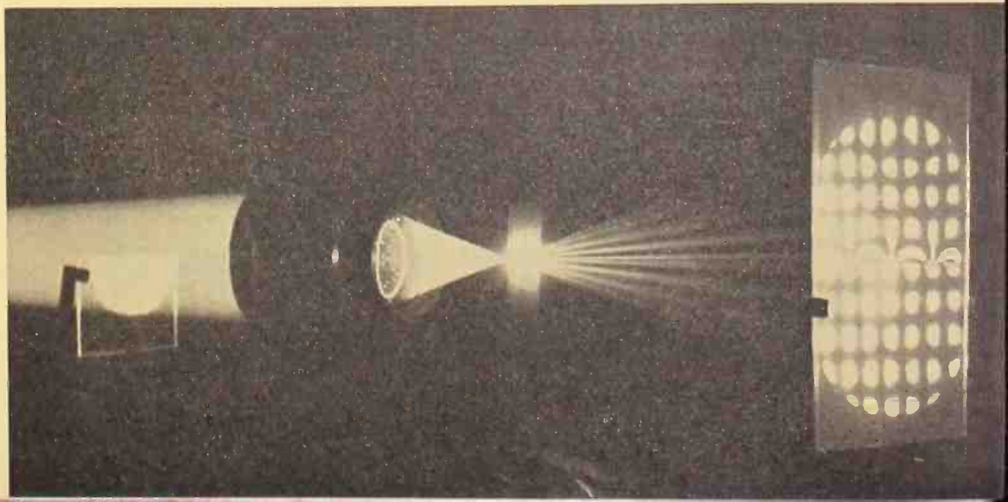
In another application of the shadow method at the Bureau, space-charge fields in several types of apparatus employing electron beams are being investigated. In this connection, use of the method with a pulsed electron source for the stroboscopic study of fields that vary with time is under study.

It has been suggested that the electron-optical shadow method may also be of value for the calculation of field intensities within a waveguide. Use of waveguides as conductors and circuit elements in ultra-high-frequency radar and communication often leads to arrangements whose geometry is too complicated for expression in any system of mathematical coordinates. Thus the electronics engineer, having in many cases only an intuitive picture of the field distribution at junctions and elbows of the guide, must rely on empirical methods in designing waveguide techniques and equipment. By the use of suitable auxiliary techniques, it is hoped that the shadow method may be adapted to the calculation of field intensities in regions of a guide that are not at present susceptible to analytical treatment.

The Bureau is also applying the principle of the shadow technique to the study of spherical aberration in electron lenses. When a fine wire mesh is placed in the focal region of a lens having spherical aberration, the shadow image of the network is enlarged either centrally or at the periphery, depending on the position of the mesh and the nature of the lens error. The resultant pattern may thus be interpreted to give information of value in correcting the lens.

The magnetic field about a small horseshoe magnet, photographed by means of the new electron-optical shadow technique. Here the screen of an electron microscope shows the electron shadow of a fine wire mesh distorted by the deflection of the electrons as they pass through the field of the magnet. Total width of the magnet is about one-fourth inch.

The electron-optical shadow method is illustrated by means of an analogous experiment in light optics. Mounted lens system converges light from a distant source to form a reduced image of the source at a point just to the left of a wire screen. A magnified shadow image of the wire screen is formed on the ground-glass screen by projection from the reduced image. Here the lower half of the light beam is intercepted by a piece of plastic deformed along its edge in such a way as to deflect some of the light rays before they pass through the lens. The result is a distortion of the corresponding part of the shadow network. In the NBS method, the glass lens system is replaced by a magnetic lens, and the plastic is replaced by the magnetic or electrostatic field to be studied.



DESIGN of an ECHO BOX

By JOSEPH H. VOGELMAN
Chief, Development Branch, Watson Laboratories.

A highly accurate and adjustable echo box is essential in testing radar units. This box is tunable over the range 130-154 mc.

An echo box was required which would be tunable over the frequency band 130 to 154 megacycles per second, and capable of providing the operator of the radar system with a simple means of daily checking of performance of the system, without any interruption of its tactical operation. The quarter-wavelength coaxial echo box described herein was designed as the most feasible solution to the problem. The operation of the echo box and its application to the measurement of radar performance have been adequately covered in the literature[1] and will not be repeated.

The basic requirements for the echo box as set by the radar system for which it is intended are as follows:

Tuning Range—130 to 154 mc.

Decay Rate—Less than 1 db. per microsecond

Bandwidth of cavity—10 kc.

Level Difference between peak pulse power and receiver sensitivity at the echo box input—100 db.

To meet the decay rate requirement, the order of magnitude of the Q required is determined from the relation:

$$Q = \frac{27.3\,f}{d} \quad \ldots \ldots \quad (1)$$

where f is in mc. and d is in db./μs. For 130 mc. this gives a Q of 3549, and for 154 mc., a Q of 4204.

To meet the bandpass requirement of 10 kc. the loaded Q required is determined from the relationship:

$$Q_L = \frac{f}{\Delta f} \quad \ldots \ldots \quad (2)$$

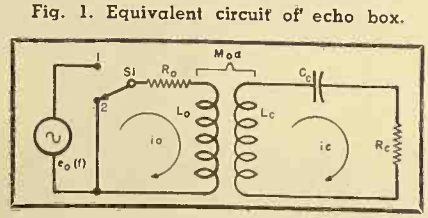
where f and Δf are in the same units. For 130 mc., Q_L is 13,000 and for 154 mc., Q_L is 15,400.

Since the Q requirement to meet the bandpass requirement is the greater, this value governs the design of echo box. Previous experience has shown that the loaded Q due to input and output coupling will have a ratio to unloaded Q of the order of 0.9. Further decreases in Q will result from the suppression of undesired modes and other compensation networks. To account for these losses, the unloaded Q for which the echo box will be designed is taken as 20,000.

For the purpose of this section the following symbols and dimensional units will be used:

a = inner conductor radius in cm.
b = outer conductor radius in cm.
f = frequency in mc.

Fig. 1. Equivalent circuit of echo box.



L = length of inner conductor in cm.
λ = free space wavelength in cm.
A = attenuation in db. per cm.
d = length of waveguide beyond cut-off attenuator in cm.

For a coaxial echo box, maximum Q is obtained when $b/a = 3.6$. Adding 25 per-cent to the Q to take care of short losses, the dimensions can be determined from the following relationship:

$$Q = \frac{302\,bf^{1/2}\ln b/a}{1 + b/a} \quad \ldots \ldots \quad (3)$$

$$b = \frac{.0093\,Q}{f^{1/2}} = 25.4 \text{ cm.} \quad \ldots \ldots \quad (4)$$

Then $a = 7.055$ cm.

For a satisfactory echo box it is necessary that modes other than the TEM be sufficiently below cut-off to prevent extraneous resonances or holes due to partial cancellations between TEM and a higher mode. To an accuracy of 7 per-cent the cut-off frequency for higher modes than TEM is found from the relationship:

$$\lambda = 2\pi\frac{b + a}{2} \quad \ldots \ldots \quad (5)$$

which corresponds to a frequency of 293 mc. The frequency range 130 to 154 mc. is far enough below this value to insure that no higher modes will exist.

Where $a = 7.055$ cm. and $b = 25.4$ cm., the Q is 24,400 at 130 mc. and 26,500 for 154 mc.

These values of Q are calculated to include only the conductor loss but do not consider the short losses. For this preliminary calculation, the length of the center conductor for resonance will be taken as a quarter wavelength. The Q can be corrected for short loss by the relationship:[2]

$$Q' = \frac{\left(\frac{1}{2a} + \frac{1}{2b}\right)LQ}{\left(\frac{1}{2a} + \frac{1}{2b}\right)L + \ln\frac{b}{a}} \quad \ldots \quad (6)$$

In making corrections for short loss, the shortening of the center conductor of the resonant line, due to the discontinuity capacity caused by termination of the inner conductor while the outer conductor is allowed to continue, is neglected for the present, to simplify the preliminary calculations. Under the above limitations the corrected Q's become 19,500 and 20,500 respectively for 130 mc. and 154 mc.

To determine the over-all length of the quarter-wavelength echo box, it is necessary to investigate the length of outer conductor required to give negligible reflection from the far end. The outer conductor beyond the termination of the center conductor acts as a waveguide beyond cut-off attenuator. If the length is such that a one-way attenuation of at least 30 db. is obtained, the reflection from a short at the far end of the attenuator will be -60 db. or 0.1 per-cent in voltage. This value is sufficiently small to be neglected.

For the lowest mode $TE_{1,1}$ the attenuation of a cut-off attenuator is obtained from the relationship:[1]

$$A = \frac{16.0}{b}\sqrt{1-\left(\frac{3.42b}{\lambda}\right)^2} \quad . \quad . \quad (7)$$

For 130 mc. $A = .586$ db. per cm., and for 154 mc. $A = .565$ db. per cm.

The length required for 30 db. attenuation is obtained from the relationship $d = 30/A$. For 130 mc. this gives $d =$ 51.2 cm. = 20.2 inches, and for 154 mc. $d =$ 53.0 cm. = 20.9 inches. The total length required for the cavity $= \lambda/4 + d = 22.7 + 20.2 = 42.9$ inches.

The quarter-wavelength echo box would have an over-all length of 42.9 inches, a diameter of 20 inches and require a plunger movement of approximately 3.5 inches.

Tuning Mechanism

Whinnery, Jamieson and Robbins[3] have shown that for a coaxial line, where the outer conductor is below cut-off for all cylindrical waveguide modes and is of infinite length, the termination of the inner conductor results in a discontinuity capacity whose magnitude is a function of the inner and outer conductor diameters. For a coaxial line of $b/a = 3.6$ and $b = 25.4$ cm., the discontinuity capacity, $C_d = 3.57$ $\mu\mu$fd. is determined from the plot by Whinnery, Jamieson and Robbins of $C_d/2\pi b$ against b/a.

For a capacity loaded quarter-wavelength resonant line, the line length required for resonance is determined from the relationship:

$$\frac{L}{\lambda} = \frac{\tan^{-1}\left(\frac{1.59 \times 10^5}{f\,c\,Z_0}\right)}{2\pi} \quad . \quad . \quad . \quad . \quad (8)$$

where f = frequency in mc.
c = capacity in $\mu\mu$fd. = 3.57
$Z_0 = 138 \log_{10} b/a = 76.77$ ohms
L = length of inner conductor in cm.
λ = free space wavelength = $29979/f$

For $b/a = 3.6$:

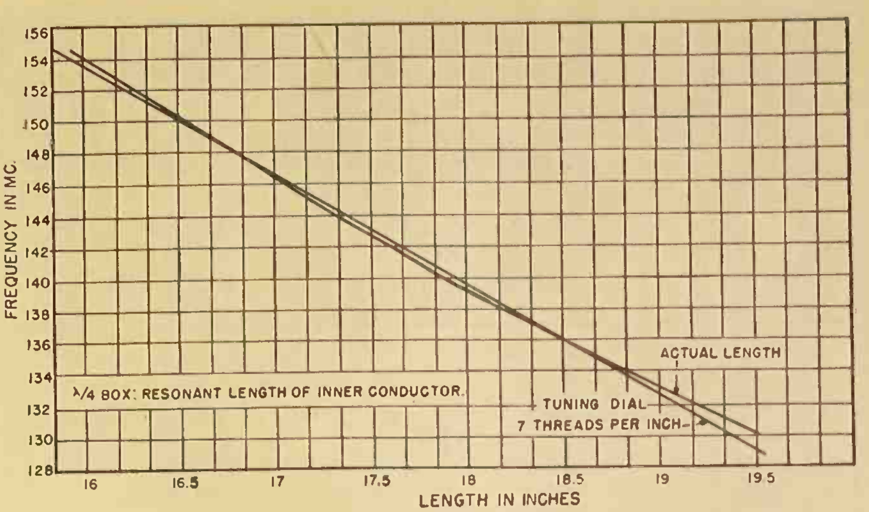
$$\frac{L}{\lambda} = \frac{\tan^{-1}\left(\frac{580.08}{f}\right)}{360} \quad . \quad (9)$$

From (9) the length required for every megacycle has been calculated and will be found in Table III. The total center conductor displacement for the frequency band is 3.516 inches. If linear motion is assumed, displacement per megacycle is 0.146 inches. This may be closely approximated by a screw of seven threads per inch. If the plunger is adjusted to be correct at 136 mc. and the frequency indicating dial designed to read 1 megacycle per revolution with 100 division vernier, then the dial reading can be found from the relationship:

Dial Reading =

$$136 + 7(18.516 - l) \quad . \quad . \quad . \quad (10)$$

The dial readings have been calculated and tabulated in Table III together with the error resulting from the use of a linear tuning dial. The actual frequency and the dial readings are plotted against plunger length in Fig. 2, and the frequency error against dial reading is plotted in Fig. 3. The tuning correction is engraved on the tuning dial every 0.1 mc. of correction to permit frequency accuracies of better than 0.1 megacycle per second. The tuning corrections are tabulated in Table II together with the frequency to which they correspond.



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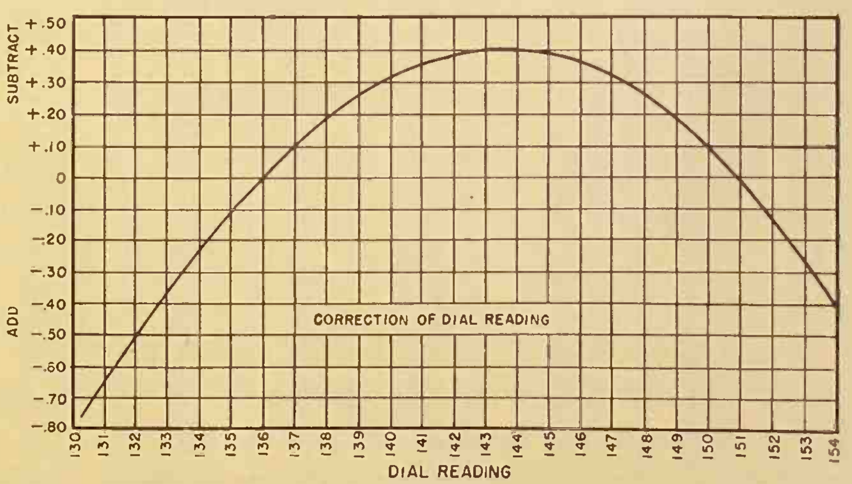

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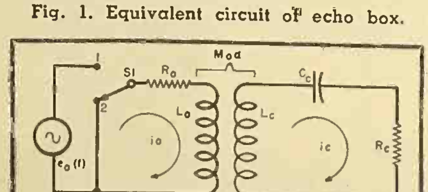

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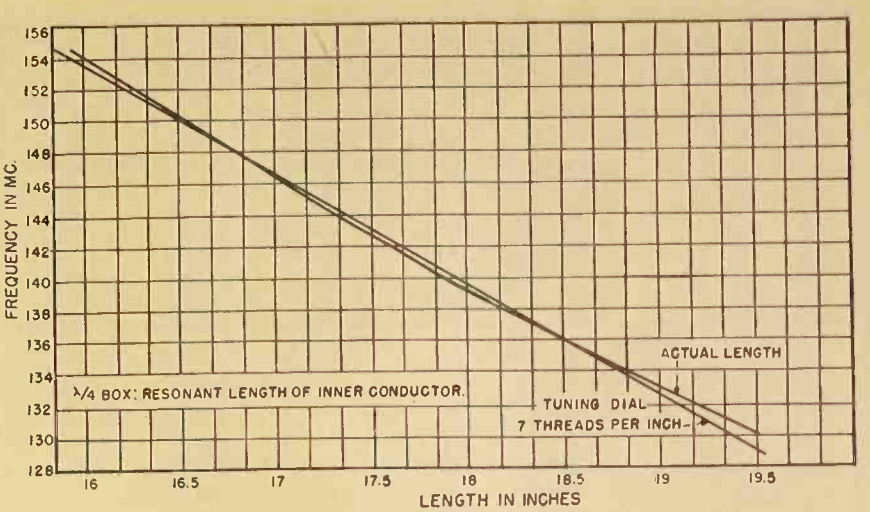

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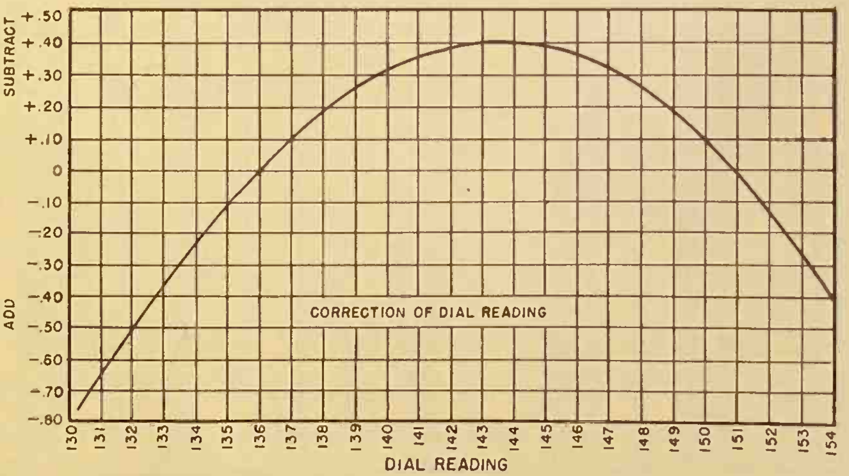


Freq In Mc.	R_o Inherent Resistance In Per-cent Normalized To 142 Mc.	R Desired Resistance In Per-cent Normalized To 142 Mc.	R_c Compensation Available in Per-cent Normalized To 142 Mc.	R_L Compensated Resistance In Per-cent $\frac{R_o+0.08R_c}{1.08}$	Relative Ringtime In Per-cent $\frac{R}{R_L}$	Reduction In Ringtime In Per-cent $\frac{1-R_o}{R_o+0.08R_c}$
130	104.51	109.23	167.220	109.15	100.07	11.34
135	102.55	105.19	137.512	105.14	100.05	9.69
140	100.71	101.43	110.243	101.41	100.02	8.05
142	100.00	100.00	100.00	100.00	100.00	7.41
145	98.96	97.93	85.616	97.97	99.96	6.47
150	97.29	94.67	63.807	94.81	99.85	4.99
154	96.02	92.21	51.763	92.91	99.25	4.31

Table I. Ringtime compensation-loop at 41.5 cm. from short, K=8.0%.

Dial Reading Corresponding To Correction	Frequency Correction In mc.
130.00	+0.80
130.65	+0.70
131.30	+0.60
132.00	+0.50
132.70	+0.40
133.40	+0.30
134.20	+0.20
135.05	+0.10
136.00	0.00
137.00	−0.10
138.10	−0.20
139.70	−0.30
143.40	−0.40
147.40	−0.30
148.90	−0.20
150.00	−0.10
151.00	0.00
51.80	+0.10
152.60	+0.20
153.30	+0.30
153.95	+0.40

Table II. Dial reading corrections.

L = length of inner conductor

λ = wavelength in free space

I_0 = current at $d = 0$ is constant for compensated echo box

k = coupling coefficient

For the region beyond the end of the center conductor, the current is assumed to fall off with distance as in a waveguide below cutoff, excited in the $TM_{0,1}$ mode (the mode excited by an end probe in a cylindrical guide).

$$I = k\,I_o \cos\left(\frac{360\,L}{\lambda}\right) e^{-\frac{2\pi d'}{\lambda_c}} \quad (12)$$

where λ_c for $TM_{0,1}$ mode $= \frac{2.405}{2\pi b}$

$$d' = d - L$$

$$b = 25.4 \text{ cm.}$$

$$I = k\,I_o \cos\left(\frac{360\,L}{\lambda}\right) 10^{-\frac{(d-L)}{25.4}} \quad (13)$$

The introduction of the loop into the cavity introduces resistance so that the problem can best be treated by dealing with resistances normalized to the cavity shunt resistance at 142 mc. The equivalent resistance introduced by the loop is proportional to the square of the current as given by Eqts. (11) and (13). The resistance loading at the loop will be taken as equal to the cavity shunt resistance at 142 mc. and the coupling varied to give the proper compensation.

By trial and error the best position of the loop and the optimum coupling was determined to be as follows:

a. Loop at 41.5 cm. from short

b. Coupling $k = 8.0\%$

Table III is a compilation of the data showing the inherent resistance, desired resistance, compensation available, compensated resistance, relative ringtime, and reduction in ringtime as a result of compensation, all normalized to 142 mc. as determined from Eqts. (13) and (15) and the corresponding values of λ and L from Table III. By means of loop compensation it has been possible to reduce the variation of ringtime with frequency to less than 1 per-cent. Knowing the reduction in ringtime due to compensation, the loop coupling can simply be adjusted experimentally by inserting it to such a depth as to cause the echo box under test to produce a ringtime less by the specified reduction percentage than the ringtime without the compensating loop. This adjustment at 142 mc. and a recheck at another frequency is all that would be required in production testing.

It has been found desirable to adjust all echo boxes of a single type to have ringtimes within 1 per-cent under identical conditions, so that measurements made with one echo box could be duplicated with another echo box. The simplest method found to accomplish this is to insert a frequency insensitive loop close to the short in the outer wall of the cavity. In the first production run a box of average ringtime is selected as the standard and the loop in it is adjusted to decrease the ringtime 2 to 3 per-cent. Thereafter all other echo boxes are compared to the standard and the insertion of their standardizing loops are experimentally adjusted to give the same ringtime as the standard. A loop identical to the input loop but with variable insertion has been found satisfactory for this application.

Table III. Resonant length of inner conductor, dial reading, and error.

Freq in mc.	λ in Centimeters	$\frac{L}{\lambda}$	L in Centimeters	L in Inches	Dial Reading in mc.	Error in mc.
130	230.61	.21491	49.560	19.511	129.03	−0.97
131	228.85	.21465	49.122	19.339	130.24	−0.76
132	227.12	.21439	48.692	19.170	131.42	−0.58
133	225.41	.21413	48.267	19.003	132.59	−0.41
134	223.73	.21388	47.851	18.839	133.74	−0.26
135	222.07	.21361	47.436	18.675	134.89	−0.11
136	220.44	.21335	47.031	18.516	136.00	0.00
137	218.83	.21309	46.630	18.358	137.11	+0.11
138	217.24	.21280	46.229	18.200	138.21	+0.21
139	215.68	.21257	45.847	18.050	139.26	+0.26
140	214.14	.21231	45.464	17.899	140.32	+0.32
141	212.62	.21205	45.086	17.750	141.36	+0.36
142	211.12	.21179	44.713	17.604	142.38	+0.38
143	209.65	.21153	44.347	17.459	143.40	+0.40
144	208.19	.21128	43.986	17.317	144.39	+0.39
145	206.76	.21101	43.628	17.177	145.37	+0.37
146	205.34	.21076	43.277	17.038	146.35	+0.35
147	203.94	.21050	42.929	16.901	147.31	+0.31
148	202.56	.21024	42.586	16.766	148.25	+0.25
149	201.21	.20998	42.250	16.634	149.17	+0.17
150	199.86	.20973	41.917	16.503	150.09	+0.09
151	198.54	.20947	41.588	16.373	151.00	0.00
152	197.23	.20921	41.262	16.245	151.90	−0.10
153	195.95	.20896	40.946	16.120	152.77	−0.23
154	194.67	.20870	40.628	15.995	153.65	−0.35

Ringtime

To determine the ringtime obtainable from the echo box it is necessary to know the theoretical unloaded Q, identified as Q'. This can be found from:[2]

$$Q' = \frac{386.84\,f^{1/2}}{\frac{1}{a}+\frac{1}{b}+\left(\frac{2.575}{L+(\lambda/15.57)\sin(720L/\lambda)}\right)} \quad (14)$$

For $a = 7.055$ cm., $b = 50.8$ cm., and values of f, L, and L/λ from Table III, Q' can be calculated.

For 130 mc. $Q' = 19{,}600$

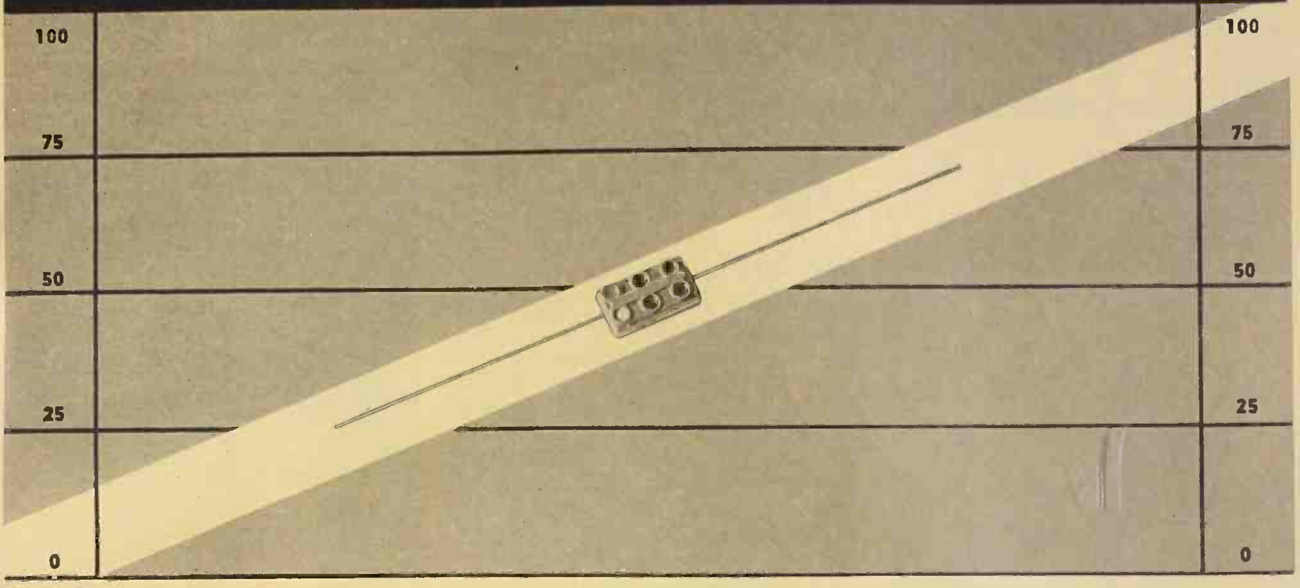
" 142 mc. $Q' = 20{,}000$

" 154 mc. $Q' = 20{,}480$

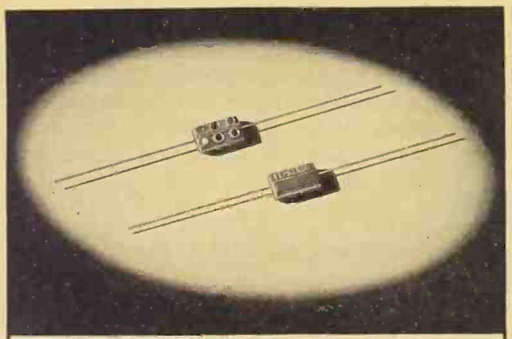
The ringtime without compensation can be found from the following equation:

(*Continued on page* 31)

For Peak Performance...



EL-MENCO CAPACITORS



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2 — 525 mmf. cap. at 300v DCw.
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NEWS BRIEFS

SCIENTISTS DISCUSS POWDER METALLURGY

The physics of powdered metals was the subject of a Symposium arranged by Walter E. Kingston of the Metallurgical Laboratories of *Sylvania Electric Products Inc.*, Bayside, New York recently.

Among the outstanding authorities who participated and are shown below, left to right, were Dr. Morris Cohen of

the Massachusetts Institute of Technology; Dr. G. F. Huettig of the University of Graz, Austria; Walter E. Kingston, chairman of the Symposium and manager of *Sylvania's* Metallurgical Laboratories; Dr. Adolf Smekal of the University of Darmstadt, Germany; and Dr. A. J. Shaler of the Massachusetts Institute of Technology.

More than 125 attended the three day sessions which were held in the Post Theatre, Fort Totten at Bayside.

OSBORNE TO HEAD USNC

Dr. H. S. Osborne, Chief engineer of the *American Telephone and Telegraph Company*, has been elected by the United States National Committee of the International Electrotechnical Commission to serve as its chairman for the coming year.

Other officers elected were Vice-Presidents: P. H. Chase, chief engineer, *Philadelphia Electric Co.;* Frank Thornton, Jr., engineering manager, association activities, *Westinghouse Electric Corp.;* Treasurer, G. F. Hussey, Jr., (Vice-Admiral, USN, Ret.), secretary American Standards Association.

Through the USNC, the electrical groups in the United States take part in international work on standards in the electrical field, working with the national committees of 26 other countries that are members of the International Electrotechnical Commission.

NEW QUARTERS FOR V&V

Voice and Vision, Inc., Chicago, designers and installers of built-in television and radio equipment for the home, have moved into their new quarters at 314 North Michigan Avenue.

According to Dr. R. E. Samuelson, President, the expanded facilities will enable the firm to better handle the increasing demand for integrating sight and sound with modern architecture and interior decoration.

WESTINGHOUSE FORMS SPECIAL PRODUCTS DIVISION

A Special Products Development Division that will bring new products from the research to the commercial production stage and will handle special military developments has been formed by *Westinghouse Electric Corporation*,

Pittsburgh, Pa. The Division will be managed by Frank W. Godsey, Jr., who formerly directed the New Products Department, now absorbed by the new division.

In addition to conducting market surveys and recommending action on new product lines, the Division will carry on "pilot plant" work on new products. Such special military projects now under way include work on guided missiles, aircraft armament systems, and new weapons for Navy ships.

GE TV TUBE PRODUCTION

Production of 8½-inch metal television picture tubes has been started by the *General Electric Company* at its Electronics Park plant at Syracuse,

N. Y. The new size tube gives 50 percent more picture area than the seven-inch tube now used in low-priced receivers.

To house the new Syracuse tube facilities which will be in addition to its picture tube operation at Buffalo, N. Y., the company is converting and adding to an existing building. When completed later this year, the building will have 15,000 square feet of manufacturing space in addition to engineering and office areas.

NATIONAL MOLDITE EXPANDS

Expanded facilities now available for the production of molded iron cores has been announced with the erection of *National Moldite Company's* new plant at 1410 Chestnut Avenue, Hillside, N. J.

The announcement came from Sales Manager Sidney Lowenberg who states that newly developed, modern machinery in the powder and mixing rooms will increase the efficiency of production operations. A new division completely equipped for the production of molded coil forms has been installed.

TWO SCIENTISTS RECEIVE AWARDS

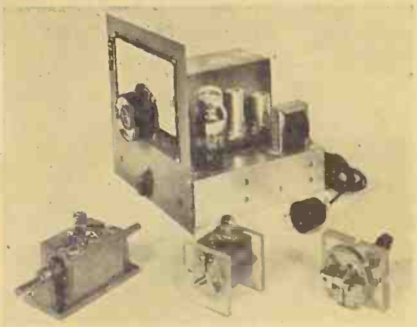
Dr. John W. Mauchly, physicist, and J. Presper Eckert, Jr., electronic engineer, of Philadelphia who have developed UNIVAC, the electronic computing machine used by the U. S. Census Bureau in compiling 1950 census information, have received the coveted Howard N. Potts Medals.

Awarded by the Franklin Institute, Philadelphia, the medals were presented to the two scientists for their work in the design and construction of the world's first large-scale, general purpose, digital electronic computing machine which is known as ENIAC. These partners also developed and built BINAC, and formulated the basic plans and suggested the general design for EDVAC, the electronic computer developed by the University of Pennsylvania.

CONVERTER FOR UHF TV

A program of development of u.h.f. television converter units has recently been carried out by Stanford Research Institute's Department of Electrical Engineering under the sponsorship of John H. Poole of Long Beach, California.

The project has consisted of two parts, the first being the development of an inexpensive fixed-tuned converter which adapts existing sets to receive experimental u.h.f. broadcasts from Mr. Poole's station, KMZXAZ, which is now under construction.



The second phase of the program has consisted of investigating circuits and techniques by means of which partial or entire coverage of the 475-890 megacycle band may be attained.

COLOR TELEVISION COMMITTEE

The National Bureau of Standards has organized a Color Television Committee, at the request of Senator Edwin Johnson of Colorado, for the purpose of surveying the present status and future prospects of color television. The Committee will confine its attention to the scientific and technical phases of the problem and will present a report to Senator Johnson in his capacity as chairman of the Senate Committee on Interstate and Foreign Commerce.

The membership of the NBS Color Television Committee is as follows: E. U. Condon, Dir. NBS, Chairman; Newbern Smith, Chief, Central Radio Propagation Laboratory, NBS, Vice-Chairman; Stuart L. Bailey, Consulting Engineer of Washington, D.C. and President of IRE; W. L. Everitt, Dean, College of Engineering, University of Illinois; and Donald G. Fink, Editor, *Electronics*.

FREQUENCY MONITORING SYSTEM

A frequency monitoring system has been devised by R. E. Gould and H. A. Bowman of the National Bureau of Standards by which any Bureau laboratory may obtain the proper correction to be applied to a commercial interval timer driven by the city power line.

The system, which depends on a frequency error indicator, also designed at the Bureau, is simple and straight-forward in application. The cumulative error, arising from variations in the frequency of a commercial electric power supply used to drive the interval timer, is obtained over the period of observation by comparing the speeds of the two small black

(*Continued on page* 28)

NEW TUBES

TELEVISION TUBE

Raytheon Manufacturing Company's new Cathode Ray Tube Division at Newton, Mass., is now producing an 8½" television picture tube which is interchangeable with their standard 7JP4.

The new Raytheon 8BP4 at the right alongside their type 7JP4 (left) is said to offer an increase in useful screen area of approximately 50%.

Sales to set manufacturers in the East are being handled by E. Kohler

with headquarters at 50 Broadway, New York City, while sales to Mid-Western manufacturers are being handled by C. R. Hammond at 445 Lake Shore Drive, Chicago, Illinois.

SYLVANIA TUBES

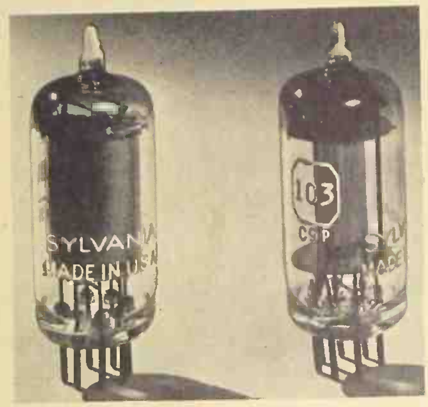
Noise Diode

A noise generating diode suitable for measurements at frequencies up to 500 megacycles has been announced by *Sylvania Electric Products, Inc.*, 500 Fifth Ave., New York City. The new T 5½ tube, type 5722, is designed for

standard laboratory measurement and is operated with 150 volts on plate and at filament voltages ranging between 2 and 5.5 volts depending on desired plate current or noise output.

Miniature Electron Tubes

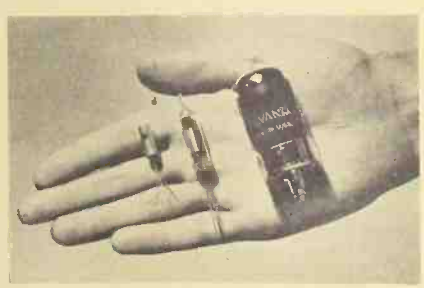
A T 5½ pentode power amplifier type 1W4 and a T 5½ triode amplifier or oscillator type 1C3 have also been announced. Both tubes are designed for



battery operation and have 1.4 volt d.c. filaments requiring only 50 milliamperes. Rated power output of the 1W4 pentode is 35 milliwatts with 45 volts on the plate and 200 milliwatts with 90 volts. The 1C3 general purpose triode is designed for 90 volts operation. This tube has an amplification factor of 14.5.

Miniature Crystal Mixer

Sylvania, Inc., is also showing the increasing possibilities of miniaturization in radio circuits.



Shown are mixer tubes of the standard and subminiature types together with a laboratory model of a four-terminal germanium crystal mixer.

CATHODE RAY TUBE

A multiple-intensifier-type cathode ray tube featuring a highly sensitive vertical-deflection system is announced by *Allen B. Du Mont Laboratories, Inc.*, 1000 Main Ave., Clifton, N. J. Potentials of the Type 5XP- as low as 24 to 36 volts peak-to-peak are sufficient for one inch vertical deflection on the screen.

Of the many features of this 5XP- is the satisfactory operation at high ratios of E_{b3} to E_{b2} voltages and this ratio may go as high as 10:1. A shield placed between deflection-plate pairs D_1-D_2 and D_3-D_4 prevents interaction between plate pairs. At present the Type 5XP- is available with a choice of phosphors including P1, P2, P4, P5, P7, P11, screens.

The Instrument Division will furnish additional information upon request.

RCA TUBES

Multiplier Phototube

The *RCA* head-on, multiplier phototube 5819 is intended for use in scintillation counters for the detection and measurement of nuclear particle radiation, and in other applications involving low-level, large-area light sources. It

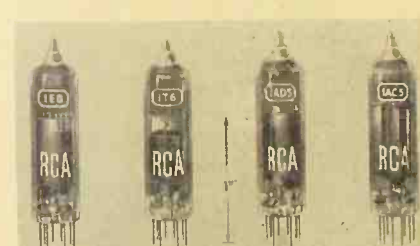
has high sensitivity to blue-rich light and negligible sensitivity to infrared radiation.

An outstanding feature of the 5819 is its semi-transparent photocathode which has a diameter of 1½ inches and an area of 1.8 square inches. This relatively large cathode area permits efficient collection of light from large-area light sources, such as are encountered in scintillation counters.

Subminiature Line

A line of subminiature tubes consisting of four types is being offered to equipment designers by the Tube Department at Harrison, N. J.

The four types are: a power pentode 1AC5, a pentagrid converter 1E8, a



sharp-cutoff pentode 1AD5, and a diode-pentode 1T6. These tubes have a seated length of 1½" and a diameter only slightly greater than ⅜" and are con-

(*Continued on page 28*)

TECHNICAL BOOKS

"ELECTRICAL TRANSMISSION OF POWER AND SIGNALS", by E. W. Kimbark. Published by *John Wiley & Sons, Inc.*, 440 Fourth Avenue, New York 16, N. Y. 461 pages. $6.00.

This first textbook to apply transmission-line theory to all three fields of power, telephone, and ultrahigh-frequency transmission, is rigorous and authoritative in its presentation. The theory is given in three main parts: transmission-line parameters, steady-state phenomena, and transient phenomena.

Transmission-line (hyperbolic function) charts; and tables and graphs of the characteristics of power-line conductors, power transmission and distribution lines, telephone lines and cables, submarine telegraph cables, and radio-frequency lines are included.

An extremely useful reference book for professional engineers, its greatest value will be found in electrical transmission courses, particularly those on general theory with a range from direct current to microwaves.

"ELECTRIC AND MAGNETIC FIELDS", Third Edition, by Stephen S. Atwood. Published by *John Wiley & Sons, Inc.*, 440 Fourth Ave., New York 16, N. Y. 475 pages. $5.50.

Written to provide a smooth transition from the study of mathematics, mechanics, and physics to advanced professional-level electrical engineering, this book offers fundamental field theory in simple mathematical terms.

In this third edition the author has divided the book into four parts: the electric field, the magnetic field, the ferromagnetic field, and the fourth part treats, in an elementary manner, the interactions between electric and magnetic fields.

Practice in expressing simple physical ideas in simple mathematical language is presented as is practice in the methods of "field mapping". A large number of drawings give the correct shapes to the lines of flux and the equipotential surfaces. Formulas throughout have been recast in the rationalized M. K. S. system.

"TRANSFORMATION CALCULUS AND ELECTRICAL TRANSIENTS", by Dr. Stanford Goldman. Published by *Prentice-Hall, Inc.*, 70 Fifth Avenue, New York 11, New York. 439 pages. $8.35.

Dr. Stanford Goldman, currently professor of electrical engineering at Syracuse University and consulting physicist to the United States Air Force, has written this thorough, modern and practical discussion of transients.

Included among the many features of this book are simple solutions to many problems previously considered complicated, such as the Nyquist criterion for stability, and the relation between amplitude and phase characteristics. The Laplace Transformation and the method of contour integration in the solution of transient problems is given thorough treatment. Asymptotic solutions of electrical problems is handled systematically, and all mathematics beyond calculus is developed in detail in the book.

Dr. Goldman's principal aim in presenting this volume is to develop the methods of the Laplace transformation and its inverse for the solution of problems in electrical circuit transients.

"MICRO-WAVES AND WAVE GUIDES", by H. M. Barlow. Published by *Dover Publication, Inc.*, 1780 Broadway, New York 19, N. Y. 122 pages. $1.95.

To meet the need of a large group of engineers and physicists for a complete exposition of the subject of microwave techniques, Professor Barlow of the Electrical Engineering Department of University College, London, has included in his book all the essentials for an advanced understanding.

A physical picture of wave-guide modes, synthesized from constituent plane waves in association with ordinary transmission line elements, is presented in this helpful volume. The mathematical analysis is comparatively straightforward, lending itself to profitable comparison in some respects with ordinary transmission line theory. The coaxial cable, representing as it does the common meeting ground of wave-guide modes and the simple transverse electromagnetic wave, is thoroughly discussed.

The measurements and applications of microwaves are given to furnish the reader with an appreciation and knowledge of the methods adopted in actual practice.

A co-ordinate system has been chosen to define the components of the electric and magnetic fields. The M. K. S. system of units has been used throughout and as far as possible the symbols employed are those generally accepted for the purpose. The usual convention has been employed in the graphical presentation of the electromagnetic field as lines of force.

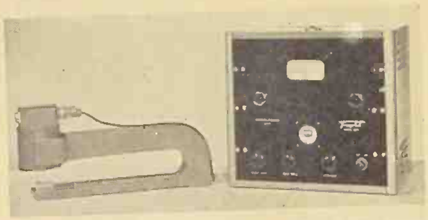
Engineers and physicists will find this volume a complete survey of this important field.

NEW PRODUCTS

BETA GAUGE

The second of a series of industrial measuring and control instruments using radioactive isotopes currently under development at *Tracerlab, Inc.*, 130 High St., Boston, Massachusetts is the SM-3 Beta Gauge.

The essential components of the gauge are a source of beta radiation from Strontium-90 and a radiation detector. One of the outstanding advan-

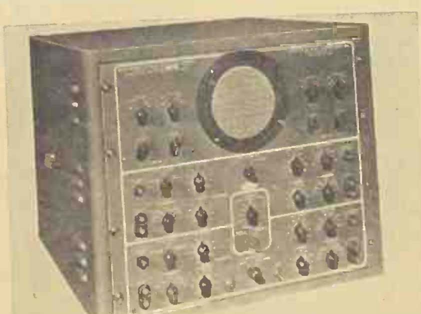


tages of the instrument is the fact that no physical contact is made with the material being measured. The sheet material to be measured is interposed between the source and the detector and a part of the radiation is absorbed by the sheet material in proportion to its weight per unit area.

A few typical uses of the *Tracerlab* Beta Gauge are measuring cellophane and other thin plastic films, plastic and rubber sheets up to 3/16" thick, paper ranging from heavy board to extremely thin condenser paper less than .0002" thick and sheet metal including steel and brass up to .040" thick.

CATHODE-RAY INDICATOR

The Special Products Section of *Allen B. DuMont Laboratories, Inc.*, 1000 Main Avenue, Clifton, New Jersey has



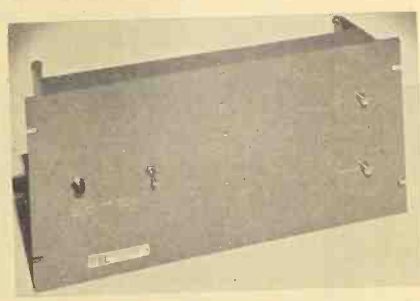
developed a new Four-Beam Cathode-ray Indicator which is capable of displaying simultaneously four related or unrelated, independent phenomena on a single cathode-ray tube screen.

The indicator is similar externally to the *DuMont* Type 279 Dual-Beam Cathode-ray Oscillograph, but is equipped with the specially designed *DuMont* Type K1027P11 Cathode-ray Tube, which contains four independent electron guns, rather than the Type 5SP-Dual-Beam Cathode-ray Tube used in the *DuMont* Type 279.

Details concerning the facilities of the Special Products Section may be obtained by writing the Instrument Division.

WIDE BAND CHAIN AMPLIFIER

Spencer-Kennedy Laboratories, Inc., 186 Massachusetts Avenue, Cambridge 39, Massachusetts has added to its line of traveling wave amplifiers the Model 204 Wide-Band Chain Amplifier for use



in the general laboratory measurements field as well as in nuclear physics and television testing.

The instrument has a bandwidth of 200 megacycles and a gain of 40 db. With an impedance of only 200 ohms, and a nominal transmission characteristic of ± 1.5 db. from 100 kc. to 200 mc., the amplifier has a substantially linear phase shift.

Further information may be obtained by writing to Department RT.

MOBILE COMMUNICATION EQUIPMENT

A highly-selective two-way mobile communication system for operation in the 3-50 megacycle portion of the frequency spectrum has been announced by the Communications Section of the *RCA* Engineering Products Dept., Camden, N. J.

The Fleetfone, a companion system to the recently announced Carfone mobile equipment, is available in three models to meet individual needs. For operation from a 6-volt battery, the Fleetfone is available with either 30 or 60-watt output. In addition, there is a 30-watt model which operates from a 12-volt battery.

This unit is completely contained in a single metal-shielded unit which permits mounting the equipment in practically any position, on either a horizontal or a vertical surface. The controls and loudspeaker are combined in a single compact unit for attachment under the dashboard. This unit is now available from either the Communications Section of *RCA*, or from local field representatives.

TUNING FORK RESONATORS

Temperature-compensated tuning fork resonators are available in frequencies from 1000 to 3000 c.p.s. and in

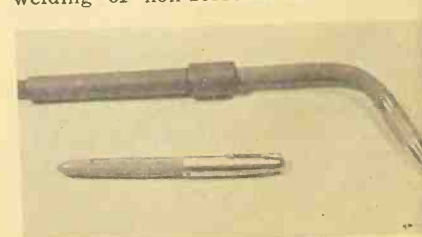
accuracies from 1 part in 3000 to 1 part in 100,000 from *Philamon Laboratories*, 5717 Third Avenue, Brooklyn 20, N. Y.

These tuning forks are provided complete with their drive and pickup coils mounted in solder-sealed evacuated steel cans and are thoroughly aged for maximum stability of operation. They are available as individual components, as a part of sub-assemblies, or in completed equipment.

MINIATURE INERT-ARC ELECTRODE HOLDER

General Electric's Welding Division, Schenectady, N. Y., has announced a miniature Inert-Arc electrode holder which features a flexible front-end assembly made of malleable copper tubing surrounded by a sheath of silicone rubber so that it can be bent in any direction to reach hard-to-get-places.

Specifically designed for the fluxless welding of non-ferrous metals in the



thinner gages, the holder is availabl[e] in two models: one for 0.010- an[d] 0.020-in. tungsten electrodes and th[e] other for 0.040- and 1/16-in. tungsten electrodes.

Small, light, and extremely adaptable, the new welding tool will find application in the manufacture and repair of surgical instruments, cutlery, business machines, control and measurement equipment, capillary tubing, electronic tubes, duct work, wire fittings, small sheet metal enclosures, metal novelties, etc.

ELECTRONIC CELL

An Electronic Standard Cell available for any specified d.c. output voltage from 0 to 100 and for any load up to 30 ma. is announced by *Hastings Instrument Company, Inc.*, Box 1275, Hampton, Virginia.

This electronic cell is not subject to freezing and is not damaged by momen-

tary short circuits. It can be used either as a reference voltage in bridge or potentiometer circuits or for supplying current continuously as an instrument power supply.

Precise output voltages such as 0.10, 1.00 or 100.00 volts d.c., or the usual standard cell voltage of 1.018 can be supplied. Electronic Standard Cells designed on the same circuit principles for output voltages above 100 volts d.c. for operation on other input voltages, higher current drains, or with non-standard chassis construction are available on special order.

TWIN POWER SUPPLY

Model 1210 electronically regulated twin power supply featuring a unique

switching arrangement has been announced by *Furst Electronics*, 12 S. Jefferson Street, Chicago 6, Illinois.

The output voltages of the Twin Power Supply can be adjusted over wide ranges by the operation of two control-knobs on the front panel. A selector-switch, also located on the front panel, allows two ways of operation: two independent outputs which can be used independently of each other; and one single output capable of supplying twice this current, obtained by connecting both regular circuits in parallel.

In addition, a "stand-by" position on the selector-switch is provided for use when the voltage should be removed from the high-voltage terminals.

UHF MEGALYZER

Kay Electric Company, Pine Brook, N. J. has incorporated a coaxial type wide band mixer in its VHF Megalyzer to obtain improvement in performance and sensitivity.

The frequency band of the UHF Megalyzer is now 30 to 500 mc. The sensitivity has been increased to the point that signals down to 100 microvolts may be easily seen on the included oscilloscope.

Equivalent input noise is approximately 20 microvolts and the frequency response is within 4 db. Signals may be studied within a 30 mc. range on the oscilloscope at one time.

ELECTRONIC RESISTOHMETER

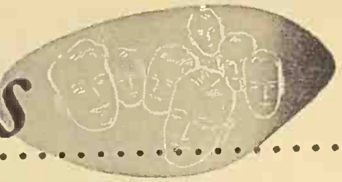
The Crown Industrial Products Co., 1336 W. 69th St., Chicago, Illinois announces a new Electronic Resistohmeter. This unit is a Wheatstone

bridge designed for measuring resistance and insulation resistance in both low and extremely high ranges.

The indicator used with the bridge is a 6E5 electron ray tube. The Resistohmeter is guarded internally so that leakage across the bridge components due to high humidity does not enter into, or affect the operation or accuracy of the bridge.

(*Continued on page* 29)

Personals



HENDLEY BLACKMON, managing editor of *Electrical World* since 1947, has been appointed Assistant Manager of Engineering Association Activities for *Westinghouse Electric Corporation.* He will be headquartered at the East Pittsburgh Works and will assist Frank Thornton, Jr., Manager of the Activities. Mr. Blackmon will work with *Westinghouse* engineers in the preparation of papers to be presented before Engineering Associations.

WILLIAM WARREN DAVIS, formerly on the staff of the Naval Ordnance Laboratory at White Oak, Maryland, has been appointed to do research on the high speed electrostatic memory of the electronic digital computing machines at the Electronics Division of the National Bureau of Standards. Mr. Davis received his degree of bachelor of science in engineering physics from Ohio State University and did graduate work at the University of Maryland.

H. B. FANCHER has been appointed Section Engineer of Broadcast Studio Equipment for *General Electric Company* in Schenectady, New York. Mr. Fancher joined the Transmitter Division in 1940 and during the war was active in the development of microwave relay equipment and radar countermeasures. He was named assistant section engineer in charge of television equipment in February 1948 and served in that capacity until his present appointment.

ALFRED H. MASSALLEK has been appointed Executive Design Engineer of *Shure Brothers, Inc.*, Chicago, where he will supervise new designs and act as consultant to other departments concerning design problems. Associated with the radio industry for the past fifteen years, Mr. Massallek was Chief Mechanical Engineer of the *Majestic Radio and Television Corp.*, Chief Draftsman of the *Zenith Radio Corp.*, and Design Engineer for the *Stewart-Warner Corp.*

DR. OLIVER D. SLEDGE has joined the staff of the National Bureau of Standards to do research in the Microwave Standards Section of the Bureau's Central Radio Propagation Laboratories. Formerly a professor of electrical engineering at the Georgia School of Technology, Dr. Sledge has done extensive work in the fields of electronic and radio engineering. He is an associate member of Sigma Xi, and is a senior member of the IRE.

DR. CHEN TO TAI of Soochow, China, has been appointed senior research physicist in the department of electrical engineering at Stanford Research Institute, Palo Alto, California. Dr. Tai, who received his Doctor of Philosophy degree in 1947 at Harvard University, will be in charge of the theoretical section of the Institute's Aircraft Radio Systems Laboratory. He is an associate member of the IRE, and a member of the APS and Sigma Xi.

Field Intensity

(*Continued from page* 13)

chart for Radial B is shown in Fig. 3. The small numbers along one margin are log reference numbers and were marked on the chart each time pertinent data was recorded in the log. The numbers on the opposite margin are the field car speedometer readings. It should be mentioned that the median value is not obtained by averaging the signal intensities recorded on each section of these charts but is found by determining the field intensity received 50 per cent of the distance throughout each sector. These field intensity values must then be corrected for a receiving antenna elevation of 30 feet and for any effects due to the field car body as determined by the method given previously in this paper. The data for each sector of each radial thus obtained was then plotted on log-log coordinate paper with distance as the abscissa and field intensity as the ordinate. A smooth curve was drawn through these median field points for all sectors and this curve determines the distance to the desired contour. This is illustrated in the graph of Fig. 2 for Radial B. These distances were then plotted on the map of predicted coverage to determine the service area of the 1000 microvolt per meter contour. The 50 microvolt per meter contour was then found by employing Fig. 1 of the FCC Standards for FM Broadcast Stations which gives instructions for this procedure, and this contour also plotted on the map. This map shown on page 11 gives the predicted contours in dashed lines and the measured contours in solid lines. The map was assembled from 4 state maps obtained from the United States Geological Survey, Department of the Interior.

A technical statement giving a description of the procedures and methods employed, type of equipment, method of installation, and operation and calibration was prepared to accompany the collected data. All must be submitted in triplicate, except that only the original or one photostatic copy of the recording charts need be submitted.

Needless to say, considerable time is required to make a survey of this kind and properly prepare the data for presentation to the Commission and much of the work is of a tedious nature. The author wishes to acknowledge the splendid assistance and cooperation rendered by Arthur H. Hallam, WOL engineer, in making the field intensity measurements in which approximately 900 miles of driving the field survey car was required.

Stabilized Element

(*Continued from page 7*)

signal current will vary with the amplitude of the a.c. component.

Example of Application

One application in which the cathode follower voltage stabilizer has been employed is the regulation of the screen grid voltage supply for beam power amplifier tubes operated in class AB.

As an example, the case of push-pull class AB_1 operation of type 6L6 tubes will be considered in some detail: From the published data for these tubes, the following operating conditions will be assumed:

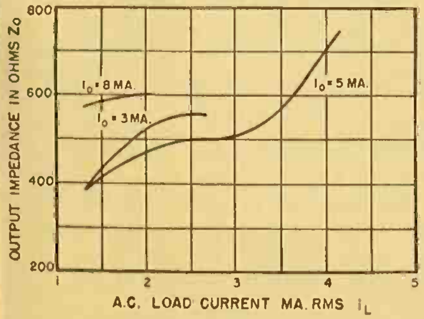
Plate voltage, E_{bb}	360 volts.
Screen grid voltage, E_b	270 volts.
Screen grid current	
zero signal	5 ma.
maximum signal	17 ma.
Cathode resistor	250 ohms.

The plate voltage at which the stabilizer will operate is:

$$E_p = E_{bb} - E_b = 360 - 270 = 90 \text{ v.} \quad (7)$$

The tube selected must be capable of supplying the maximum current required by the load with zero bias, or preferably, with some negative bias, at this plate to cathode voltage. From published curves for the type 6J5 tube, with 90 volts applied to the plate and zero grid bias, the plate current would be approximately nine milliamperes, thus this tube would not be suitable. However, the type 6SN7 with the two triodes connected in parallel should pass 18 ma. under the required conditions. Cutoff grid voltage at 90 volts plate potential is approximately 6 volts, and over the range of 0—17 ma, the variation in grid voltage is about 5.5 volts. By Eqt. (2), the direct current regulation will thus be 2.04%; or the effective supply resistance over this range is:

Fig. 5. Plot of a.c. load current vs. output impedance in ohms. These curves are somewhat sketchy due to the limited capacity of the a.c. load current generator employed, but serve to indicate certain limitations in the circuit.



$$R_{dc} = \frac{5.5}{17} 10^3 = 458 \text{ ohms} \quad (8)$$

By Eqt. (6), taking an average d.c. operating current of ten milliamperes, the effective supply impedance to small components of signal frequency current is 160 ohms.[1]

The attenuation ratio to power supply ripple components by Eqt. (4) is 0.048.[1] This is equivalent to 26.4 db. attenuation.

It should be noted that, in this example, the direct current requirements of the screen grid circuit would load the tube selected for the stabilizer to its maximum capacity. For this reason, the stabilizer should not be required to handle the a.c. signal components of the screen current, or to provide appreciable filtering of ripple from the power supply. These functions of the stabilizer may be prevented by providing a suitable bypass or filter capacitor across its output terminals. Should the filtering and bypassing actions of the stabilizer be considered desirable, a larger tube should be employed, or two tubes of the type indicated should be operated in parallel. The latter arrangement would result in the same direct current supply resistance, a reduction of fifty per-cent in the small current alternating current supply impedance, and but slightly increased filter attenuation ratio.

The power required by the heater of the stabilizer tube is 3.78 watts. For comparison, a voltage divider dissipating this amount of power in a bleeder resistor would require 14 milliamperes of bleeder current while the equivalent direct current supply resistance would be 3800 ohms. The equivalent supply impedance to alternating current and the ripple attenuation ratio would be largely a function of the bypass capacitor employed. With such a voltage divider, the screen voltage would fall some 45 volts at maximum signal level, indicating a regulation of almost 17%. This is sufficient to limit seriously the power output of the amplifier.

It can be shown that a voltage divider capable of providing the same regulation in this application as the cathode follower stabilizer would require a bleeder current of about 190 milliamperes. The power dissipated in the bleeder would be approximately 52 watts.

1. *In the calculation of the effective supply impedance, R_O, and the ripple attenuation ratio, it was assumed that the a.c. impedance of the screen grid circuit was one-half of the d.c. resistance at 10 ma. current. A large error in this value will have but little effect on the results obtained, as may be seen by Eqts. (4) and (6) when $R_p = 3350$ ohms and $R_L = 31{,}500$ ohms.*

Timer and Clock

(*Continued from page* 5)

If more accurate time intervals were required, and assuming that an accurate frequency standard be available, the input pulse repetition rate could be raised to 1000 cycles, 10,000 cycles,

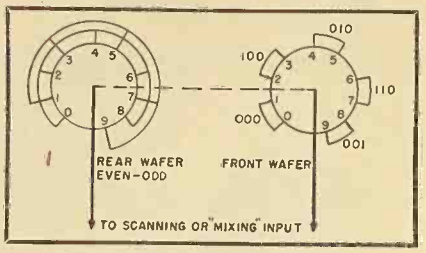


Fig. 8. Two deck wafer switch.

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(*Continued from page* 22)

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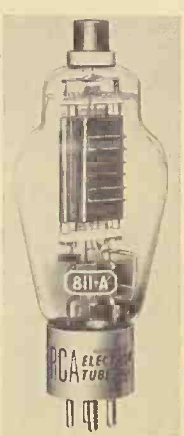

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(*Continued from page* 21)

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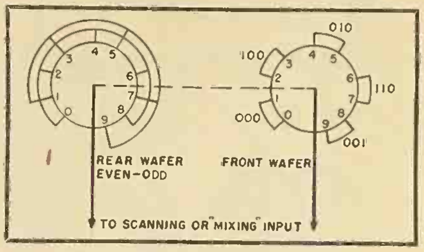

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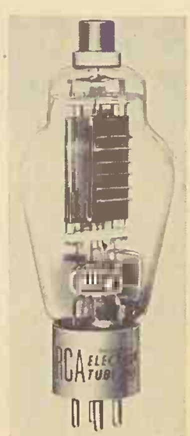

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TIMING MARK GENERATOR

A 1000 cycle pulse generator for exposing 1/1000 second timing marks on the film in the high speed Fastax cameras is now available from *Potter Instrument Company, Inc.*, 136-56 Roosevelt Avenue, Flushing, N. Y.

According to reports, the output pulse power is adequate for supplying timing

marks to as many as 14 cameras simultaneously or 14 one quarter watt argon glow lamps. A 100,000 cycle per second crystal oscillator included in the instrument precisely controls the timing marks.

The unit is completely self-contained and can be used for either laboratory or airborne work as the power supply will operate from 50, 60 and 400 cycle supplies at 110 volts.

TELELINK EQUIPMENT

General Electric's Transmitter Division at Electronics Park, Syracuse, N. Y., has announced that its Telelink equipment for three types of television microwave relay systems is now available commercially.

The new equipment, all of which operates in the 1900-2110 mc. band, includes transmitters, receivers and antennas for intercity, studio-to-transmitter, and semi-portable relays. Transmitter output for all three ranges from 5 to 10 watts. The frequency response of the system is flat to plus or minus 1 db. out to 5 mc., with modulation and demodulation linear within plus or minus 5 per-cent.

Further information about this TV relaying equipment can be obtained by writing *GE* Transmitter Division.

ASBESTOS TUBES

Originally designed as a heat resisting base for electric coils and bobbins, the asbestos tube manufactured by *Precision Paper Tube Co.*, 2045 W. Charleston St., Chicago 47, Ill., can also be used for insulation in such units as electric heaters, thermal heating devices, for insulating rods, etc., for both heat and as a dielectric.

These tubes can be made in any length, with wall thicknesses from .010 up. They are made by spirally winding specially prepared asbestos tape to predetermined sizes around a mandrel, then di-forming into either square, rectangular or oval cross sections.

The company has invited users of electric coils and manufacturers who have a problem which they believe this tube may solve to send for a sample made to their specifications.

POWER SUPPLY

A regulated power supply, Model A, designed to provide a stable source of d.c. for experimental setups has been announced by *The Howard Co.*, 934 Argyle Rd., Drexel Hill, Pa.

According to the manufacturer, the unit is light, compact and inexpensive, and can be supplied in the cabinet shown or panel mounted for rack installations. All component parts are of high quality (filter capacitors are oil-

filled paper) and each unit is guaranteed against defective workmanship and materials, except tubes, for one year.

Specification information may be obtained by writing the company.

SAMPLING DEVICE

A high speed subminiature mechanical sampling device having two poles, each of which contains sixty contacts, has been announced by *The Applied Science Corporation of Princeton*, Princeton, N. J. These poles may be synchronized in any phase desired.

Driven by a 12 or 28 volt d.c. motor and having a power consumption of only a few watts, the sampling rate of this device is nominally 300 r.p.m. Over-all dimensions are 3⅛" x 2⅛" x 4⅜".

These switches facilitate investigation of a large number of separate quantities or of a single quantity under a number of various conditions.

In addition to telemetering applications, they may be used for the display

of characteristic curves and multichannel voltage comparison.

PHOTO CREDITS

Pages
3, 4 .... Northrop Aircraft, Inc.
8, 14, 15 ...... National Bureau of Standards
11 .... Esterline-Angus Co., Inc.

Heater-Compensated

(*Continued from page* 8)

to a common line voltage and the screen grid voltage of the amplifier tube set at its proper value, the heater-compensated power supply shows a maximum deviation of 0.01 volt from the nominal 350-volt output for a ten-volt change in the input. This is a variation of less than 0.0005 per-cent in output voltage for a one per-cent change in the line. The extremes in line voltage were taken as 100 and 120 volts.

The compensating voltage exhibits a time lag dependent on the time necessary for the cathode temperature to come to equilibrium. The effect of this time lag can be reduced by connecting a series resistance-capacitance circuit between the input terminal and the screen grid of the amplifier. When a sudden change of line voltage occurs, this *RC* circuit applies the proper voltage to the screen grid of the amplifier to compensate for the thermal time lag of the cathode temperature. The time constant of the *RC* network was chosen to equal that of the cathode temperature change.

Heater compensation gives much better operation in most power supplies using degenerative voltage stabilizers, without sacrifice of design simplicity. The principles of heater compensation can also be applied to good advantage in both a.c. and d.c. amplifiers.

NOTE:

For further tehnical details on this work, see "Cathode Heater Compensation as applied to Degenerative Voltage Stabilized D-C Power Supplies" by Robert C. Ellenwood and Howard E. Sorrows, J. Research NBS 43, 3 (September 1949) RP 2027.

Quadrature Networks

(*Continued from page 9*)

$$\frac{e_1}{e_2} = \frac{I_1R\,(1-j)}{e_2} - 1 \quad . \quad . \quad (5)$$

From (2):

$$I_1R = I_2R\,(2-j) = e_2\,(2-j) \quad . \quad (6)$$

Substitute (6) in (5):

$$\frac{e_1}{e_2} = (2-j)\,(1-j) - 1 = -3j \quad (7)$$

$$\frac{e_2}{e_1} = -\frac{1}{3}\,j \; . \; . \; . \; . \; . \; . \; . \quad (8)$$

This shows that the output voltage lags the input by exactly 90 degrees and has an amplitude of ⅓ the input. The essential requirements of this special case are that this source impedance be very low and that the loading on the network be extremely light.

These conditions are easily met by feeding the circuit from a cathode follower. See Fig. 1G.

When two precision resistors and two precision capacitors are calculated and assembled into the circuit shown, an accuracy of plus or minus ½ per-cent may be realized.

Design of An Echo Box

(*Continued from page 18*)

$$t_r = \frac{0.7333\,Q'}{f(1+\beta_a)}\left\{\log \beta_a \left(1 - e^{-\frac{3.14 f \tau (1-\beta a)}{Q'}}\right) + \frac{\Delta}{20}\right\} \quad . \quad . \quad (15)$$

Where t_r = ringtime in microseconds
f = frequency in mc.
τ = pulse width in seconds
Δ = level difference between peak pulse power and receiver sensitivity at the echo box input in decibels.
$\beta_a = Q'/Q_L - 1$

For the application for which this echo box is required $\Delta = 100$ and $\tau = 5 \times 10^{-5}$ seconds. It has been found experimentally that the maximum ringtime is obtained, while still permitting sufficient loading for crystal current output measurements, if β_a has a value in the vicinity of 0.1. This value depends on the degree of output coupling required to give adequate crystal current for the particular repetition rate and pulse width of the system under test and must be determined experimentally in conjunction with the system with which it is to be used. For the present consideration $\beta_a = 0.1$ is sufficiently accurate to permit determining the relative order of magnitude of the ringtime.

d. From Eqt. (15) the ringtime at 142 mc. is found to be 363 x 10^{-6} seconds. From Table I the reduction in ringtime due to compensation at 142 mc. is 7.41 per-cent so that the resultant ringtime is about 336 microseconds.

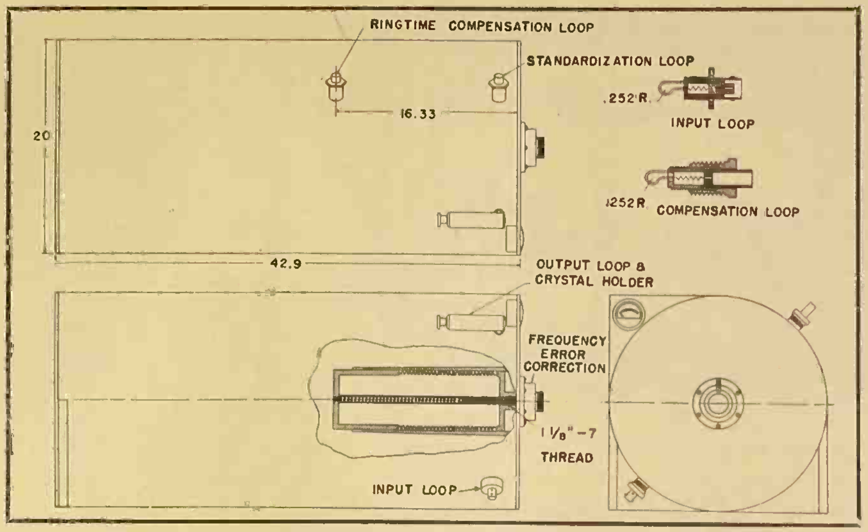

Fig. 4. Drawing showing construction of 130-154 mc. coaxial echo box.

Since β_a is $Q'/Q_L - 1$, then for $\beta_a = 0.1$ at 142 mc., $Q_L = 18500$.

From the definition of $Q_L = f/\Delta f$ the bandwidth of the coaxial cavity for 142 mc. is found to be approximately 7.7 kilocycles.

The loop dimensions can be closely approximated from the relationship:

$$A_L = .005048 \sqrt{\frac{R_0\, b^3}{\sqrt{f}}} \quad . \quad . \quad . \quad (16)$$

where A_L = loop area in square cm.
R_0 = input transmission line impedance
b = inner radius of outer conductor in cm.
f = frequency in mc.

Though the value of A_L is only an approximation it has been found sufficiently accurate to provide a good starting point for the final experimental determination of the loop dimensions. For the mid-band frequency of 142 mc. the loop area A_L is found to be 1.29 square centimeters, corresponding to a loop diameter of 0.641 centimeters or 0.252 inches.

Conclusions

A quarter-wavelength coaxial echo box has been designed having the following electrical and mechanical parameters:

a. Diameter—20 inches outer conductor, 5.555 inches inner conductor
b. Length—42.9 inches over-all
c. Plunger Variation—3.516 inches
d. Tuning—Direct reading frequency dial with 100-division vernier dial
e. Tuning accuracy with dial correction = 0.1 mc.
f. Average unloaded Q — 20,000
g. Average Loaded Q — 18,000
h. Average Cavity Bandwidth—7.7 kilocycles
i. Average Ringtime—336 μsec.
j. Ringtime Variation with Compensation is equal to 1.0 per-cent
k. Loop Radius—0.252 inches

The resulting echo box design meets the requirements of the system with a good margin of safety. An over-all construction diagram (Fig. 4) shows the outline of the physical layout of the echo box. The input and compensating loops have 50-ohm resistors built in so as to provide matching for the transmission line and the loops.

REFERENCES

1. *Green, E. I., Fisher, H. J., and Ferguson, J. G. "Techniques and Facilities for Microwave Radar Testing." AIEE Technical Paper 46-40 Jan. 1946.*
Wilson, I. G., Schramm, C. W., and Kinzer, J. P. "High Q Resonant Cavities for Microwave Testing." The Bell System Technical Journal, July 1946.
Montgomery, C. G. "Technique of Microwave Measurements." Radiation Laboratory Series Vol. II, McGraw-Hill 1947.
2. *Vogelman, Joseph H. "Development of An Echo Box For 130-154 MC/S Band." Watson Laboratories Memorandum Report No. WLEAE-1-101.*
3. *Whinnery, J. R., Jamieson, H. W., and Robbins, T. E. "Coaxial Line Discontinuities" Proceedings of the Institute of Radio Engineers, Nov. 1944*

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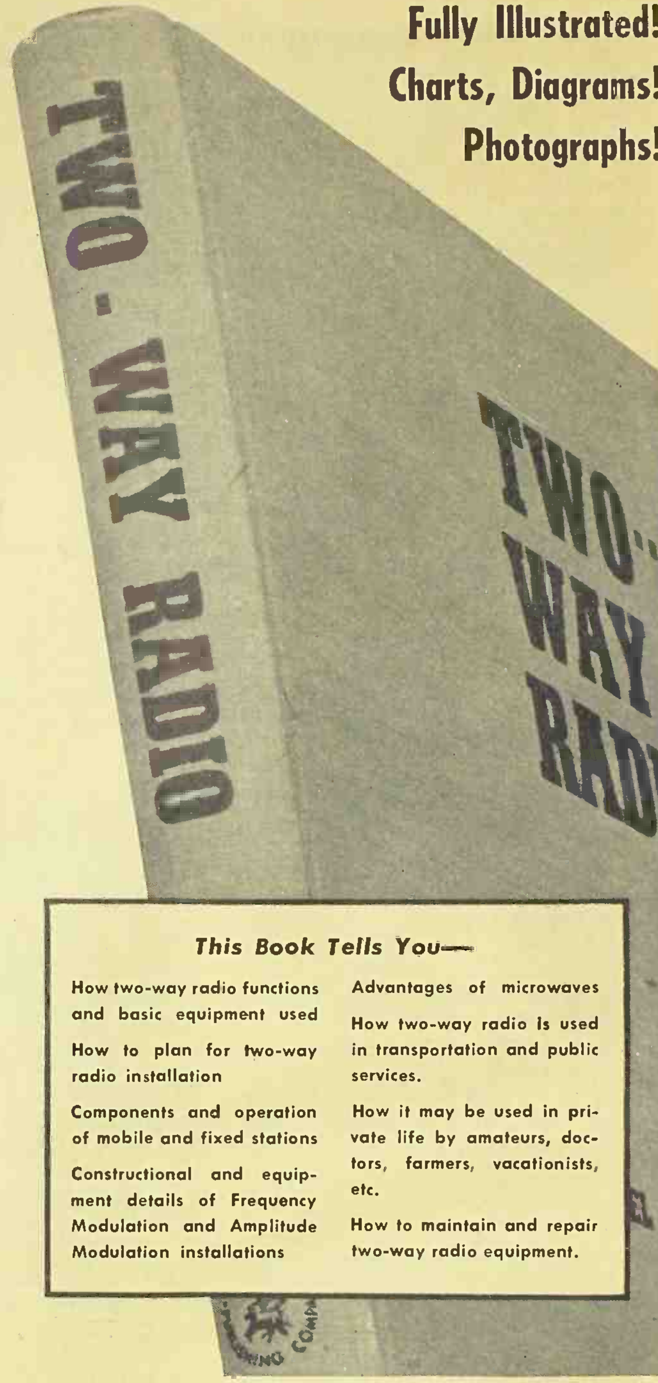

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