RADIO-ELECTRONIC *Engineering* SECTION

RADIO & TELEVISION NEWS

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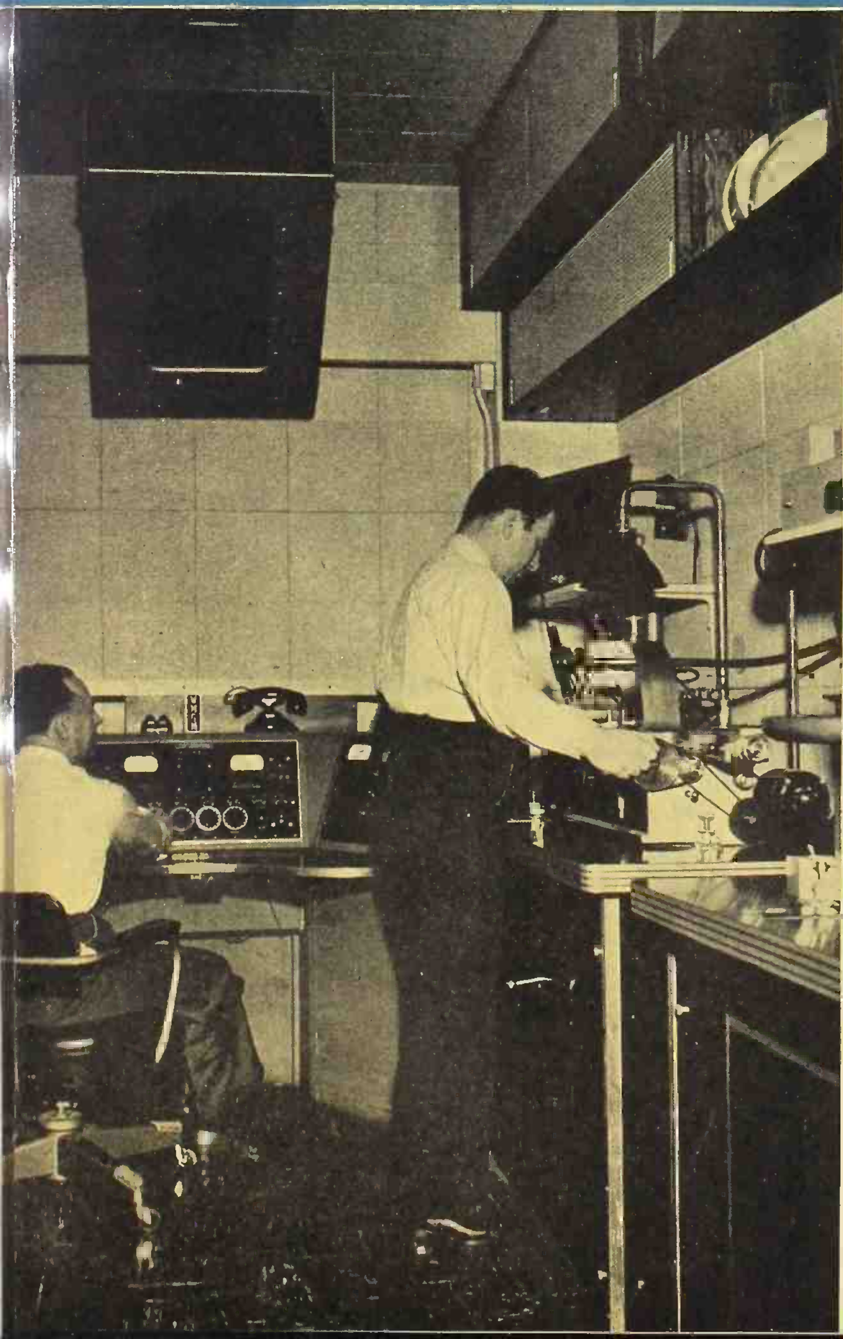

NOVEMBER, 1951

DEPARTMENTS

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The main recording room of station WMGM where shows are piped in from mixing consoles. The program is first recorded on Ampex tape machines, then edited and transferred through a re-recording console and a special amplifier to a master disc on the Scully lathe.

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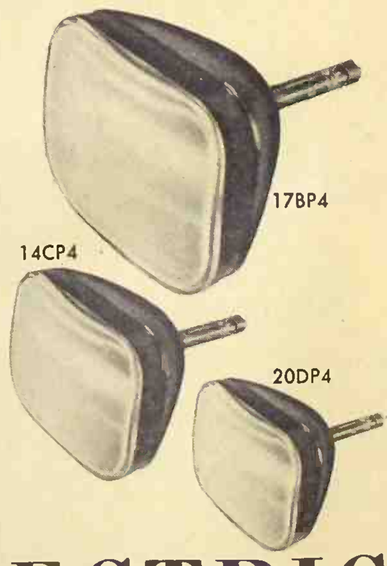


Sylvania Electric 1901-1951 Products Inc. Five Decades of Progress — 50th Anniversary

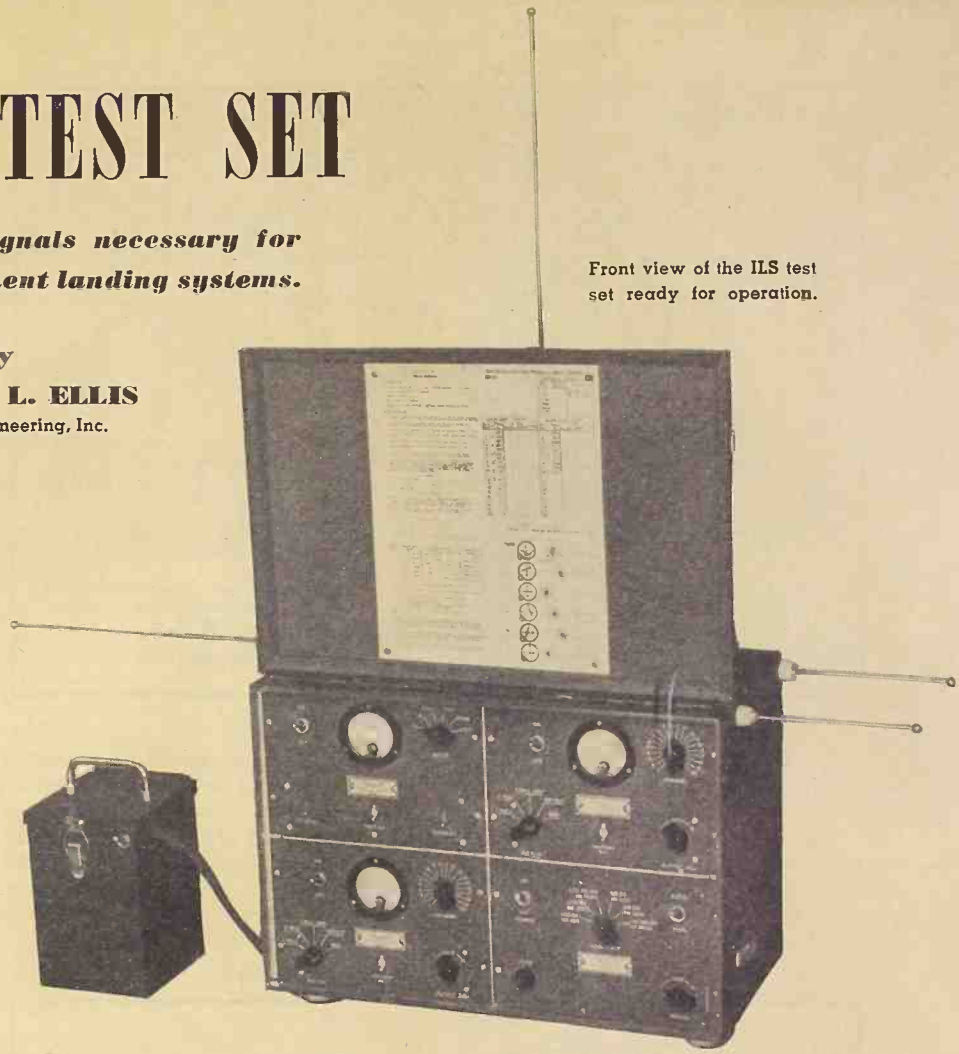
SYLVANIA ELECTRIC

RADIO TUBES; TELEVISION PICTURE TUBES; ELECTRONIC PRODUCTS; ELECTRONIC TEST EQUIPMENT; FLUORESCENT TUBES, FIXTURES, SIGN TUBING, WIRING DEVICES; LIGHT BULBS; PHOTOLAMPS; TELEVISION SETS

ILS FIELD TEST SET

This set simulates all signals necessary for checking aircraft instrument landing systems.

By
CHARLES L. ELLIS
Gables Engineering, Inc.



Front view of the ILS test set ready for operation.

ONE OF THE major problems which confronted the airlines in their use of instrument landing system (ILS) facilities for making landings under bad weather conditions was the desired frequent checking of aircraft ILS installations to insure proper operation. In answer to this problem, *Gables Engineering, Inc.* manufactured the Model G-250A ILS Field Test Set. This test set has now been used successfully by some of the major airlines for nearly three years.

General Description

The G-250A ILS Test Set was designed specifically for airline use for the purpose of simulating ILS and marker transmitters to provide a rapid and comprehensive check of the over-all performance of aircraft ILS installations.

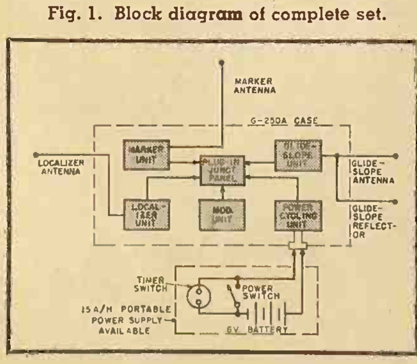
The test set is a portable self-contained unit housed in an aluminum alloy case 18 inches wide, 12¼ inches high and 9¾ inches deep. The case is equipped with shockmounts to minimize shock to the test set encountered in handling. The weight of the complete test set was held to approximately 38 pounds in realization that weight is an important factor in portable test equipment. To further facilitate handling and to reduce the probability of damage, the test set is equipped with retractable antennas. A waterproof hinged cover is provided on the front of the case to permit "all weather" use of the test set.

The test set consists of three independent crystal-controlled r.f. generators operating on the marker frequency and within the localizer and glide slope frequency bands, a power/cycling unit which automatically or manually controls the ILS test signals and a modulator unit which utilizes a 30 cycle magnetic reed-controlled oscillator to derive the 90 cycle and 150 cycle ILS modulation frequencies. Provisions are incorporated in the localizer and glide slope generators for twenty test frequencies in their respective operating bands. Desired test frequencies are selected by means of individual rotary switches on the front panels of the generators.

The design of the test set provided for unit construction to facilitate servicing and maintenance of the unit. All of the individual units are equipped with cables which plug into a junction panel assembly mounted inside the cabinet behind the glide slope generator. The modulator unit is located behind the localizer generator. Opening the hinged cover gives access to the operating controls mounted on the front panels of the marker, localizer, glide slope and power/cycling units. An external 6 volt d.c. primary power source is required to operate the test set.

The G-250A unit was designed as a ramp test set which would provide reliable indications as to the degree of satisfactory operation of the ILS installations and yet its operation be sufficiently simple and straightforward to permit operation by non-technical personnel. During regular checking operations no critical adjustments are required to be made by the operator.

Fig. 1. Block diagram of complete set.



It might be emphasized that the test set will provide an over-all system check of the entire aircraft ILS installation. This includes antennas, transmission lines, connectors, recivers, aircraft wiring and indicators. In actual use, the test set has revealed faulty transmission plugs, shorted, open and intermittent lines, loose connections, interchanged localizer and glide slope antenna transmission lines and faulty cross-pointer indicators as well as defective receivers.

Operation

The design of the G-250A permits a complete check of the localizer, glide slope and marker installations to be made by one radio mechanic in less than three minutes. This is made possible by the automatic cycling feature incorporated in the unit. The only action required of the radio mechanic is to extend the test set antennas to operating position, select the proper ILS frequencies, select automatic cycling and then observe the ILS cross-pointer indica-

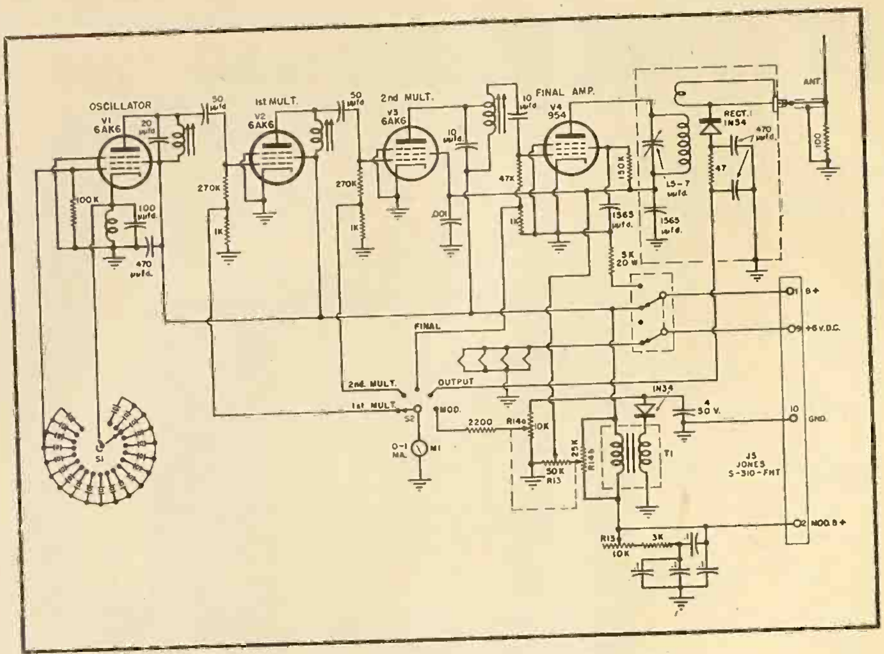


Fig. 2. Schematic diagram of the localizer unit.

tions and marker lights in the aircraft cockpit.

The exact location of the test set relative to the aircraft is not critical, approximately 20 to 40 feet forward of the aircraft. Satisfactory operation may be obtained from test positions up to 75 feet from the aircraft. The presence of various types of metal work stands has no appreciable effect on the testing procedure. In the case of large metallic objects, such as hangar walls, located within 25 feet of the aircraft, it has been found that in some cases a reflected signal will affect the normal field pattern of the test set. If this condition is encountered the test set may be moved slightly and normal operation will be obtained.

During automatic operation the automatic cycling unit keys the r.f. output of the preselected localizer and glide slope channels with the 90, 150 and 90/150 cycle modulation tones. The r.f. output from the marker generator is continuous with automatic keying of the 400, 1300 and 3000 cycle modulation tones. The speed of the cycling is adjustable by means of the PERIOD control provided on the front panel of the power/cycling unit.

Manual operation is of particular value in trouble-shooting an individual system.

Modulator Unit

The modulator unit is a four stage oscillator/amplifier-mixer/limiter/wave shape amplifier combination whose function is to supply appropriate 90 cycle and 150 cycle voltages to modulate the localizer and glide slope units (Fig. 3).

The first stage V_1, utilizes one section of a 6J6 tube as a magnetic reed-controlled 30 cycle oscillator. The other triode section of the 6J6 functions as a wave shape amplifier. The output from this triode is approximately a sawtooth voltage and is fed to the parallel connected 90 and 150 cycle band-pass filters FIL_1 and FIL_2.

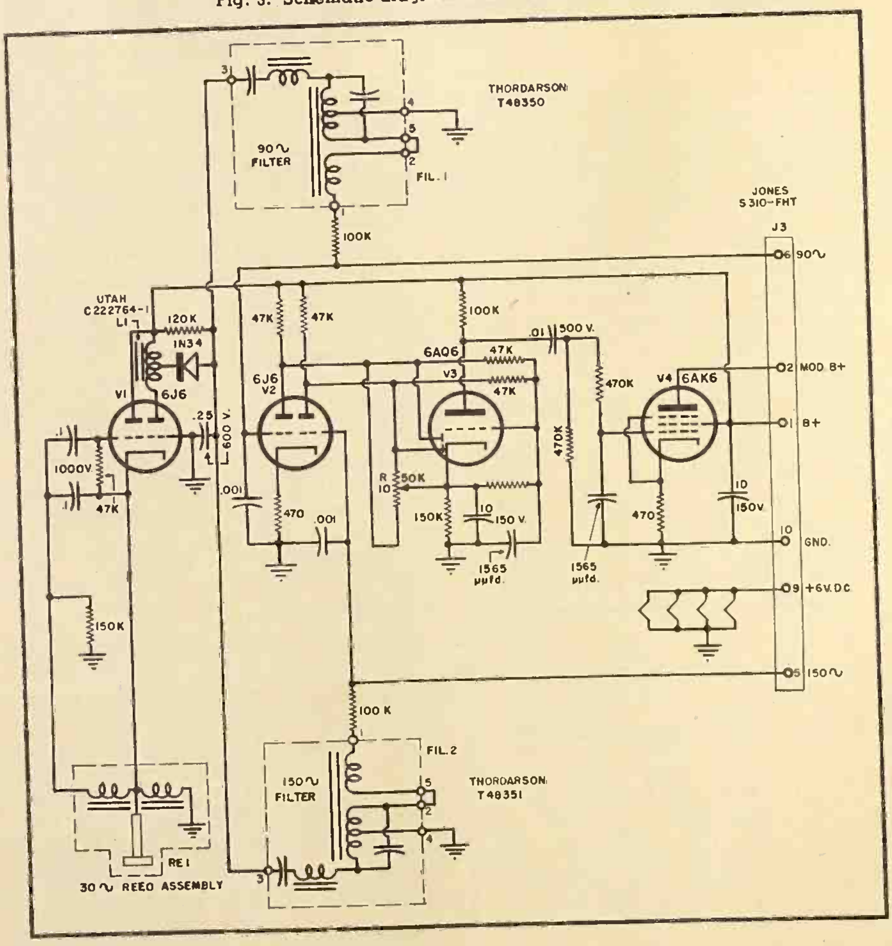
The second stage V_2, utilizes both sections of a 6J6 tube as 90 cycle and 150 cycle amplifiers. The outputs of the band-pass filters are applied to the grid circuits of V_2 through 100,000 ohm resistors. Selection of 90, 150 or 90/150 cycle voltages is accomplished by alternate grounding or removal of ground from the grids of V_2 by the remote function switch S_1, in the power/cycling unit.

The third stage V_3, functions as a limiter. The individual or mixed 90 and 150 cycle voltages from V_2 are applied to the diode plates of V_3. The diode-cathode circuit is designed to effect limiting of positive voltage peaks. The triode section of V_3 limits the negative voltage peaks as a result of the relatively high grid voltage driving the tube beyond cut-off. The resultant output of V_3 is a square wave voltage.

The fourth stage V_4, functions as a wave shape amplifier. The square wave voltage obtained from V_3 is fed through an integrating circuit to the grid of V_4. The voltage developed in the plate circuit of V_4 is essentially a sine wave. This voltage is fed to the localizer and glide slope final amplifier through their respective modulation transformers.

Two variable adjustments are pro-

Fig. 3. Schematic diagram of the modulator unit.



vided within the modulator unit. The frequency of the 30 cycle reed may be adjusted by the small vernier screw attached to the end of the 30 cycle reed RE_1. The main centering control R_{10} is connected between the diode plates and cathode of V_3. Adjustment of this control equalizes the 90 and 150 cycle voltages applied to the diode-cathode circuit of V_3. This balanced 90/150 cycle voltage comprises the centering modulation voltage.

The 90 and 150 cycle modulation voltages are selected separately and are adjusted in magnitude to equal the reference 4 db modulation ratio of course sensitivity. This adjustment is made by the respective modulation controls in the localizer and glide slope units.

Power/Cycling Unit

The basic power supply is a *Mallory* type VP554 six volt Vibrapack which is mounted as a sub-assembly on the power/cycling chassis (Fig. 4). Primary voltage is fed through a panel mounted fuse F_1, and ON-OFF switch S_3, to the Vibrapack unit. The positive high voltage output is connected through a current regulating variable resistor R_1, and a pi filter L_1 and C_3, to the load circuits. An OA2 voltage regulator tube V_1, is connected from the load side of the pi filter to ground to provide regulated 150 volts to operate all units in the test set.

A *Ledex* type rotary switch S_1 is used to control the application of audio modulation voltage and B+ voltage to the ILS signal generators. The stepping mechanism, when energized, rotates the switch through the function sequence indicated on the front panel. A 3PST relay REL_1, and a sensitive relay REL_2, control the automatic and manual operation of the *Ledex* switch. A 1000 μfd. condenser C_2, and a potentiometer R_2, connected in parallel across the 8700 ohm winding of relay REL_2, comprise the time period control of automatic switching.

When the function switch S_4 is placed in AUTO position, six volts is connected through the normally-closed contacts of REL_2 to the coil of REL_1. The closure of the contacts of REL_1 connects the coil of REL_2 to ground. This energizes REL_2 and removes the voltage from the coil of REL_1 which permits its contacts to resume their normally-open position. This in turn removes the ground connection from the coil of REL_2. REL_2 remains energized until the delay condenser C_2 discharges, at which time the contacts of REL_2 again resume their normally-closed position. The foregoing cycle is repeated at a rate determined by the setting of the potentiometer, R_2. Each time REL_1 is energized, six volts is applied to the coil of the *Ledex* switch which steps to its next position.

When the function switch S_4 is placed in MAN position, the *Ledex* switch will step until its position corresponds to the function manually selected on switch S_2. At each step the *Ledex* "throw" contacts open and interrupt the six volts supplied to REL_1. This de-energizes REL_1, which in turn breaks the six volts supplied to the *Ledex* switch. This occurs at the end of each 30 degree step of the *Ledex* function relay until the position of S_1 corresponds to the function selected on S_2.

Marker Unit

The marker r.f. generator is a three stage crystal-controlled oscillator/frequency multiplier/amplifier operating at a single frequency of 75 mc. (Fig. 5). V_1 functions as a crystal-controlled oscillator, being controlled by a 12,500 kc. crystal. This 12,500 kc. signal is applied to the grid of V_2 which operates as a tripler stage supplying a 37.5 megacycle signal to the grid of the final amplifier V_3. The final amplifier functions as a doubler stage and feeds a vertical quarter-wave antenna. A portion of the output voltage is rectified by $RECT_1$ and fed into the metering circuit as a power output reference. The metering circuit utilizes a 0-1 ma. meter that may be switched to indicate A and B+ voltages, oscillator, tripler and final amplifier plate currents in addition to the rectified output.

Modulator stage V_4 functions as an audio oscillator. The audio voltage generated is applied to the modulation transformer T_1, which modulates the B+ voltage to the final amplifier. The audio frequency is determined by the position of the function switch S_1 in

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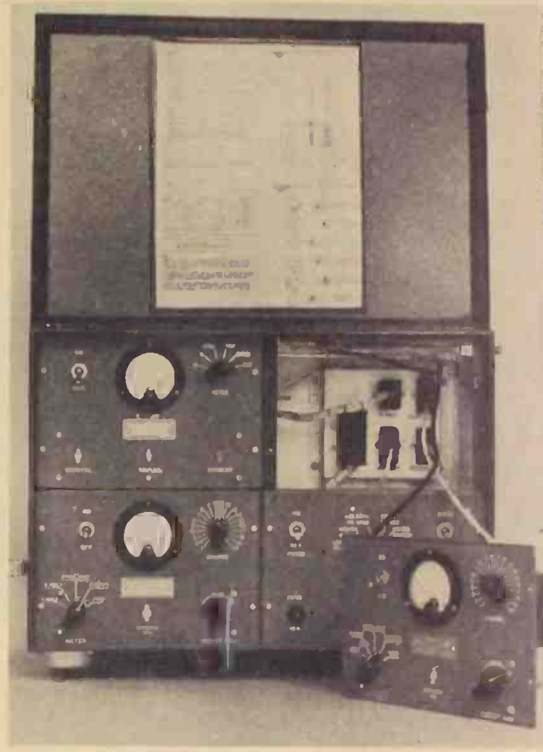
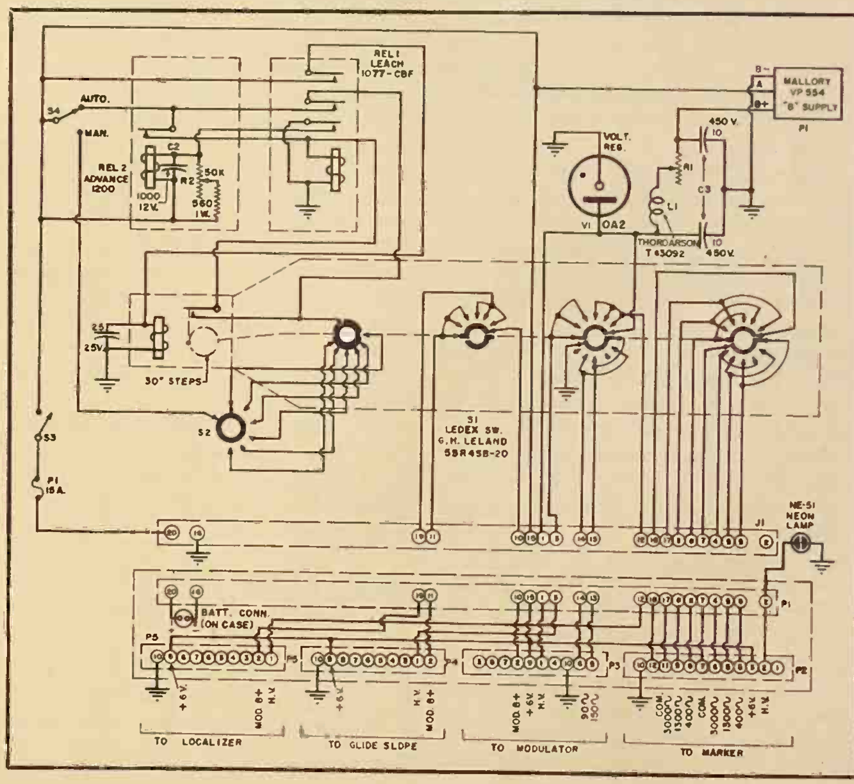


Front view of the instrument with the glide slope panel removed.

Fig. 4. Schematic diagram of the power/cycling unit.



The PULSE STANDARDIZER

Fig. 1. Front view of the pulse standardizer. Two complete, isolated units are included on a single front panel.

By
ROBERT R. RATHBONE
Servomechanisms Laboratory
Massachusetts Institute of Technology

A device for converting random non-uniform pulses into pulses conforming to an arbitrary standard.

ONE OF the most useful features of the pulsed-circuit test equipment built at the M.I.T. Servomechanisms Laboratory is the inclusion of some type of pulse-standardizing circuit in many of the units; *i.e.*, a circuit which converts non-uniform pulses into ones which conform to an arbitrary standard. Ideally, every piece of test equipment used in pulse work should have its own internal standardizing circuit; but since most laboratories have to utilize all available units, a practical solution is to build a packaged standardizer which can be inserted easily into a test setup.

Although a separate standardizer is not as convenient as a built-in type, its standardizing circuit is not limited by the requirements of companion circuits or in the type, size, and number of components which can be used. This advantage gives the designer a free hand in selecting the standardizing method which will best suit his needs.

No single technique of standardizing pulses is ideal for all applications. For standardization at pulse-repetition frequencies up to 20 kc., the plate-current pulse of a blocking oscillator can be used; and for application at 2 mc., the combination of an inverter and *R-L-C* peaker is a good all-around method.

The pulse standardizer described below uses this last technique. The unit is similar in principle to the standardizing section of the Pulse Mixer, described in the September issue of RADIO-ELECTRONIC ENGINEERING, but has several refinements of design that permit it to standardize at 3 mc. with no loss in maximum output and up to 5 mc. with only a 10% decrease from the standard. Credit for the original design should go to Harry Kenosian, now with the *Burroughs Adding Machine Company*.

The pulse standardizer shown in Fig. 1 is a duplex unit containing two identical, independent standardizers, one above the other, on a single panel and chassis. Over-all measurements of the assembly with tubes mounted on the rear are 5½ x 7 x 19 inches.

Each section is designed specifically to take pulses of different amplitudes and shapes and reform them into 0.1 μsec, half-sine-wave pulses (the standard used with all the special test equipment described in this series of articles). Except for the fact that pulses must be at least 6 volts positive and at least 0.2 μsec apart, the circuits are insensitive to variations at the input. Power is supplied from a central laboratory supply.

The first stage of the pulse standardizer (Fig. 3) acts as an input amplifier. Positive input pulses are applied to the grid of one half of a 5687 (V_{1A}) through either of the parallel jacks, J_1 or J_2. The cut-off bias (-11.5 volts) causes only the tops of the pulses to be amplified. The input amplitude above 6 volts is not critical, but should not exceed the rated back voltage (50 volts) of the crystal diode CR_1. The length of the input pulses is also not critical, since the 1:1 pulse transformer (T_1) and the 25 microhenry inductance (L_1) in the plate circuit shorten each pulse to approximately 0.1 μsec. This shortening improves the resolution time for long input pulses, and insures that the following stages will not be sensitive to changes in pulse length at the input. The first and second photographs in Fig. 2 show input and output pulses at this stage.

The second half of the 5687 (V_{1B}) is an inverter, changing the positive pulses from the first stage to negative pulses. Each negative pulse has a steep negative-going edge which is used to cut off the *R-L-C* peaker in the third stage (Second Stage, Fig. 2). The only part of the negative-going edge that is useful in this respect is from the flat-top portion of the pulse down to the cut-off bias of the peaker tube (−8 volts).

The crystal diode CR_3 permits the steep negative-going edge of the inverter output to be coupled directly to the grid of the *R-L-C* peaker and cut it off sharply. When the signal voltage goes positive, the stray capacitance at the input of the peaker tube prevents the voltage at the grid from following the inverter voltage. This action effectively puts the back resistance of

Table 1. Current requirements, 2 sections.

Voltage	Current	
	1 mc. pulses	*No signal*
+250 d.c.	25 ma.	1.75 ma.
+150 d.c.	175 ma.	105.0 ma.
− 15 d.c.	30 ma.	30 ma.
6.3 a.c.	4.4 amp.	

the crystal between the inverter and the peaker. The stray capacitance then discharges to ground potential through R_9, so that the peaker grid is always at ground potential when a negative pulse is transmitted to it from the inverter (see Third Stage, Fig. 2). As a result, the output amplitude of the peaker is constant regardless of how large a negative pulse is produced by the the inverter, and thus is independent of the input-pulse amplitude at the first stage.

The *R-L-C* peaker controls the amplitude and shape of the pulses which are fed into the output circuit of the equipment. It consists of a normally-on 6AG7 (V_2) with a tuned *L-C* plate circuit (the *C* is the stray capacitance in the circuit). When the peaker tube is on, current flows steadily through L_2 and no signal voltage is produced. When the peaker tube is cut off by a negative pulse from the inverter, the voltage across L_2 rises and the current flows into the stray capacitance of the circuit, forming a positive half-sine wave. As the voltage across L_2 goes negative, the crystal diode CR_4 conducts, and with R_{10} permits critical damping so that a positive pulse with only a single negative overshoot is formed (Third Stage, Fig. 2). The length of the positive pulse, in this case approximately 0.12 microsecond, is determined by the *L-C* constants, and the length of the negative overshoot depends on the particular setting of R_{10}.

Since pulse amplitude at the peaker output is determined by the amount of current through the tube, and since pulse length is determined by the *L-C* constants, the size and shape of pulses at the output of the peaker are independent of the input to the first stage of the standardizer.

The output of the peaker is *R-C* coupled to a 6AG7 buffer amplifier V_3. *R-C* coupling without d.c. restoration is used because the inductor L_2 cannot have a d.c. voltage component across it. This is true whether steady-state or intermittent pulses are used. A 500 ohm potentiometer R_{15} is inserted in series with the cathode of the buffer to control the output amplitude. The pulse transformer T_2 is connected to the output J_3 through a bus-driver crystal CR_5, and a polarity-reversal switch S_1, and must see a 93 ohm terminated line. The output pulses are standard in shape, with common amplitudes (bottom picture in Fig. 2).

Power to operate the equipment is obtained from a central laboratory power source. If the unit is used on a bench, a power cable is connected between the Jones plug on the rear of the chassis and the bench power box; if it is used in a rack, the power is controlled by a rack power control unit. Power requirements for operating both sections simultaneously are given in Table 1.

Each section of the pulse standardizer operates independently, and both may be used simultaneously. The circuits were designed to standardize reliably at a pulse-repetition frequency of 2 mc., with a maximum output of 37 volts. The amplitude control is not calibrated, but output is linear.

Tests show that driving the last stage with the amplitude control fully on will improve resolution time. This technique in effect uses the grid circuit as a

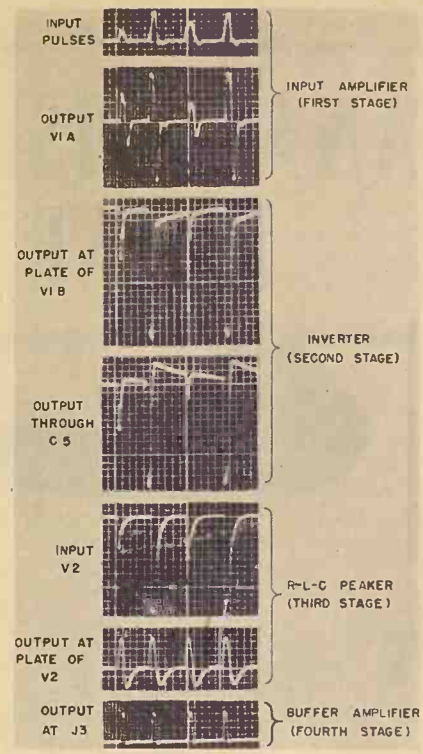


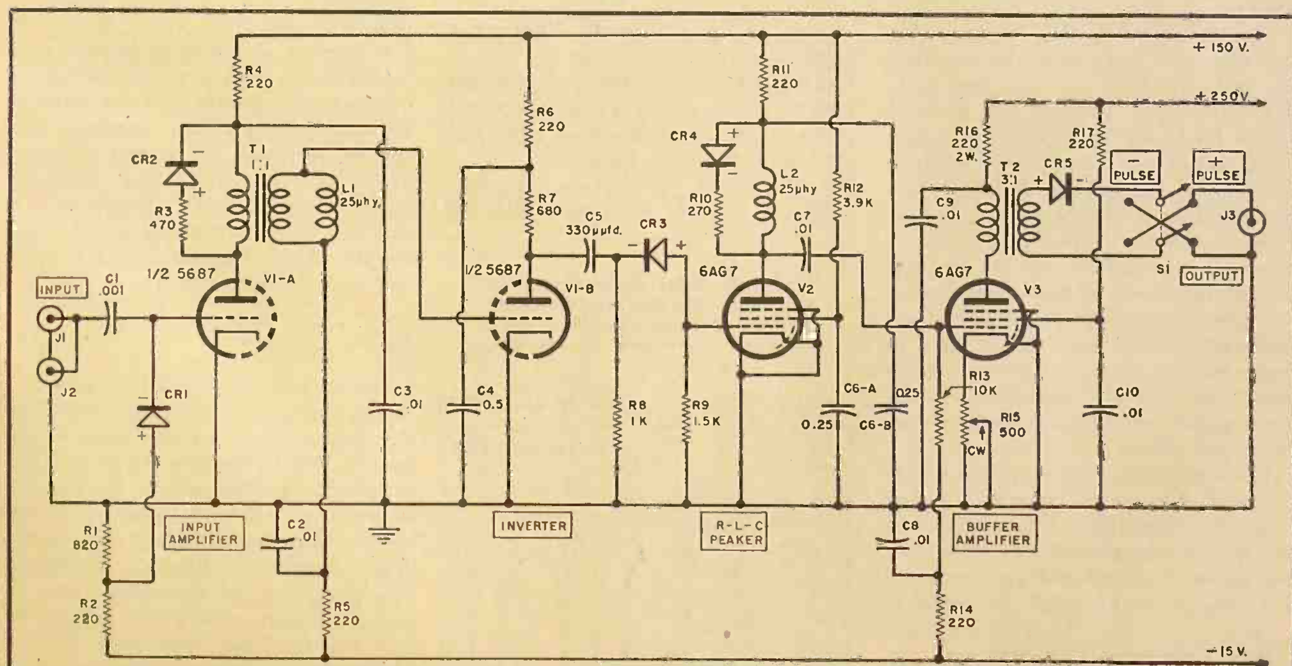
Fig. 2. Waveforms at various locations in the pulse standardizer.

limiter, and pulses occurring at a 3 mc. rate will reach the standard maximum output. Above that, if a sacrifice of 10 per-cent of the output can be tolerated, pulse repetition frequencies up to 5 mc. may be used.

Caution should be taken with the amount of positive noise fed to the

(*Continued on page* 31)

Fig. 3. Complete circuit diagram and parts values for the pulse standardizer.



ANALYSIS OF NON-RECURRENT PULSE GROUPS

By
LEONARD S. SCHWARTZ*
and **NORMAN P. SALZ****

A simplified graphical method for determining the frequency spectrum of non-recurrent pulse groups.

THE ANALYSIS of the frequency spectra associated with pulses of given shape is of importance in the spacing of frequency channels because a knowledge of the frequency components will determine the separation between channels necessary to minimize adjacent-channel interference. Frequency spectra of recurrent pulses or single isolated pulses have been widely described in the literature, but spectra of non-recurrent groups of pulses such as occur in teletype forms of transmission or in pulse code modulation have not received comparable attention. It is the purpose of this article to discuss the frequency spectra of non-recurrent groups of pulses and to explain a simple graphical method for determining the characteristics of these spectra.

The graphical method described in this article is based upon the fact that the presence of more than one pulse has the effect of "gouging out" portions of the frequency spectrum of a single pulse. Intuitively, this is not surprising because for a single isolated pulse the spectrum is continuous and for recurrent pulses it is discrete. The occurrence of more than one pulse to form an isolated group of pulses represents an approximation to the condition of recurrent pulses, and one expects to find a buildup of energy in the regions about the discrete frequency components which constitute a repetitive succession of pulses.

The application treated in this article is based upon the envelope of a factor called the "Repetition Function" which results from the grouping of more than one pulse in a non-recurrent manner. The "Repetition Function" is the agent for "gouging" out the frequency spectrum of a single isolated pulse. Mathematically, the "gouging" is done by multiplying the expression for the amplitude of frequency components by the "Repetition Function." However, the observation that the approximate envelope of the "Repetition Function" is a simple mathematical expression which can be easily plotted in the form of a universal curve justifies the adoption of a graphical method of solution like that to be described.

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Rectangular Pulse

In the well known case of the rectangular pulse of width δ and amplitude E the expression for the amplitude of frequency components is:

$$B(\omega) = \left(\frac{E\,\delta}{\pi}\right)\left(\frac{\sin \pi f \delta}{\pi f \delta}\right) \quad . \quad . \quad (1)$$

A plot of the expression $B(\omega)$ as a function of $(f\delta)$ is shown in Fig. 2. But the voltage time function of direct interest from the practical point of view is not the rectangular pulse but the one now to be discussed.

Cosine-Squared Pulse $(1\text{-cos } \omega_o t)/2$

One is actually concerned with the pulse given by the time function $E\,(1\text{-cos } \omega_o t)/2$, because this pulse more nearly approximates the shape of those actually used in practical forms of transmission. The amplitude-frequency relation for this pulse is:

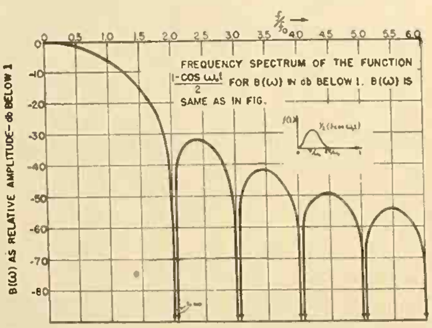
$$B(\omega) = \left[\frac{E}{(1-f^2/f_o^2)}\right]\left[\frac{1}{2\pi\ f_o}\right] \times \left[\frac{\sin \pi\ f/f_o}{\pi\ f/f_o}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

in which $1/f_o$ is the period of the pulse whose time function is given by:

$$f(t) = E\,(1\text{-cos } \omega_o t)/2$$

The plot of $B\ (\omega)$ as a function of f/f_o is given in Fig. 3. The frequency spectrum of the time function shown in Fig. 3 is replotted in Fig. 1 with the relative amplitude expressed in decibels.

Fig. 1. A replot of the frequency spectrum of the time function shown in Fig. 3 (also Eqt. 2) with relative amplitude expressed in decibels.



Repetition Function

In teletype operation or in pulse code modulation pulses are transmitted in non-recurrent groups. It is of interest, therefore, to find the resultant frequency spectrum for a non-recurrent group of pulses. It is found that the frequency spectrum of a single pulse is modified by a multiplying factor called the "Repetition Function" ($R.F.$) which has the form:

$$R.F. = \frac{\sin r\ \pi\ fT}{\sin\ \pi fT} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

in which r is the number of pulses, f is the component frequency, and T is the time between leading edges of the pulses. The "Repetition Function" can be directly applied only if the spacing between all pulses in a group is the same. As an example of how the "Repetition Function" modifies the frequency spectrum of a non-repeating group of equally spaced rectangular pulses, one has the following expression for the amplitude of frequency components:

$$B(\omega) = \frac{E\delta}{\pi}\left[\frac{\sin \pi f \delta}{\pi f \delta}\right]\left[\frac{\sin r \pi fT}{\sin \pi fT}\right] \quad \ldots \ldots \quad (4)$$

The expression for the frequency spectrum of a non-repeated group of pulses with time function $f(t) = E(1\text{-}\cos \omega_0 t)/2$ is

$$B(\omega) = \left[\frac{E}{(1 - f^2/f_0^2)}\right]\left[\frac{1}{2\pi f_0}\right] \times \left[\frac{\sin \pi f/f_0}{\pi f/f_0}\right]\left[\frac{\sin r \pi fT}{\sin \pi fT}\right] \quad \ldots \quad (5)$$

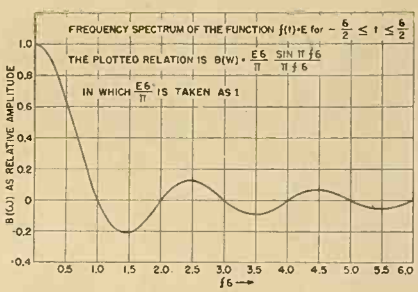


Fig. 2. A plot of the expression B (ω) of Eqt. (1) as a function of fδ.

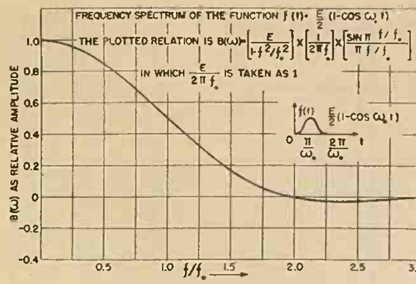


Fig. 3. A plot of the expression B (ω) of Eqt. (2) as a function of f/f_0.

It is evident that the "Repetition Function" modifies the amplitude frequency spectrum, but as yet it is not clear in what way. As a first step in the explanation of how the modification takes place, Figs. 4 and 5 are plotted (normalized to 1.0 by dividing the "Repetition Function" by the number of pulses) for "Repetition Functions" with 7 and 24 pulses respectively. Data are recorded for arbitrary values of the product (fT). An easy way of interpreting the "Repetition Function" is to focus attention on its denominator, since this does not change with the number of pulses. Study shows that the reciprocal of the denominator forms the envelope (shown by means of the dashed curve in Figs. 4 and 5) of the oscillatory curve produced by the numerator, with increasingly good approximation as the number of pulses increases. The fact that the reciprocal of the denominator of the "Repetition Function" is only an approximation to the envelope of the "Repetition Function" is seen in the fact that for values of f such that the product (fT) is integral-valued, the reciprocal of the denominator is infinite, although the true envelope does not go to infinity. In Figs. 4 and 5 the normalized "Repetition Function" never exceeds $\pm$ 1.0, attaining these values at points where the reciprocal of the denominator is infinite. That the "Repetition Function" does in fact have maximum values of $\pm$ 1.0 after normalization is shown with the aid of L'Hospital's Rule involving differentiation of the numerator and denominator. The use of this rule is justified since the function has an indeterminate form at integral values of (fT), *i.e.*, at the harmonic frequencies.

It is of interest to consider the behavior of the "Repetition Function" as the time between pulses increases. Figs. 6, 9 and 10, plotted for different times between two pulses, show that the peaks of the "Repetition Function" come together, and the width of the peaks decreases as the time between pulses increases.

From a study of Figs. 4 and 5 several inferences as to the nature of the pulse spectra may be made. The greater relative amplitude of the frequency components for integral values of (fT) compared with those of the single pulse are attributed to the larger amount of energy contained in the multiple-pulse groups, the amplitude of the pulses having been kept constant as their number increased. The increase in amplitude of components occurs essentially only in frequency bands about the harmonic frequencies, the maximum amplitudes of such bands being proportional to the number of pulses. In general the amplitudes at other frequencies relative to the amplitudes of the harmonic frequencies decreases as the number of pulses increases. Moreover, the width of each frequency band about the harmonic frequencies becomes smaller in proportion to the number of pulses. Hence, in the limit, as the number of pulses increases indefinitely, these bands will become infinitesimal in width, and the amplitudes of the harmonic frequencies will become finite instead of infinitesimal.

Fig. 8 shows a graph of the frequency spectrum of a group of 7 pulses with the time function $f(t) = E(1\text{-}\cos \omega_0 t)/2$. The action of the "Repetition Function" in "gouging out" portions of the area under the spectral curve of the time function can be seen by reference to Fig. 3.

The observation that $\frac{1}{\sin \pi f/f_0}$ is a good approximation to the envelope of the "Repetition Function" except at the harmonic frequencies and that even at these points improves as an approximation as the number of pulses increases, provides a ready means for generalizing the behavior of the "Repetition Function," making it essentially independent of the number of pulses. Although the "Repetition Function" itself is dependent upon the number of pulses and the spacing between the pulses, its envelope is not so dependent, at least over the greater part of its usable range. Hence, attention is confined to the envelope which is plotted in Fig. 7. In addition to being independent of the number of pulses (except where curves are "dashed") and of the spacing between pulses, provided this spacing is constant throughout, the envelope curve is also independent of the shape of the pulses. As can be seen,

Fig. 4. A plot of relative amplitude of the repetition function against (fT) for seven pulses.

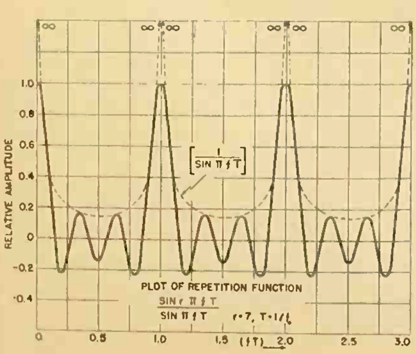


Fig. 5. A plot of relative amplitude of the repetition function against (fT) for twenty-four pulses.

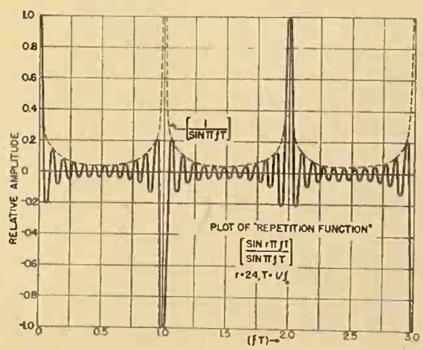
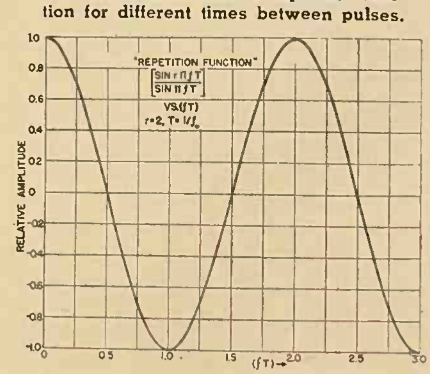


Fig. 6. This figure, together with Figs. 9 and 10, show behavior of repetition function for different times between pulses.



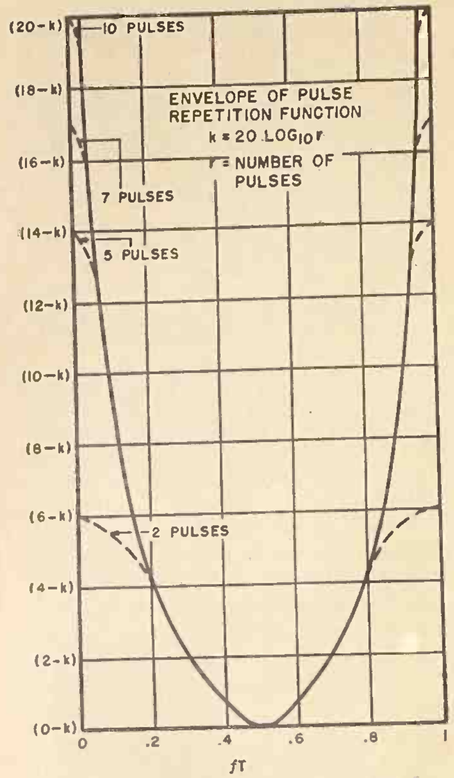


Fig. 7. Curve showing independence of the envelope of the repetition function from the number of pulses. This independence does not apply on the dashed sections of the curve. The envelope curve is also independent of the shape of the pulses.

the envelope factor of the "Repetition Function" does not correctly represent the latter in the region of $(fT) = 0$ and $(fT) = 1$. In order for the representation to be exact for a specific number of pulses near and at these points, appropriate "dashed" curves are extended from the "universal curve" to the ordinates at $fT = 0$ and $fT = 1$.

The quantity "T" in (fT), the product variable along the horizontal axis of Fig. 2, is the separation in time between the leading edges of the pulses in a group, and in the case of pulses which are adjacent, $T = 1/f_0$. If the pulses are separated by one pulse period, $T = 2/f_0$, and if by two pulse periods, $T = 3/f_0$ etc. For $T = 1/f_0$ and $(fT) = 1$, $f/f_0 = 1$; and for $T = 2/f_0$ and $(fT) = 1$, $f/f_0 = 0.5$ where in all cases f is the frequency of any harmonic component. In general:

$$\frac{f}{f_0} = \frac{1}{n+1}(fT) \quad . \; . \; . \; . \; . \; . \; . \quad (6)$$

where n is the number of integral pulse-periods between pulses. It is observed that as the time between the pulses increases the "gouging" action occurs at shorter intervals.

Now consider the meaning of the vertical axis designation. For a given number of pulses a quantity K in decibels is determined from the relation:

$$K = 20 \log_{10} r \quad . \; . \; . \; . \; . \; . \; . \quad (7)$$

r being the number of pulses. For example, assume there are five pulses. Then $K = 14$. Since for $(fT) = 0$ or 1 the envelope of the normalized "Repetition Function" must have the value 1, the curve must cross the ordinate at 0 db down, *i.e.*, at (14-K). Now further suppose that it is desired to know the resultant spectrum amplitude at a side frequency corresponding to $(fT) = 0.1$. To know this, the number of db down from 0 db the envelope curve is at $(fT) = 0.1$ must be found. In this example it is seen to be 3.5 db. If this quantity in db is subtracted at the appropriate point from the amplitude, expressed in db, of the frequency spectrum of a single pulse, the resultant amplitude of the frequency spectrum at that point of a group of five pulses is obtained.

It is noted that the maximum reduction in amplitude occurs for $(fT) = 0.5$. For $T \geqq 3/f_0$, it is probably a good approximation to plot only that amplitude for which $(fT) = 0.5$ and to sketch the remainder of the resultant amplitude curve by inspection. It is emphasized that the usefulness of Fig. 7 is not limited to values of f/f_0 ranging

Fig. 9. This figure, together with Figs. 6 and 10, shows behavior of repetition function for different times between pulses.

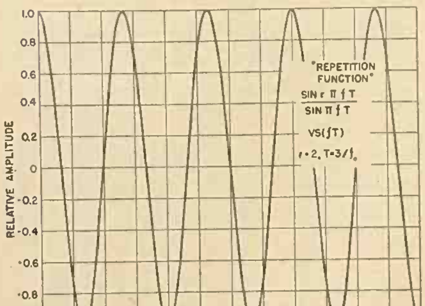
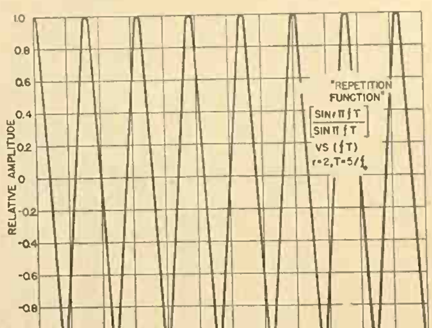


Fig. 10. Similar to Figs. 6 and 9 except for a different value of the time between the two pulses under consideration.



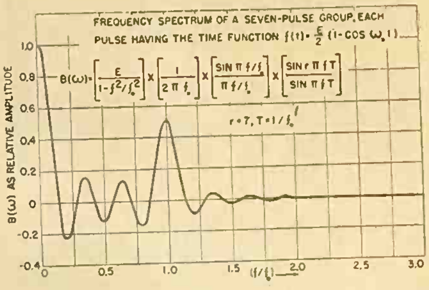


Fig. 8. Graph of the frequency spectrum of a group of seven pulses.

between 0 and 1, but can be extended to any value of f/f_0 by analyzing a curve like Fig. 1 in intervals of f/f_0 such as 0 to 1, 1 to 2, 2 to 3 etc. In each of these intervals Fig. 7 can be used to obtain the resultant spectral curve. It is also emphasized that the above discussion is directly applicable only in the case of pulses which are regularly spaced. If the pulses are not regularly spaced, a step by step analysis must be conducted for groups of pulses with regular spacing intervals and the results combined to give the resultant spectrum.

The present analysis, however, covers the case of two or more groups of regularly spaced pulses, the spectrum for which is obtained by multiplying the spectrum function of a single pulse by two or more "Repetition Functions." For example, consider a time function consisting of three groups of two pulses each with a spacing of T_1 between pulses in each group, a spacing T_2 between the leading edges of the first and second groups, and a spacing T_3 between the leading edges of the first and third groups. In this case the spectrum is given by:

$$\left(\begin{matrix}\text{Spectrum of}\\ \text{single pulse}\end{matrix}\right)\left(\frac{\sin 2\pi fT_1}{\sin \pi fT_1}\right) \times \left(\frac{\sin 2\pi fT_2}{\sin \pi fT_2}\right)\left(\frac{\sin 2\pi fT_3}{\sin \pi fT_3}\right) \quad . \quad (8)$$

Conclusion

It has been found possible to develop a simple graphical means of determining the resultant frequency spectrum of one or more pulses in a non-recurrent group. The method, though limited in being directly applicable only for regularly spaced pulses or for groups of such pulses, is, on the other hand, valid for any pulse shape whatever.

The authors gratefully acknowledge their indebtedness to Sylvan Sherman of *Hazeltine Electronics Corporation* in helping with the detailed study of pulse spectra and of the "Repetition Function."

FERROMAGNETIC LOOP ANTENNAS

By

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The use of ferromagnetic cores increases the Q and the effective height of loop antennas.

MUCH INTEREST has been recently shown by the radio industry in the use of loop antennas equipped with ferromagnetic cores. Such antennas, because of their small dimensions, efficiency, and relative immunity to surrounding metal, became very popular in portable receivers, and there are reasons to believe that larger installations and mobile receivers may also be equipped with this new tool. Until now the designers were guided mostly by the cut-and-try method and the results thus obtained were very encouraging. On the other hand, some ideas have been advanced which may lead to confusion and extravagant claims. It is the purpose of this article to clarify the function of a loop antenna with ferromagnetic core and to substantiate the existing theory by actual findings.

The first practical ferromagnetic antenna appeared on German planes during World War II, and the description of captured equipment was fully presented in English papers.[1] This rotatable type antenna, used for an aircraft radio compass, was of the low impedance type and was wound on a core of oval cross-section (3.5″ x 2.5″) extending 12″ in length. The magnetic material of high density and permeability ($\mu = 60$) produced an effective permeability of about 10 in the coil windings spread over the entire core. By actual comparison it was found to be equal in efficiency to a 12″ round loop previously employed by the aircraft in the open. With the increase of speed the 12″ loop could not be tolerated on account of drag and inability to rotate and the German solution of the problem fitted very nicely into a small depth blister, forming a part of the fuselage.

At that time our prevailing radio compass equipment consisted of a rotatable 8″ diameter loop located in a tear-drop plastic housing some 10″ maximum diameter and 40″ long. It operated satisfactorily up to speeds of 250 mph with a drag of 12 pounds. As early as 1938 the author was experimenting with h.f. iron core materials in loop antennas and it took several years to convince the authorities that the fear of added weight of iron on the plane was not justified, since the eventual adaptation of these loops would reduce the dimensions of the housing, which is now in the shape of a dome of small dimensions, and the drag at the same speed was reduced 10 times. Unfortunately, instead of radical changes in design, as manifested by the Germans, we were still guided by the policy of "replacements and substitutions," by building the equipment separately rather than to adapt the body of a plane to a new type of an elongated loop antenna. The result was that we were able to duplicate the results in a smaller space and at a smaller drag, without notable improvement in performance because the loops had their L/D (length to diameter ratio) not greater than 2.

During the early stages of work it was discovered that the first essential of the loop antenna, its effective height, was increased by an amount numerically equal to the effective permeability of the core in the coil.[2] This statement was later modified somewhat by a theoretical investigation of Burgess,[3] who states that the theoretical increase in effective height is somewhat less than the effective permeability for short loops, and approaches that quantity as the loop becomes longer. A glance at the curves of "Effective Permeability of Cylindrical Cores"[4] shows how far in a given magnetic material its μ_{eff} increases with elongation of the cylinder or solenoid. These curves were published when the best h.f. magnetic materials had a "material permeability" of 40. It was then evident that at a given L/D maximum μ_{eff} is soon reached, and in order to get a higher degree of permeability, a longer core is the answer. Today, with the advance in new magnetic materials known as ferrites, this permeability reaches the values of hundreds, depending on frequency and permissible losses.

The elongation and new ferrites made present day use of magnetic loops in receivers possible, where they are of direct tuning type known as "high impedance loops."

In this type of circuit the total gain of the loop antenna may be expressed as $Q \cdot h_{eff}$, where Q is the loop and associated components, and h_{eff} is the effective height of an equivalent vertical antenna and denotes the most prominent characteristic of a loop.

To investigate the pick-up properties of a loop antenna, a standard Hazeltine method may be employed, which consists of a 3-turn shielded loop in the output of a signal generator. The receiving loop, under test, is spaced coaxially from the first loop at a distance of several feet and connected to the separate tuning condenser, thus forming an input circuit which, in turn, feeds into the first grid of a sensitive receiver. If the receiver's avc is disconnected and no overload present, its output voltage is substantially proportional to the sensitivity. Either this voltage is kept constant, in which case the signal generator's output is varied, or the latter is kept constant and different output voltages are noted. It is always advisable to be able to come back to the original settings and conditions, for which purpose a small standard air

Early type of elongated iron core loop.

loop wound on a 3" coil form is measured first to insure the comparisons of various loops. To illustrate efficiency of ferrite loops: the standard loop was first wound with solid wire to the standard inductance (150 μhy.) to which all other loops are matched, with a Q of 125-150; later it had to be rewound with 100/44 Litz to meet competitors having a winding diameter 10 times smaller!

With the aid of this air core standard loop, several ferrite loops could be compared in sensitivity, bearing in mind that we always measured the product of h_{eff} and Q. One long ferrite loop .330" in diameter and 7" long had a Q of about 200 and compared equally to a 3" air core loop of Q in excess of 200. This extraordinary gain may be attributed to the relative immunity of the ferrite loop to the proximity of metal, the air loop being much more sensitive. Judging by the areas, which are proportional to the square of the diameter, we have a gain of 80 times, thanks to the core. Another loop with a .460" diameter core, 8" long, did not show such a spectacular increase; on account of magnetic losses, its Q could not be brought up above 150, although its effective permeability was much better. In this case we were faced with comparing the combined action of two quantities, h_{eff} and Q, but there was no direct way of evaluating h_{eff}, unless actual Q in the circuit was known.

During the days of low impedance design loops for aircraft, special equipment was developed for measuring efficiencv of those loops. In that application, the Q of the loop, with associated cable, was quite low and relatively unimportant. A glance at the low impedance loop circuit (Fig. 1) shows that when a low impedance loop is fed into a matched primary of a transformer, whose high-Q secondary is tuned, the variations in Q of the loop are reflected into the secondary to a much reduced degree. Thus a 50% variation in the Q of a loop will be reflected into the secondary tuned circuit and will result in a small percentage change in the secondary Q. Therefore, by placing this low impedance setup into the previously described measuring system, one will be able to measure or compare the effective height of a loop antenna, providing precautions are taken to shield the step-up transformer, tuning condenser, and all the leads to prevent direct pick-up.

The effective height is given by:

$$h_{eff} = 2\pi\ N\ A\ \mu'/\lambda$$

where N is the number of turns; A, the area of the coil; μ', a magnetic coefficient closely approaching the effective permeability of the core in the given coil; and λ is the wavelength, the latter increasing toward lower frequencies.

Thus, the efficiencv is alwavs lower toward lower frequencies. One can also see that unlike the inductances in which, for the best results, we try to use a minimum number of turns so as to reduce copper losses, in designing the loop, the greatest number of turns permissible for a given inductance should be sought; hence spreading the turns along the axis will, a priori, produce the best loop. At the same time, elongation of the coil and core will produce higher effective permeability, which, according to the formula, is again beneficial. The larger diameter (area A) will also improve the loop, providing that L/D is maintained large enough for μ_{eff}. To verify these conclusions, several loops with ferrite cores were built and measured:

2" long .460" dia. with 21 turns to $L = 25$ μhy., $\mu_{eff} = 9.6$
4" long .460" dia. with 22 turns to $L = 25$ μhy., $\mu_{eff} = 20$
8" long .460" dia. with 22 turns to $L = 25$ μhy., $\mu_{eff} = 38$

Here we can see that in spite of permeability increase, (by increasing the length) the number of turns remains the same as the turns become more and more spaced. Effective permeability of each loop was computed by either measuring the inductance of an identical solenoid wound on wooden sticks of the same diameter and length, or by computations by the known formula for solenoidal inductance (Nagaoka), both methods being in substantial agreement. As an example of an extremely short loop, one was wound on a ferrite cylinder of 1" diameter by 2" in length, which required 15 turns to make the same inductance. An air core loop of the same inductance of 2" diameter and 1" in length with 22 turns was used as the standard of comparison. Low impedance loop circuits usually are less sensitive than high impedance circuits so that the signal generator output was stepped up to get the same order of voltage output.

Table 1 gives all five loops with their dimensions and effective permeability; h_{eff} is computed at $\lambda = 300$ m. (1 mc.) together with figures of sensitivity obtained by measurement.

Comparison of h_{eff} and sensitivity show direct proportionality in the first three cases with respect to permeability. The 2" loop has somewhat lower sensitivity, indicating that in shorter loops the magnetic effect is less than μ_{eff}, as predicted by Burgess. Change of area in loops 4 and 5 produces an expected increase in sensitivity. The air core loop does not behave as an iron cored loop with permeability 1, lagging behind in sensitivity, but h_{eff} is valid in all three variables N, A and μ' for iron cored loops.

Comparison of the first three ferrite loops distinctly shows the advantage of elongation, first, because of increased permeability, and second because of spreading out the turns, thus allowing higher N. It is true that a 4" long loop requiring half of the material, produces half the sensitivity. But the same weight of magnetic material, axially distributed, will produce higher μ and h_{eff} in spite of decreased cross-section. Comparing an 8" long loop with one 2" long and 1" diameter, we find that more material is required in the latter, but sensitivity is less than half.

The same reasoning is applicable to the higher inductance loops (150-200 μhy.), which will be used in the high impedance loops. In fact, these higher inductance loops can be tested in the same manner at a lower frequency, such as 200 kc., which can be used as low impedance loops with a proper transformer. On the other hand, knowing N, A, and measuring μ_{eff}, one knows by calculations that h_{eff} is the figure of merit of any loop. The curves of "effective permeability" mentioned above can be extrapolated by a well-known formula for demagnetization effect, $\mu_{eff} = \mu/(1 + D\mu)$, where D is the demagnetization coefficient which has been computed by Thompson for uniform cross-section magnetic bars. Thus, knowing the toroidal permeability of a certain ferrite, one can compute its ef-

Table 1. Characteristics of the various loop antennas which were tested.

Loop (length)	N	μ	μN	Sensitivity Volts	Area A		h_{eff} (cm)
8" ferrite	22	38	840	9	.165" sq.		.185
4" "	22	20	440	4.5	"		.098
2" "	21	9.6	200	1.8	"		.047
2" "	15	5.0	75	3.5	.79" sq.	(1" dia.)	.08
1" air core	22	1.0	22	2.0	3.14	(2" dia.)	.095

fective height before going into actual design. Commercial ferrites have "material permeability" from 100 to 200 for the broadcast frequency, and 500 to 1000 for lower frequencies. It is well to remember that higher permeability will invariably produce higher losses and that for the same material the product of $Q \cdot \mu_{eff}$ is substantially constant; in other words, one cannot have both at the same time.

It follows that in the actual design of the ferrite loop antenna there will always be a balance between an acceptable Q and maximum utilization of magnetic material. Since both μ and Q contribute to the pick-up factor of a high impedance loop, we should try to meet optimum conditions. Winding directly on the core may produce detrimental results for Q and for magnetic pick-up, as the coil becomes a partially "closed" magnetic circuit, which should be an open type to pick up lines of force from space. Usually a wire with vinylite covering or d.c.c. of about 0.01" thick, is sufficiently spaced from the core to avoid those results.

It takes from 60 to 80 turns to build up a loop of $L = 150\text{-}200$ μhy. for the broadcast range; for maximum μ an even distribution over 80% of the length of the core is required. For better Q several solenoidal sections closely wound with widely separated turns is the best. However, the differences are insignificant.

The most important question is how high Q should be. Remember, we cannot have both μ and Q. In my opinion, Q should be limited to the value of 125-150, which can easily be maintained with normal circuit components over the years of service. Magnetic material producing such Q will yield an effective permeability of about 40 in long loops. Another ferrite available with μ_{eff} of about 25 will yield a Q as high as 250. In both cases we have approximately the same pick-up factor, but the lower Q assures stability and economy of components, and above all, easy alignment of the first circuit with the oscillator. All ferrite cores are subject to permeability variation with temperature in spite of all compensations, so that it is safer to have less selective input for maintaining synchronization with the oscillator at all times.

Thus, for the best results in ferrite loop construction:

1. Ferrite material should be chosen for the proposed range for maximum effective permeability with permissible losses for high Q in high impedance loops.

2. Low impedance loops tolerate much lower Q so that μ may be increased.

3. Elongated cylindrical cores of $L/D = 10$ and better, will give greater effective height.

4. For a given weight of a material, it is more advantageous to increase the length of a cylinder rather than its cross-section.

5. The winding of the coil should be spread over 80% of the entire length of the core.

6. The wire may be laid directly on the core surface, providing the wire is sufficiently insulated.

7. Q of the loop is just as important as its effective height; however the general design of the receiver, the quality of the component parts and ease of tracking limits the Q to about 150.

8. Should higher Q be chosen, the core material temperature characteristics should be studied and suitable temperature compensation should be included in the circuit to prevent drift.

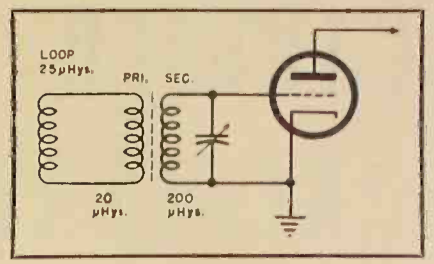


Fig. 1. Low impedance loop circuit.

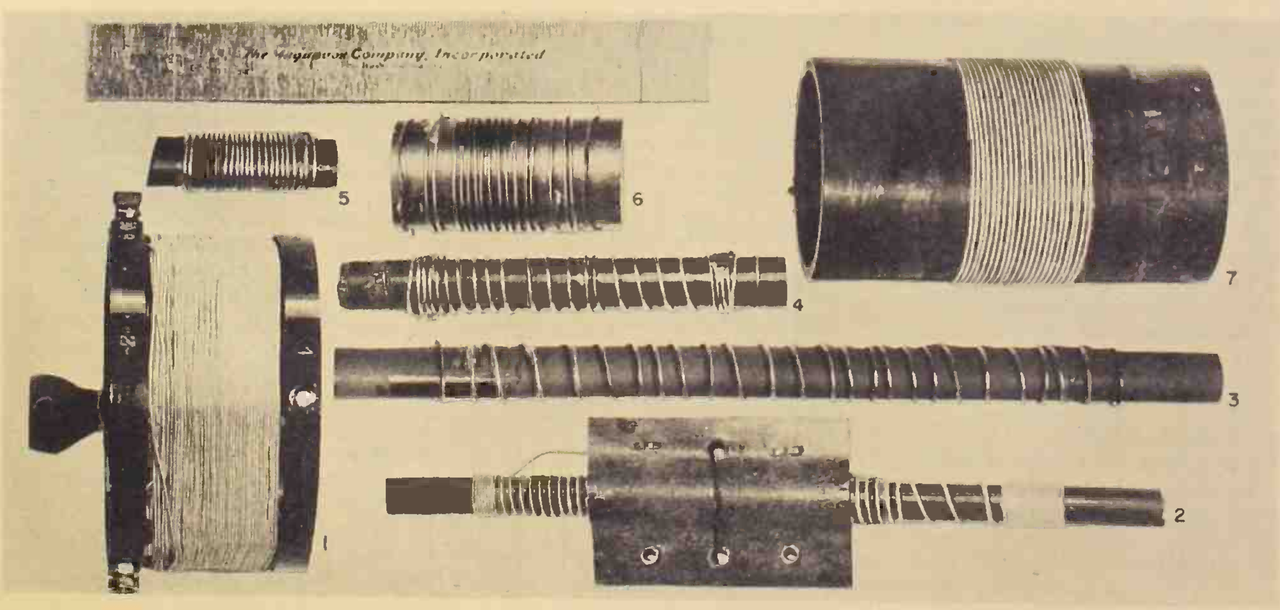
9. Theoretical considerations by Burgess and our actual experiments suggest the use of hollow ferrite tubing for cores, as the most economical utilization of magnetic material.

With this new high-permeability, low-loss material, it is interesting to review other antenna applications, where it can offer its tremendous advantages:

Aircraft. In the past, 8" air loops of low impedance were used, and although adequate for itinerary reception, there was a tendency to increase pick-up to correspond to the 12" loop. The German loop is a good example, made with a powdered iron core. It is interesting to note that with small L/D no advantage appears with increased μ. To utilize it, one has to elongate the loop much beyond the old sizes. It appears from calculations that a loop 2" in diameter and 20" long will give adequate reception as an effective μ of the order of 20 will be realized, in which case such a loop will be equivalent to a 14" diameter air loop. Obviously, rotation of such loop for direction finding will require a large blister and some mechanical force. In that case, it is more rational

(Continued on page 24)

The various ferromagnetic loop antennas which were tested by the author.



CARRIER-TYPE REGULATED POWER SUPPLY

By
JOSEPH HOULE

Wide-range voltage control with excellent regulation and low hum obtained by means of an unusual design in the d.c. amplifier.

A typical carrier-type regulated power supply incorporating the principles outlined in this article.

Regulated power supplies are being used more widely every day, in industrial instrumentation, in computers, in TV stations, and in the laboratory. Many laboratory applications require a supply capable of delivering regulated voltage over a wide range, preferably extending down to zero. Most regulator circuits cannot do this.

By way of illustrating the problems involved in attaining wide-range voltage control, consider a circuit which will supply regulated d.c. from zero to 300 volts, based on a disclosure by E. L. C. White[1], and using conventional circuit principles. A series control tube is controlled by a conventional d.c. amplifier. The grid-cathode potential of the d.c. amplifier is a comparison between a reference voltage from a VR tube and a tap on the output circuit. In order to make the d.c. amplifier tube operable at low output voltages, its cathode must be returned to an auxiliary negative supply, made up of an extra rectifier, some filtering, and gas regulator tubes.

Inadequacies in this type of circuit have led to the investigation of the carrier-voltage principle for use in the d.c. amplifier. A regulator using the straight circuit is bulky, because of power wastage in the auxiliary negative supply, and because of the large number of separate filament windings required. In addition, it is difficult to get a reasonably low hum level without excessive complication.

Carrier-Type Regulator

The heart of a series-tube regulator is the d.c. amplifier. The regulated supply shown in Figs. 1 to 4 employs a d.c. amplifier of unusual design, and attains unusually good performance. The main characteristics are:

Output: 0-300 volts d.c., continuously variable.
Regulation: 0.1 volt over load range 0-50 milliamperes (2 ohms internal impedance at d.c.).
Hum level: 3 millivolts.

Fig. 1. Transfer characteristics of the d.c. carrier amplifier in the regulator of Fig. 4.

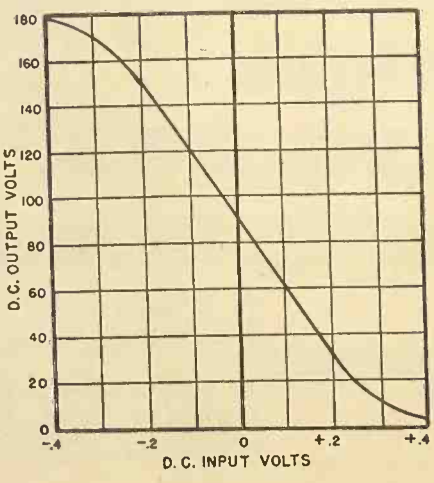


Fig. 2 indicates the principle. An oscillator feeds a small signal to the input of an a.c. amplifier. In series with the amplifier input is a varistor modulator circuit, which in practice may be simply a single germanium diode, with the d.c. control signal connected to vary the bias current in the diode. At the output of the amplifier, the d.c. is recovered by a conventional rectifier.

A disadvantage of this type of amplification is its low input impedance. In the voltage regulator application, however, this is no drawback. The advantages are that the d.c. stability is excellent, and that the d.c. output circuit is free from ground.

In particular, the "floating" output circuit frees the d.c. amplifier characteristics from any dependence upon the value of the regulator output voltage. Thus the voltage output range attainable now depends only on the series tube characteristics and on the voltage available at the high-voltage bus.

A balanced modulator would not be desirable in this application, because of its ambiguity about zero; the extra complication is not needed anyway.

Fig. 5 is a simplified schematic of a regulated supply using a carrier amplifier system. V_1 is a single stage a.c. amplifier, whose output feeds a diode V_2, which in turn supplies control bias to the series power tube V_3. An oscillator supplies a carrier at, say, one-third of a volt level to the germanium

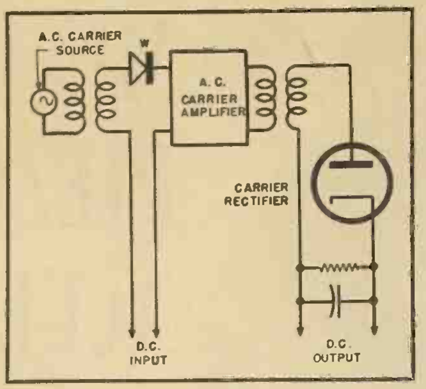


Fig. 2. Elements of the d.c. amplifier using the carrier principle.

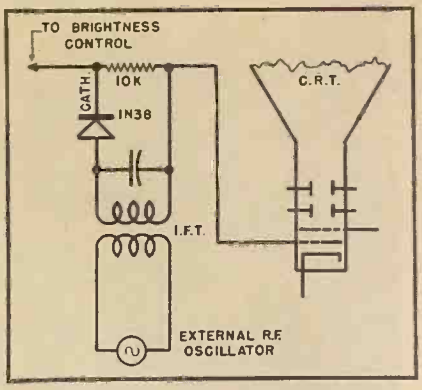


Fig. 3. Use of r.f. carrier in beam-blanking attachment for oscilloscopes.

diode modulator circuit *W*. The bias on this crystal *W* is arranged to be the difference between the d.c. output of the whole supply, e_2, and a reference voltage e_1. The reference voltage is taken from a potentiometer across a *VR* tube.

If e_2 exceeds e_1, the crystal *W* will be biased in the conducting direction, the carrier voltage fed to amplifier V_1 will increase, and the rectified negative bias on series tube V_3 will increase, controlling the d.c. output voltage e_2 downward.

Practical regulators can be built which will hold to about 0.3 volt, without much more complication than indicated in this simplified circuit.[5] Amplifier tube V_1 is normally a pentode such as the 6CB6, and rectifier V_2 a dual diode connected as a voltage doubler. The regulation of such a supply is roughly equal to the peak carrier voltage applied to the crystal modulator circuit. With the crystal diode about fully conducting, the rectified bias at the grid of V_3 must be enough to cut the tube off at no load and the minimum desired output voltage. Where V_3 is a 6Y6 and the "B" supply is 400 volts, the maximum bias to attain zero output at no load is about 120 volts.

Neither this type of regulator nor the conventional regulated supply "fails safe"; failure of the d.c. amplifier system allows the output voltage to rise to maximum. It is well to build a voltmeter into either type of supply.

Complete Circuit

The circuit of Fig. 4 was built in an effort to find the practical capabilities of the carrier system without resort to undue complexity or special components. While the circuit is more complicated than a conventional supply, the additional components are all physically small and the power dissipated in auxiliary circuits is low. Hardly any extra bulk is added. All the components are standard except the oscillator coil, which can be made by modifying a standard 7.5 or 8 millihenry r.f. choke. Coil constants are not critical but most of the capacitor values should be approximately as shown; some care in the location of components and leads is needed to avoid oscillation difficulties. A regulator being a d.c. amplifier with 100 per-cent feedback, the usual principles apply when the loop gain is high.

The power transformer, filter, and series tube or tubes may be chosen for the maximum output desired.

Half of a 12AT7, V_1, operates as the carrier oscillator at 160 kc. The coil L_1 was originally a super-regenerative detector quench oscillator unit; one may be made by pulling a tap out at about the middle of a 7.5 or 8 millihenry choke. The secondary L_1 is seven turns of wire wound alongside the main winding, developing the desired 100 millivolts of carrier with about 30 volts on the plate of the tube.

The modulator circuit follows the form in Fig. 5, being biased by the difference between the voltage at the arm of the main output control R_2, and the tap on a 3:1 divider connected across the output of the supply.

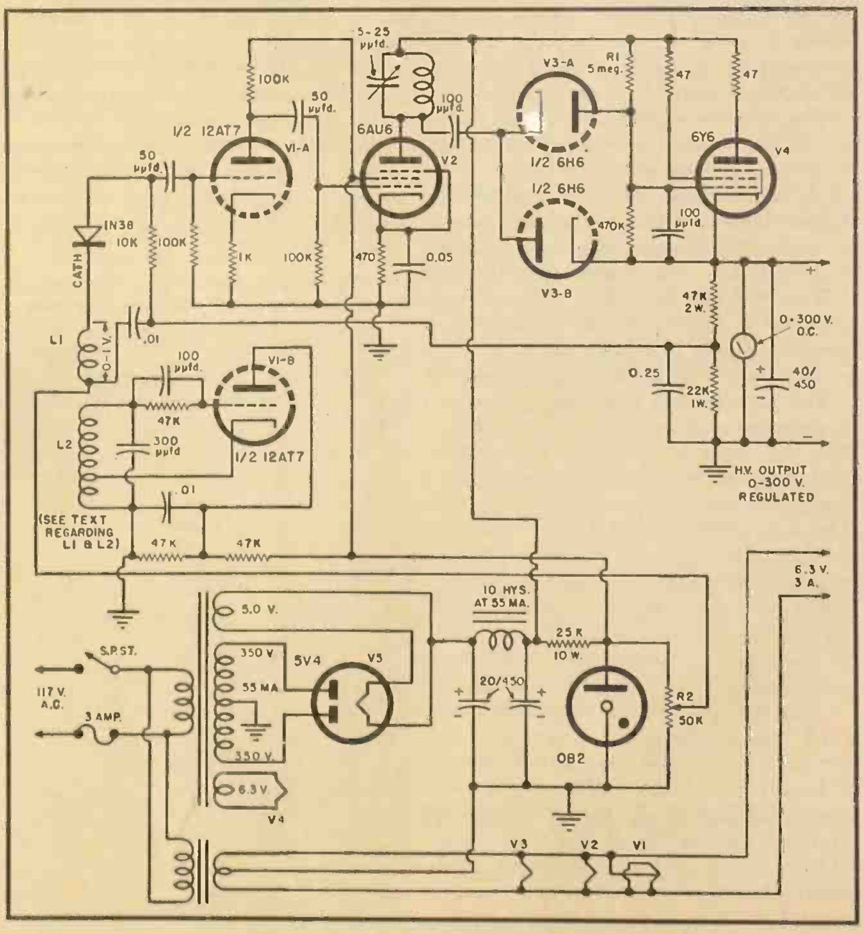
Amplifier

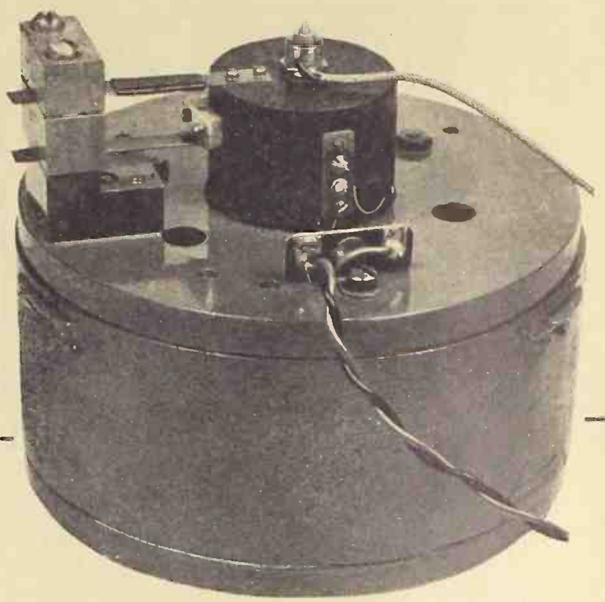
Two amplifier stages are used, the first being the other half of the 12AT7, the second a pentode. Only the plate circuit of the latter is tuned. In view of the extent of the curved portion of the characteristic of a germanium diode, there is not much use in starting out with a carrier level of much less than 0.1 volt. The gain required is about 1500, or about 3 times that attainable with a single pentode and a voltage doubler. Both stages, hence, are operated below maximum gain.

Fig. 1 shows the transfer characteristic of the whole carrier amplifier sys-

(*Continued on page* 31)

Fig. 4. Complete circuit diagram and parts values for a small carrier-type regulator delivering 0 to 300 volts d.c. at 50 milliamperes.





Miniature accelerometer mounted for test on a special wide-range magnetic vibrator.

MINIATURE PIEZOELECTRIC ACCELEROMETER

This unit, developed at NBS, is designed to detect a variety of vibratory movements and to calibrate other vibration pickups.

THE NATIONAL BUREAU OF STANDARDS has recently developed a miniature piezoelectric accelerometer which measures high-frequency vibrations directly and also checks the frequency response of vibration generators. Although the device is extremely small, it is in many ways superior to instruments now used to measure mechanical vibration and shock. Its construction is so simple that it can be produced for only a fraction of the cost of a conventional vibration pickup.

The new accelerometer, which employs a piezoelectric compressive element, was developed by L. Fleming and E. J. Regan under the NBS program of Basic Instrumentation jointly sponsored by the Department of the Navy and the Air Force and the Atomic Energy Commission. This work is one phase of a broad program directed toward extending the range and accuracy of dynamic mechanical measurements.

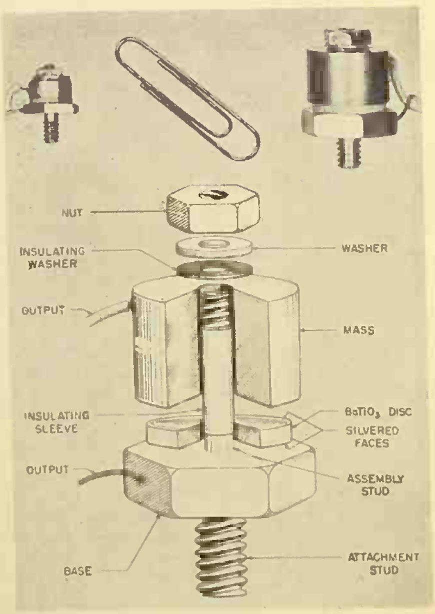
The piezoelectric compressive pickup is designed to detect a variety of vibratory movements. As an example, the unit responds to the characteristic vibration-frequencies generated by faulty bearings in an electric motor. The accelerometer is equally useful for calibrating other vibration pickups, shake tables, and low-frequency noise detecting devices. It is not primarily intended to sense seismic, aircraft, or vehicular accelerations.

Although piezoelectric crystals have been used in the past as sensing elements in mechanical shock experiments, practical difficulties have prevented their wide adoption. However, recent developments in the field of ceramics have made available piezoelectric materials that are both sensitive and easily fabricated. One of these, barium titanate ($BaTiO_3$), is used in the Bureau's piezoelectric compressive acceleration pickup.

A typical NBS pickup is composed of a ceramic disk 1/16 inch thick and 3/8 inch in diameter, stacked between a suitable base and a block of metal used for mass-loading the disk. The complete unit weighs less than 1/10 of an ounce. As a result of the "stacking" any acceleration imparted to the base produces a proportionate change in pressure on the piezoelectric disk tightly confined by the mass-loading block.

The voltage generated is proportional to the acceleration of the device being measured and is independent of its characteristic frequency up to the mechanical resonance of the accelerometer. This resonance has been extended to above 20,000 cycles per second by using a small and rather monolithic structure. As a voltage source, this particular pickup has an almost purely capacitive internal impedance of about 500 μμfd. and a sensitivity of approximately 2 millivolts per *G*.

The accelerometer (top right and left) and an exploded view (below).



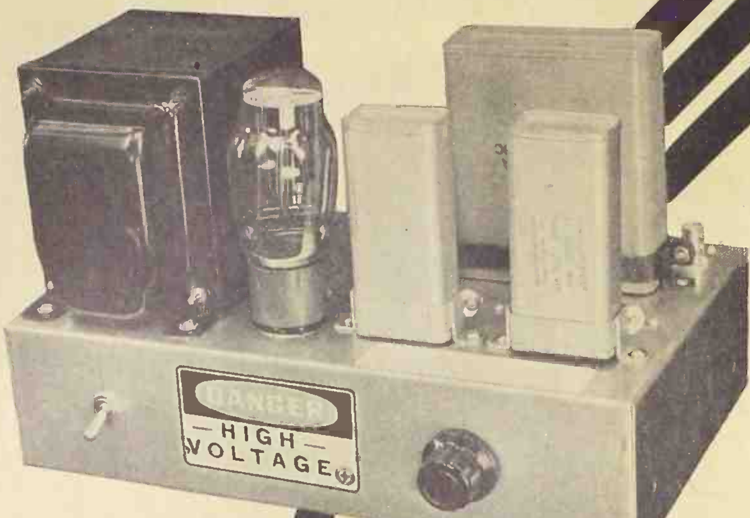
Calibration measurements indicate that the accelerometer has a response flat within 20 per-cent over the range 50 to 6000 cycles per second, and rising to a slight peak between 10,000 and 18,000 cycles per second. The peak appears due to calibration difficulties rather than to the accelerometer itself.

In order to provide electrical connections both faces of the barium titanate disk are coated with a silver paint; the ceramic is then baked in a furnace at 1300° C for about 15 minutes, and finally it is polarized, or sensitized. This last process is accomplished by cooling the material through its Curie point of 120° C. while a d.c. potential gradient of about 10,000 volts per centimeter is maintained between the faces of the disk. The voltage is applied through a pair of conductors soldered to the insulated mass and the base which bear against the upper and lower silvered faces of the disk respectively.

Barium titanate accelerometers may be constructed in any reasonable size. Their sensitivity varies directly with the thickness of the ceramic disk and the mass-loading block above it; the capacitance varies directly as the disk area and inversely with the thickness. It should be noted, however, that the smaller units are more efficient because the usable sensitivity per unit weight of the accelerometer increases as its size is scaled down.

By

EDWIN N. KAUFMAN



A power supply which was built expressly for use with a photomultiplier tube.

PHOTOMULTIPLIER CIRCUITRY

A simplified power supply and amplifier for photomultipliers.

MANY PHOTOMULTIPLIER circuits have appeared in the past few years for scintillation counting of radioactive particles, for light measurements, and for the detection of individual particles of dust in air decontamination and ventilating systems.

Many of these circuits were unnecessarily complex. The circuits illustrated in this article are simple and work satisfactorily. That the gain of a photomultiplier is very high is a well-known fact. However, it is not readily realized that photomultipliers cannot be used in even a poorly lighted room or the photocell will be driven past its safe current rating. For experimentation with the diagram herein it is advisable to wrap up the photomultiplier tube, such as the 931-A, completely with black plastic friction tape. This can then have a hole about the size of a pin head cut into the black tape facing the active surface of the photocell. Adjusting the amplifier to zero in a dark room (lights out) and then aiming this clear spot towards the artificial light in the next room will bounce the meter needle off full scale, until the amplifier gain is reduced. Most applications should be designed around simple photocells, as gain of this type is not required for a lot of industrial applications. The output current of the 931-A is rated at one milliampere but if extreme stability is required, such as for particle counting, the current should be restricted to about 1 microampere.

These tubes are very sensitive to magnetic fields, either a.c. or d.c. In the event that the tube must operate in close proximity to a magnetic field it should be suitably shielded with mu-metal. Electrostatic shielding is not always required but is generally advisable. This of course can consist of any type of metal can over the photocell with a hole cut through for the light to enter.

In applications where the photomultiplier is used for alpha counting (using a scintillation screen) the tube is mounted in a light proof shield, such as a preflush alpha counter chamber, and the samples to be counted rotated underneath the photocell. Similar arrangements can be used for beta or gamma counting.

In the application of determining the quantity of dust particles in ventilating systems the photomultiplier is placed in the air duct in such a way that only the reflected light from these dust motes enters the tube. This requires that the output of the photomultiplier be used in conjunction with a nuclear pulse amplifier[1] and scaler so that the individual particles may be counted. Naturally, this method of determining the quantity of dirt in the air is limited by particle size and the amount of illumination and back scattering of the light source.

It is not the purpose of this article to give detailed instructions for scintillation counting as this has been covered fully in many papers.[2] However, it will be of interest to many to know that the output of a 931-A photomultiplier can be used, in alpha scintillation counting, to directly drive many commercial scalers. In some cases it is necessary to

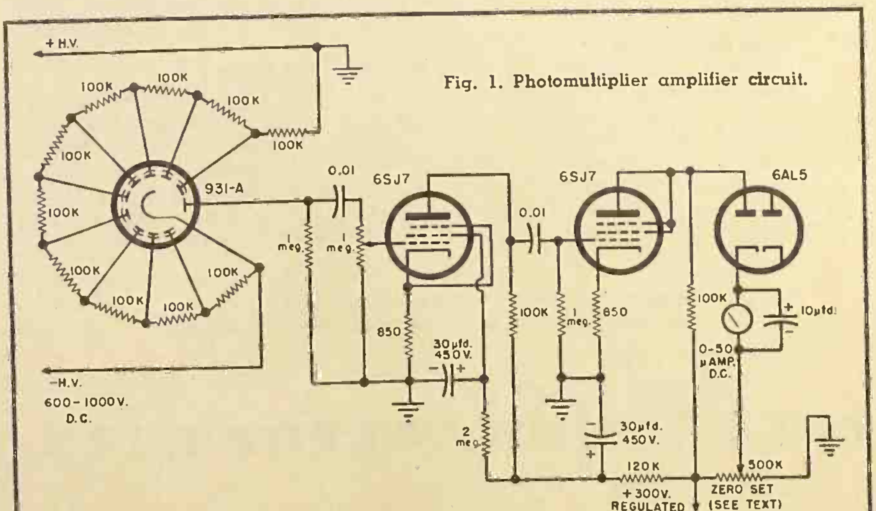


Fig. 1. Photomultiplier amplifier circuit.

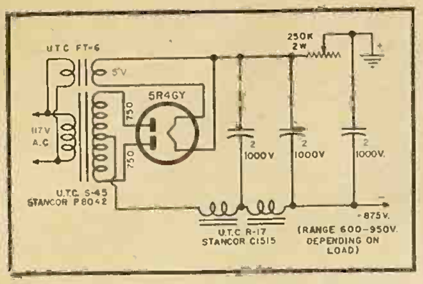


Fig. 2. Typical power supply.

adjust the scaler discriminator (usually set to .25 volts) so that the dark current pulses are sufficiently low in background registered counts/minute. In most cases the background can be adjusted to not more than 10 counts per hour.

If sufficient funds are available the *RCA* 5819 multiplier should be selected for scintillation counting. Where light intensity measurements are being made, other photomultipliers such as the 931-A are fully satisfactory and much cheaper. It is of interest to note at this point that defective photomultipliers will go into self oscillation, and that the ratio of good to bad tubes, from all causes, may be as high as one bad tube in every lot of fifteen.

The resolution of a photomultiplier and scintillation screen is about 0.1 microsecond. Therefore to get the maximum possible counting rate when counting alpha scintillations a photomultiplier should be used with a pulse amplifier and scaler. When the photomultiplier is used directly with a scaler as previously mentioned, the resolution of the circuit will depend mainly upon the *RC* time constant of the scaler input circuit and the counting rate. The *RC* timer is usually about 100 to 300 microseconds, or roughly, the dead time of many geiger tubes. Thus, although directly coupling the photomultiplier into a scaler is possible, it has the disadvantage that a coincidence correction may be required unless the input circuit is revamped; while with the pulse amplifier no coincidence correction would be required at normal geiger counting

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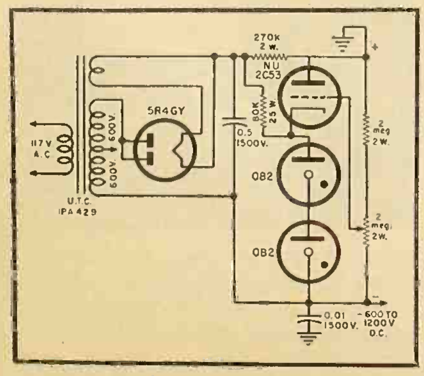
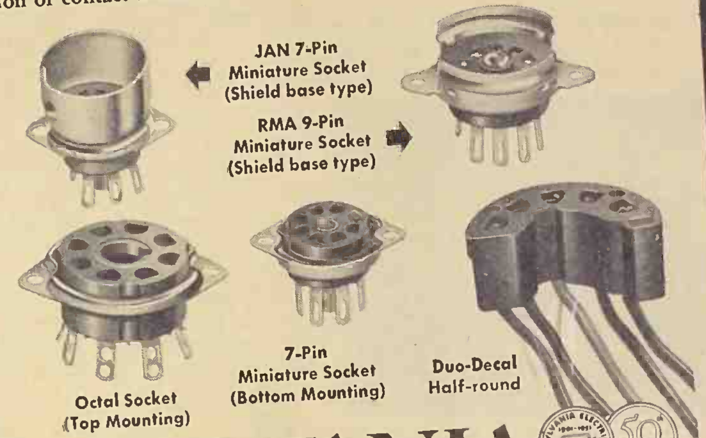
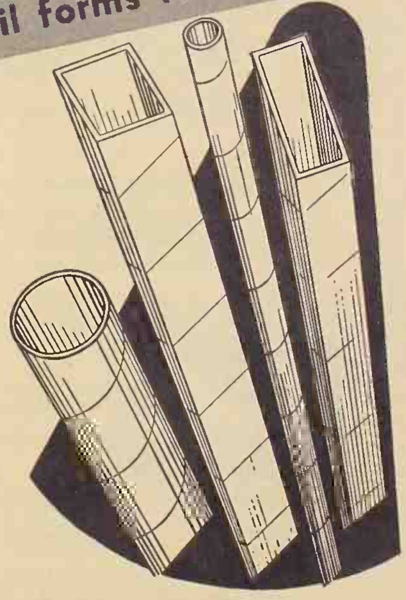
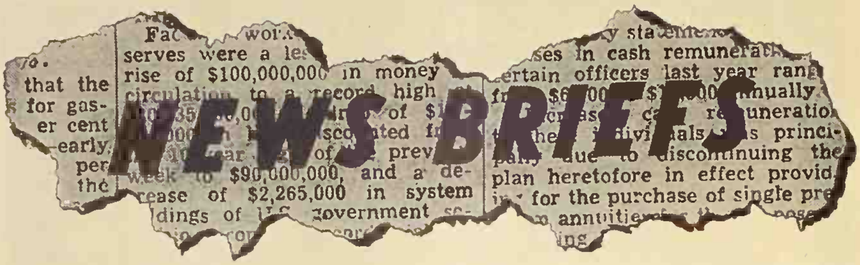
Fig. 3. Voltage regulated supply.



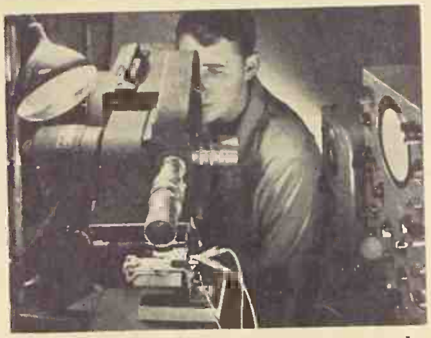






HIGH-SPEED CAMERA

A modification of the *Kodak* high-speed camera which permits both the mechanical and electrical aspects of a

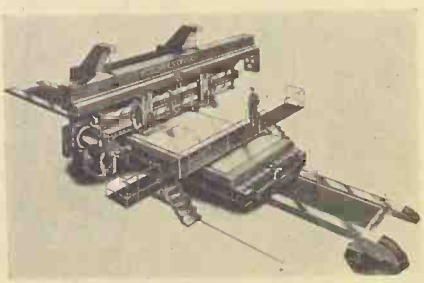


subject to be recorded simultaneously on the same film has been announced by *Eastman Kodak Company*, Rochester 4, N. Y.

The modification consists of the addition of a second lens to the camera to record the images on the tube of a cathode-ray oscillograph through the back of the film, while the mechanical aspects of the subject are being photographed on the front. This record will permit the photographer to present a complete picture of the behavior of electro-mechanical devices, and will also permit easy correlation with strain, acceleration, vibration, and other signals fed to the oscillograph in many non-electrical problems.

AIRCRAFT SKINS

A new defense weapon, believed to be the world's first machine tool for the manufacture of self-reinforced aircraft "skins," is being rushed to com-



pletion by the *Giddings & Lewis Machine Tool Co.* of Fond du Lac, Wisc.

Aimed at better adapting aircraft to the demands of near-sonic speeds, the revolutionary, three-dimension milling machine will be pioneered by the *Lockheed Aircraft Corp.* in the manufacture of F-94 jet fighters. Details of the complex new tool were designed by the *Giddings & Lewis Co.* in collaboration with engineers of the *General Electric Co.* and *Lockheed* in accordance with basic specification laid down by the aircraft corp.

The *Giddings & Lewis* Hypro Aircraft Skin Mill (Type 100), utilizes *GE* motors and control throughout. Operating in three dimensions with two feed motions, it is designed to work in a feed range from three-fourths of an inch to 150 inches a minute with infinite intermediate speeds and will mill integral-rib skin panels from solid or rough-forged aluminum alloy plate.

THIRD ANNUAL CONFERENCE

Details are being completed for the Third Annual Kansas City Section Technical Conference of the Institute of Radio Engineers to be held November 16 and 17.

"Instrumentation" has been selected as the theme of this year's conference and the schedule of papers include those dealing with instrumentation problems in aircraft and air navigation; television; broadcasting and communications; and general instrumentation of laboratories.

Further information may be had by writing to the Chairman, Publicity for 1952 Conference, Edwin J. Martin, Jr., 3245 Michigan Avenue, Kansas City 3, Missouri.

CAPITAL STOCK PURCHASE

The capital stock of *The A. W. Haydon Company* of Waterbury, Connecticut, was purchased by *The North American Philips Company, Inc.* In making the announcement, president-treasurer A. William Haydon, emphasized that there will be no changes in personnel and general operations will continue under the same executives.

Mr. Haydon also pointed out that by affiliating with the *Philips Co.* additional capital will be made available as required for expansion to meet the increasing demand for the *Haydon Co.* products. There are many other general benefits to be derived from the merger, such as added security which will be given to the employees' position.

The company began manufacturing operations in the electrical field during 1933 under the name *Haydon Manufacturing Co., Inc.*, which was sold to *General Time Corp.* in 1945. Mr. Haydon then started the present *A. W Haydon Co.* in Waterbury and went into small volume production in 1946 with 17 employees. Today the company has 165 employees and 30,000 square feet of floor space.

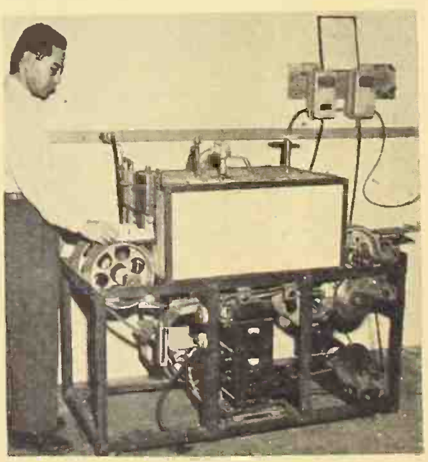
SEALING PROCESS

The sealing of the glass funnel to the metal cone of a 24 inch television

picture tube being done in the picture tube laboratory of *General Electric Company*, Electronics Park, Syracuse, New York. The illustration shows Alfred Cannizzaro operating the unit which revolves on a turntable while gas and oxygen flames seal the glass to the metal.

FURNACE

A small continuous-belt furnace has been designed and constructed by R. L. Henry and associates of the National Bureau of Standards engineering electronics laboratory. Smaller than commercially-available continuous furnaces, the new furnace is well suited for quantities somewhat too large to be efficiently handled by batch-type fur-



naces. While the unit was designed primarily for firing printed circuits, to meet the needs of the printed circuit program sponsored at NBS by the Navy Bureau of Aeronautics, it could be equally valuable for firing or annealing moderate quantities of other materials, particularly in laboratory or pilot-plant installations.

The operation of the furnace is quite simple. A continuously-moving horizonal metal belt carries the material to be fired into the furnace at one end and delivers the fired product at the other end. Temperature and belt speed are adjustable over a wide range. Normally printed plates are fired at 1350°F and spend 65 minutes in transit from cold input to cold output. Flat plates can readily be stacked six deep on the 4 inch wide belt; this gives a firing capacity of about 800 sq. in/hr. at the usual belt rate. It is a tunnel, 31 inches long, with walls of insulating brick. A guillotine-type door at the input end of the tunnel is adjustable to the height of the load.

LATEST DEVELOPMENTS

A special two day conference on major developments in feedback control systems, will be held December 6-7 at the Chalfonte-Haddon Hall Hotel, Atlantic City. The meeting will be sponsored by the American Institute of Electrical Engineers Committee on Feedback Control Systems.

Not only will developments of the past few years be reviewed during the conference but the program provides for covering many new, significant advances in design techniques and components. Of special interest at the meeting will be a session on biological servomechanisms. Topics to be discussed also include the role of statistics, discontinuous control systems, control systems operating from discrete data inputs, and a sampled data control system technique.

Mr. Jerome Zauderer, chairman of the information committee for the conference, of the *American Measuring Instruments Corp.*, 21-25 44th Ave., Long Island City, N. Y., said that the agenda is now being completed and that program and other information can be obtained by writing him.

RADIO NOISE

J. Warren Culp, a researcher for the physics laboratories, *Sylvania Electric Products Inc.*, Bayside, N. Y. revealed a comprehensive study of radio noise produced by fluorescent lamps in a paper delivered to the National Conference of the Illuminating Engineering Society held in Hotel Shoreham, Washington, D. C., recently.

Mr. Culp said that radio noise, which is a source of interference in radio and television receivers, falls into two general classes: that caused by diathermy

(*Continued on page* 29)

NEW PRODUCTS

VECTORLYZER

Advance Electronics Company, P. O. Box 2515, Paterson, N. J., announces the new A-E Type 201 Vectorlyzer which makes possible for the first time

a number of measurements which were formerly impossible or at least very difficult to be accomplished by other means. It is based on a new fundamental circuit which permits unusual speed and accuracy for measuring vector relations of alternating voltages.

The frequency range of this instrument is 8 cps to 10 mc. through panel binding posts, 20 kc. to 500 mc. through probe, and has 2, 4, 10, 20 and 40 full scale voltage range. 0-180, and 180-360 degrees, ranges with better angular sensitivity can be obtained through panel adjustment. This instrument is extremely versatile and may be modified to suit specialized applications.

OSCILLATOR

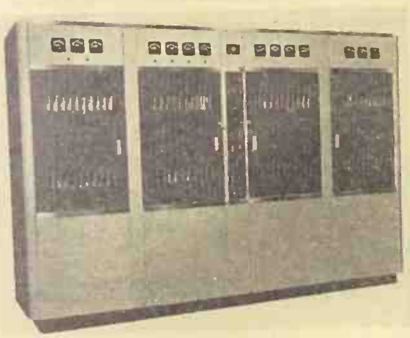
A new, wide range, ultra-low frequency oscillator Model 410-A has been announced by the *Krohn-Hite Instrument Co.*, 580 Massachusetts Ave., Cam-

bridge 39, Mass. It combines the sub-audio with the normal audio frequencies and provides both sine and square wave outputs over the entire frequency range from 0.02 to 20,000 cps. Six frequency bands are provided, each covering a full decade, with continuous control of frequency. A single 11 inch illuminated, direct reading logarithmic scale is used on all bands.

This instrument features low distortion and hum level, constant output impedance, frequency stability and amplitude constancy over the entire frequency range. Precisely engineered and constructed, the Model 410-A is ideal for medical research, for geophysical and seismological instruments, for design and development of servomechanisms, and for vibration controls.

NEW TRANSMITTERS

The *RCA* Engineering Products Department, Camden, New Jersey announces the factory production of two new and economical 5-kw. and 10-kw. AM radio transmitters, the BTA-5G



and BTA-10G, with frequency range of 535-1620 kc.

Both transmitters feature a considerable saving in floor space and reduced operating expense, with fewer tubes and tube types than previous models, lower power consumption, higher fidelity, and lower distortion. The models utilize vertical panel construction throughout to provide greater accessibility to tubes and components.

Other features include two oscillator units, each of which maintains its frequency within plus or minus five cycles. Front-panel oscillator switching permits quick selection of the auxiliary oscillator. All r.f. stages are designed for Class C operation. All tubes are visible through windows in the sliding doors to permit continual observation of their operating condition. Both transmitters operate from a 208/230 volt, 3-phase, 60 cycle power supply, and have a power factor of 85 percent.

INDUCTROLS

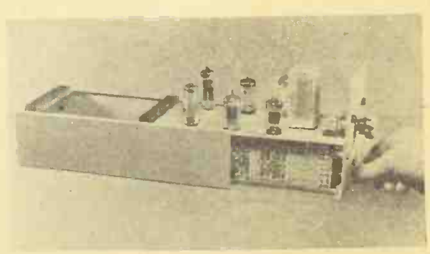
A redesigned line of single-phase Inductrols in standard ratings of 9.6 kva. to 24 kva. has been announced by *General Electric's* Transformer and Allied Products Divisions. The single-phase units widen the field of application in which uniform voltage control can be obtained economically with small regulators, and are available for single-

phase circuits, 600 volts and below with current ratings up to 1000 amperes.

These units consist of a shunt winding located in the rotor and a series winding located on the stator. Varying the position of the rotor with respect to the stator causes a variation of voltage in the series winding that will raise or lower the output voltage gradually, as required by changes in load. The equipment is housed in an all-steel cabinet, with all "live" parts enclosed.

CHASSIS

One of the more important blocks to the availability of good working plug-in unit design has been the need for the development of a standardized chassis that would mount component and circuitry for widely varied applications. *Alden Products Co.*, 117 North Main St., Brockton, Mass. announces a new basic chassis design which can be stand-

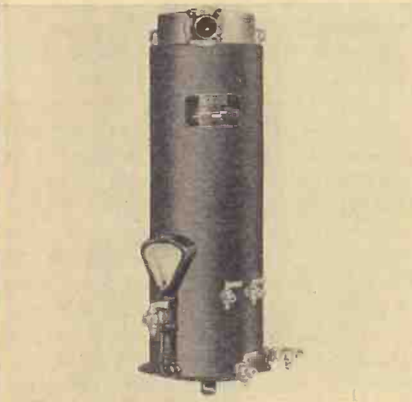


ard so that most circuit elements can be laid out and easily fabricated as unit subassemblies.

This unit has been designed for maximum accessibility to all components, for wiring and assembly using high-speed production methods, and for easy servicing of completed equipment by even inexperienced personnel. The heart of the chassis is the terminal mounting board system whereby tube sockets and all associated circuitry are mounted and interwired as an individual sub-assembly for mounting in basic chassis. Hundreds of prepunched holes on the terminal boards permit an almost unlimited number of circuit patterns to be wired without modification of any sort.

SPRAYER

The "Viscolator," developed and manufactured by *Reliable Products Manufacturing Co., Inc.*, 123 DeKalb Avenue, Brooklyn 1, N. Y., is designed to make possible the spraying of high solid content lacquer, synthetic and other similar material at elevated temperatures. This unit provides 60 per-cent more solid content spraying with hot synthetic rather than with cold. The



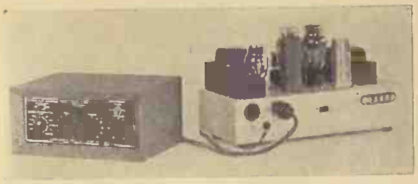
material is heated to reduce its viscosity by electricity, steam or in combination. The units are manufactured in capacities from 8 to 250 gallons per hour output in the non-recirculating and recirculating types. The recirculating type is recommended for use with hot lacquer.

The heating elements and the material carrying tubes are embedded in solid metal, producing fast heat transfer. Should the material carrying tubes clog due to negligent operation, they are easily cleaned without dismantling the unit.

REMOTE-CONTROL AMPLIFIER

Herman Hosmer Scott, Inc., 385 Putnam Ave., Cambridge 39, Mass. announces a new Type 214-A amplifier which has control and compensating features that improve music fidelity and simplify operation and installation. Remote control can be placed up to 25 ft. from the power amplifier. The 8 position record-compensator adjusts for any recording characteristic, and the selector switch changes from phono, tuner, television, or other high-level inputs.

Other features include an automatic loudness control which boosts treble and bass at decreasing volume to com-



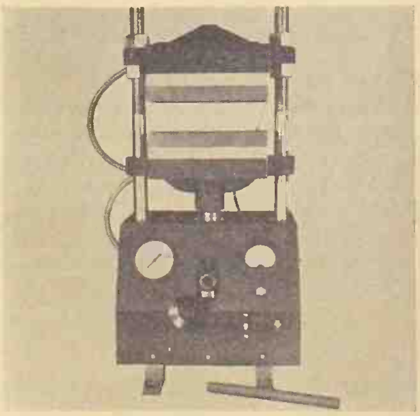
pensate for the human ear's insensitivity to high and low frequencies at low volumes; individual 3-channel continuously-variable tone controls, each having a control range from 6 db/octave boost, through flat response, to 6 db/octave attenuation. Provision is also made for adding separate Dynaural noise suppressor. It is housed in a solid walnut cabinet with etched bronze panel, and has a 6 ft. remote control cable. A bulletin will be sent upon request.

HYDRAULIC PRESS

The Hydraulics Division of *Wabash Metal Products Co.*, 1569 Morris Street, Wabash, Indiana announces the new 12 ton, model 12-10, *Wabash* hydraulic laboratory press. The hydraulic mechanism provides a total available force of 24,000 pounds.

A quality gauge, mounted in the control panel, indicates pounds per square inch on the ram. Conversion from ram pressure to force is readily made. The stroke is 6 inches, maximum daylight opening 10 inches. An unusual feature of this model is the distinct paralleling of the platens which has been accomplished by precision boring of the guide holes.

The control cabinet console incorporating a sloping panel has been enlarged



and redesigned to permit ready access to the hydraulic unit and controls. Finish of the press is black wrinkle enamel. The columns are hard chrome plated which increases wearing qualities and

(*Continued on page* 26)

Personals

DR. EDWARD U. CONDON has been appointed director of research and development of *Corning Glass Works*. His appointment was co-incident with Pres. Truman's acceptance of his resignation as director of the NBS. He had been appointed director by the President in 1945 and in 1946 attended the Naval atomic bomb tests at Bikini. He is a member of Phi Beta Kappa, Sigma Xi and Sigma Pi Sigma, Am. Inst. of Electrical Engs. & Inst. of Radio Engs.

PETER LAHANA has been added to the large staff of field engineers of *Burlingame Assoc.* Mr. Lahana was a sales and application engineer for *Sorensen & Co., Inc.*, and for *Thomas A. Edison, Inc.*, and a resident instructor in electrical engineering at Renssalaer Polytechnic Institute. His duties will be to provide up-to-the-minute production and technique information on products manufactured in Western New England and a portion of New York.

NATHANIEL B. NICHOLS has been appointed manager of the research div. of *Raytheon Mfg. Co.* Mr. Nichols received the Naval Ordnance Award in 1947 for work performed in connection with Naval fire-control systems. He is a member of the Am. Physical Society, Am. Assoc. for Advancement of Science, Am. Chemical Society, Am. Institute of Electrical Engineers, the Am. Society of Mechanical Engineers, the Instrument Society of America and Sigma Xi.

JOSEPH RACKER has just organized a new firm under his name which will provide competent radar consulting and editing services. Mr. Racker, co-author of "Pulse Techniques" and author of many articles on microwaves, was formerly a Signal Corps radar officer; chief engineer at *Associated Electronics Co.*, and assistant to the division head of *International Telephone & Telegraph Co.* The new *Joseph Racker Co.* is at 67 W. 44th St., New York 18, N. Y.

DR. LAURISTON S. TAYLOR has been appointed chief of the atomic and radiation physics division of the National Bureau of Standards, and coordinator of Atomic Energy Commission projects. Dr. Taylor has contributed extensively to scientific journals in the field of radiology, and is an associate fellow of the American College of Radiology and a member of the American Physical Society, the Washington Academy of Medicine, and Sigma Xi.

FRANK THORNTON, JR. has retired after 42 years with *Westinghouse Electric Corp.* Mr. Thornton was awarded the James H. McGraw Award in 1950 in recognition of his contribution to the advancement of the electrical industry. He is a fellow of the American Institute of Electrical Engineers, a member of American Society of Mechanical Engineers, and an associate of the International Association of Electrical Inspectors.

Photomultiplier

(*Continued from page* 19)

rates of 6,000 to 20,000 counts per minute.

To adjust the amplifier circuit illustrated in this article, zero the output meter by blanking off the photo tube completely and adjust the zero potentiometer so that the meter indicates one division above zero. The light source should be an alternating current one, such as an ordinary light bulb. The bulb can be stabilized voltage wise by using one of the many a.c. line regulators on the market.

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Ferromagnetic

(*Continued from page* 13)

to employ two such loops at right angles and to rotate a small goniometer inside the receiver.

Ship Installations. The existing radio compass loops are very bulky and, being of round or rhombic ring shape, offer much wind resistance and are subject to icing. Elongated 2" to 4" diameter loops rotatable in the manner of range finders, will require less space, weight, and wind resistance. Underwater reception of signals requires very powerful pick-up devices. Here, a very long loop in the form of a cable may be attempted, extending its length to 20, 50, or even 100, diameters. At low frequencies, applications with materials of $\mu = 1000$, the effective realizable permeability will be 140, 400, and 700 respectively.

Antenna Loading. Experiments are being carried out to reduce the physical size of an antenna by loading the antenna wires with ferromagnetic beads. Considerable reduction in length for the same pick-up appears, which will be appreciated for indoor and built-in TV antennas.

Without going into the theory of behaviour of ferromagnetic antennas, which is controversial at present, one may see that in all cases of reception the magnetic mass around a receiving system seems to act as a "shortening lens", reducing the wavelength by slowing the velocity of propagation in the immediate vicinity and thereby increasing the potential gradient of an electromagnetic radiated wave.

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2. *U. S. Patents No.* 2.266,262 *and* 2.438.680.
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ILS Test Set

(*Continued from page 5*)

the power/cycling unit. Depending upon the position of this switch, different values of capacity are connected in the audio oscillator circuit through pins 7 and 12 of J_2. The oscillator operates at 3000 cycles when condensers C_{15}, C_{18} and C_{19} are selected, 1300 cycles when condensers C_{16}, C_{20} and C_{21} are selected and 400 cycles when condensers C_{17}, C_{22} and C_{23} are selected.

Localizer Unit

The localizer unit (Fig. 2) is a 4-stage crystal-controlled oscillator/frequency multiplier/amplifier whose function is to generate a signal in the 108-112 mc. band to simulate a localizer station.

V_1 functions as a crystal-controlled oscillator and doubler stage. The oscillator operates on any one of twenty frequencies in the six megacycle band dependent upon the crystal selected by switch S_1. The plate circuit is tuned to the second harmonic of the crystal frequency. V_2 and V_3 operate as tripler stages. The final amplifier V_4 operates as a straight-through amplifier and feeds a horizontal quarter-wave antenna. The twenty operating channels are obtained by crystal selection only, the multiplier tuned circuits being slightly "stagger-tuned" to give approximately constant r.f. output throughout the localizer frequency band. To produce a modulated localizer output signal the B+ voltage applied to the screen grid circuit of V_3 and the screen grid and plate circuits of V_4 is modulated by the 90 and 150 cycle voltages generated in the modulator unit.

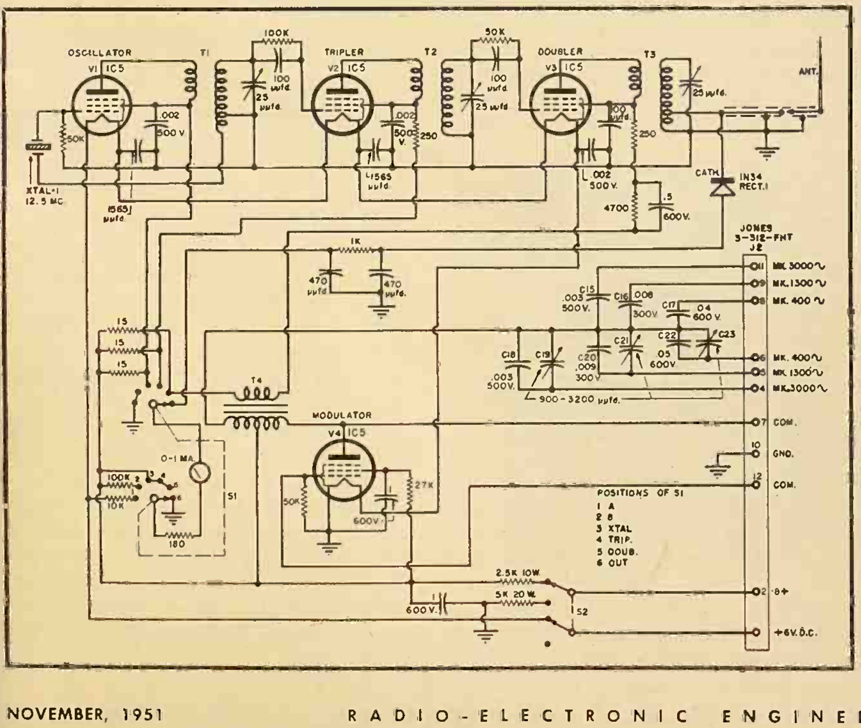
The localizer unit is equipped with three variable adjustments. Potentiometer R_{13}, which is equipped with a knob on the front panel, is used to adjust the r.f. output level. Potentiometer R_{14B}, which is connected across the modulation transformer T_1, is used to adjust the percentage of modulation. The adjustment of this control requires the removal of the localizer unit from the G-250A case. The third variable control, potentiometer R_{15}, is a fine centering adjustment used to equalize the 90 and 150 cycle modulation voltages. This control is a screwdriver adjustment and is accessible through the front panel.

A 0-1 ma. meter M_1 is installed on the front panel to meter the various circuits in the localizer unit. By means of switch S_2 the meter may be connected into the appropriate circuits to measure the grid currents of the 1st multiplier, 2nd multiplier and final amplifier, r.f. output from the final amplifier and modulation reference voltage. The r.f. output is monitored by metering the rectified d.c. voltage obtained from $RECT_1$. The modulation reference voltage is obtained by rectifying the audio voltage across the secondary winding of T_1. This d.c. voltage is applied to potentiometer R_{14A}. Since R_{14A} and R_{14B} are ganged, adjustment of the percentage of modulation with R_{14B} will simultaneously reflect a corresponding change in the modulation reference voltage indicated on the panel meter.

Glide Slope Unit

The glide slope unit is basically the same as the localizer unit. The circuitry employed is identical to that of the localizer unit up to the final amplifier.

Fig. 5. Circuit diagram of the marker unit.



Since the glide slope operates in the 330 megacycle band it is necessary for the final amplifier to function as a tripler stage rather than as a straight-through amplifier as in the localizer unit. This degree of frequency multiplication results in an output frequency fifty-four times the crystal frequency. The final amplifier feeds an antenna system consisting of a horizontal quarter-wave antenna and a quarter-wave reflector.

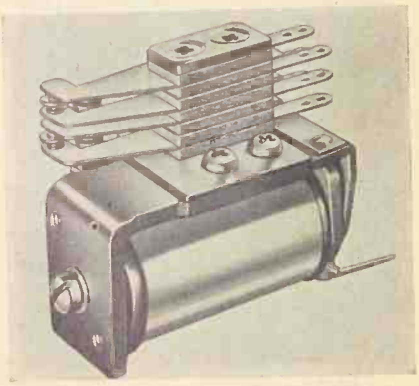
New Products

(*Continued from page* 22)

resists corrosive vapors which may be present. The model is available in either 110-115 volts or 220-330 volts a.c. operation.

SMALL RELAY

C. P. Clare & Co., 4719 W. Sunnyside Ave., Chicago 30, Illinois announces the new *Clare* Type "KX" relay which is a refinement of the *Clare* Type "K" in order to provide increased sensitivity



and operating range in the same small-sized unit.

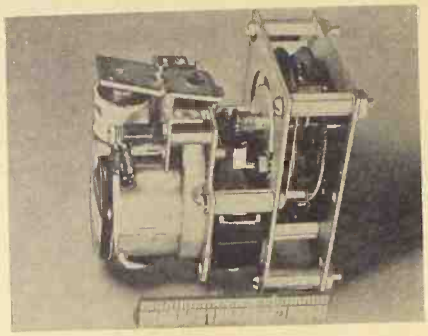
The new unit provides a slightly longer coil which can be safely wound to a maximum resistance of 8000 ohms. A slight change in the design and suspension of the armature permits this additional winding space without adding materially to the over-all length of the relay.

Dimensions vary with type of coil terminal used: 1$^{39}/_{64}$ x 1$^{15}/_{32}$ x 1 inch, weighs approximately 2 ounces; single or double wound coils; up to 175 volts d.c.; single or double armature.

DELAY RELAY

A new product now in production is is the *A. W. Haydon Company's* delayed reset time delay relay, which incorporates the time proven basic 6400 series d.c. and 11,400 series a.c. time delay relay. It makes possible a delayed reset proportional to the time delay and a circuit reclosure time proportional to the length of current interruption. Reset is accurately controlled by an escapement mechanism which adds approximately ¾ inch to the length of the standard *Haydon* time delay relay.

A typical application is a radar installation in which a 15 minute delay is provided to closure of the load cir-



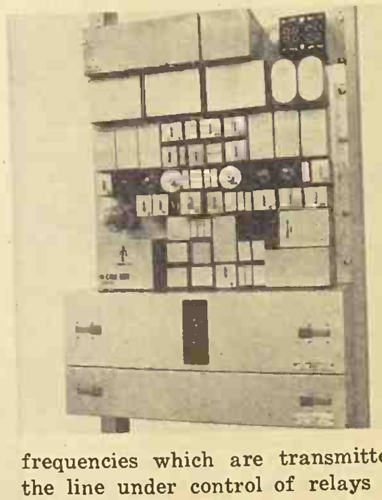
cuit. The time required for the unit to reset is 7 minutes. When a current interruption less than 7 minutes duration occurs, the time delay before reclosure is proportional to the length of current interruption. Thus a 5 minute interruption would require only 5 minutes before circuit reclosure.

The unit is available from the *A. W. Haydon Company*, 232 North Elm St., Waterbury, Conn. It is housed in a standard dust cover or in a hermetically sealed enclosure.

DIALING AUXILIARY

Facilities for dial signaling can be added inexpensively to existing H-L Western Electric Carrier Systems by use of new Type H1-D equipment announced by *Lenkurt Electric Company*, 1105 County Road, San Carlos, Calif. One terminal, as illustrated, occupies less than 9 inches of space on one side of a standard 19 inch rack to provide full-duplex carrier-frequency dial-signaling pulses at the usual rates (10 to 14 pps) on frequencies not essential to the H1 voice channels.

Capable of spanning line attenuations, the new Lenkurt auxiliary includes stabilized vacuum-tube oscillators for the generation of signaling



frequencies which are transmitted to the line under control of relays actuated by d.c. signals from the terminal equipment. Band-pass filters between the H1 terminals and their line filters restrict the voice channels to the range 4400 to 10,750 c.p.s. and release frequencies at 4150 and 11,500 c.p.s. for the signaling channels. Incoming pulses are reconverted into d.c. signals to operate switchboard or dial equipment.

SIGNAL FLASHER

A lightweight, portable electronic signal flasher, without moving parts or filaments to burn out, assuring longer battery life and greater long range visibility has been announced by the *Haledy Electronics Company*, 57 William St., New York 5, N. Y.

The new flasher of cold cathode tube design emits a sharp brilliant flash of light clearly visible for approximately a mile with never failing dependability. Unaffected by vibration, humidity or temperature in a compact splash and rainproof aluminum case measuring 6 x 6½ x 10 inches it weighs 8½ pounds, and can be carried by handle for use

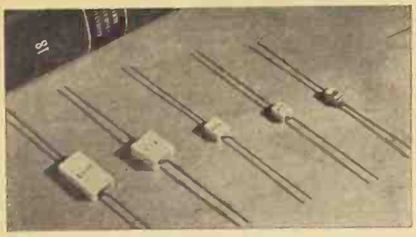
wherever signaling is required, on land, sea or air.

The flasher utilizes a set of three standard 90 volt batteries in series. An off/on switch as well as an outside knob is provided to control the number of flashes per minute. A clear or color precision Fresnel lens protects the lifetime cold cathode tube.

NEW CAPACITOR

A new style of capacitor has been added to the series manufactured by *Vitramon, Inc.*, of Stepney, Conn. The unit, shown on the right in the photograph, has an over-all length of 0.4 inch and a maximum cross section dimension of 0.2 inch.

Designated at Type 49, it is available up to 51 $\mu\mu$fd at 500 v.d.c.w. and to 110 $\mu\mu$fd at 250 v.d.c.w. and carries a permanent six-band color code and manufacturer's trademark. The new unit has the electrical characteristics typical of Vitramon capacitors for it is constructed of fine silver electrodes immersed in a high quality porcelain which forms not only the dielectric but also the impervious, glass-like block which completely insulates the structure.

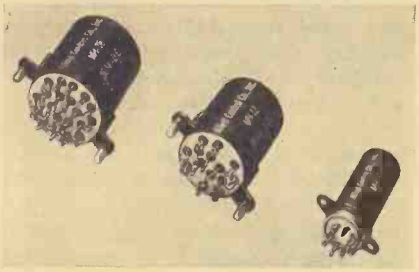


ture. Included in the photograph are also the four stock sizes of *Vitramon* capacitors.

SUBMINIATURE RELAYS

A complete series of subminiature relays has been developed by *Allied Control Company, Inc.*, 2 East End Avenue, New York 21, N. Y., for aircraft and airborne equipment. Type MH relays are available in 2, 4, and 6 pole, double throw and meet the requirements of the U.S.A.F., Specification MIL-R-5757.

These relays will withstand aircraft vibration of 10 G's and shock of 30 G's of 10 milliseconds duration, as an operating condition. Units are tested for circuit discontinuity under impact with an electronic device having a response time of less than 1 microsecond. They



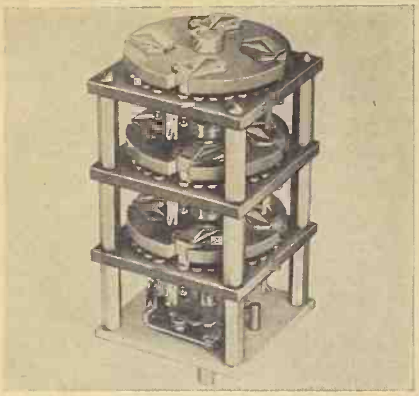
are hermetically sealed for operation to 70,000 feet.

Minimum power requirement at room temperature is less than 1 watt, and the contacts are rated at 2 amps. non-inductive at 28 volts d.c. for life expectancy of over 1 million operations. Contact operations are designed for utmost reliability, with ample contact gap, wipe, follow and pressure.

SWITCHES

The Daven Co. of Newark, N. J. announces that all switches made by the company are now constructed in accordance with applicable JAN and MIL specifications. They feature silver alloy contacts and slip rings; the *Daven* knee-action rotor; positive roller-type detent action which does not add to the depth of the unit; and switch stops which are independent of rotors.

With these switches, a large number of positions and poles may be obtained in a very small physical space. Special *Daven* switches are also available for high-speed work for such applications as telemetering, plus work, and other other military applications, with various ratios of on-off time and angular



spacing of live contacts. Further information regarding particular applications will be supplied by writing to the company at 191 Central Ave., Newark 4, N. J.

INDICATOR AND CONTROLLER

The Sterling Instruments Company, 13331 Linwood Ave., Detroit 6, Mich., announces the new Type 131 electronic displacement indicator and controller. Manufactured for use in conjunction with Schaevitz linear variable differential transformers and Schaevitz pressure transmitters, this unit can be used as a controller or indicator, or both simultaneously.

The device may be used for many applications, such as a controller for leveling operations; a remote indicator and controller for scales; a torque indicator and controller; a tension controller in processes where it is desired to test materials for elongation; a position controller in servo systems; an automatic control or shut-off for pressure systems; an automatic position

control in machining processes; or a thickness controller.

Type 131 is powered from 110 volts 60 cycles. Loads requiring up to 40 amperes may be handled by the internal relays. For greater loads, external contactors may be used.

ATTENUATOR SWITCH

A line of attenuator switches recently introduced by the *Shallcross Manufacturing Co.*, Collingdale, Pa., includes 12

round, single-deck units in one and two pole types with up to 60 contact positions and with rotations ranging from 144° to 360°. Average resistance of the silver alloy contacts of 0.003 ohms is maintained throughout a life of upwards of a million operations.

All of the new *Shallcross* attenuator switches are obtainable with or without detent mechanisms. All have silver alloy contacts, wiper arms and collector rings. Most types can be ganged by using a square switch plate slightly larger on a side than the specified diameter of the standard round plate. Bulletin L-22 describing the new switches is available from the manufacturer.

LOW FREQUENCY OSCILLATOR

The Krohn-Hite Instrument Co. of 580 Massachusetts Ave., Cambridge, Mass. announces a new low frequency

oscillator, Model 420-A, which simultaneously provides both sine and square wave voltages at any frequency between 0.35 and 52,000 cps.

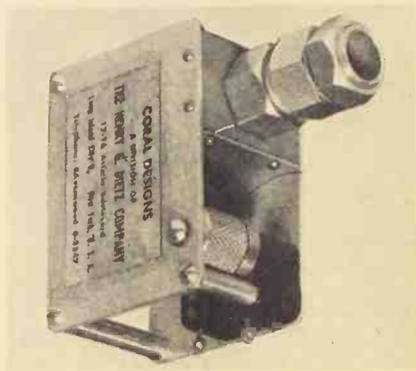
The unit features low distortion and hum at any setting of the calibrated output level control and excellent amplitude constancy over the entire frequency range. Special circuitry is employed to eliminate tuning and bandswitching transients.

The 420-A is especially useful for servomechanism, geophysical and seismological work and for vibration checks and medical research. The unit measures 12x7x8 inches. A descriptive pamphlet may be obtained upon request.

AIR FLOW SWITCH

A new improved vane type pressure air flow switch for use in forced air cooling of electronic equipment has been announced by *Coral Designs Division* of *The Henry G. Dietz Co.*, 12-16 Astoria Blvd., Long Island City 2, N. Y.

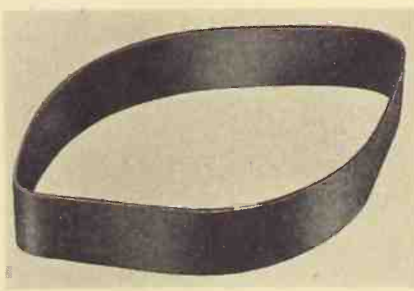
The quantity of air required for forced-air-cooled tubes is specified for various types of service and often for



various power levels. The Cat. 113 vane-type pressure air flow switch is designed to operate a control relay to guard against tube failure in the event of blower failure or air-passage obstruction. Extreme sensitivity is made possible by the use of a vane traveling in a duct which actuates a sensitive snap-action switch.

MAGNETIC RUBBER

The Brush Development Company, 3405 Perkins Ave., Cleveland 14, Ohio announces a new magnetic recording rubber made from a special neoprene base. The highly efficient magnetic oxide has been pigmented into the neo-



prene with an unusually good degree of uniformity. Included in the base material is a permanent lubricant which eliminates wear of both medium and associated recording head. Mechanical compliance of the medium provides for intimate contact with the recording head.

These recording bands have been primarily designed for use when stretched over a supporting drum. They can be supplied on special order in various sizes and shapes to meet specific requirements.

This development was initiated by and carried out in close cooperation with *Bell Telephone Laboratories, Inc.*

LEAK LOCATOR

A new and improved, portable, high-sensitivity leak locator, designed as a factory and laboratory device for detecting and locating tiny leaks during the manufacture of electron tubes of all types, vacuum bottles, or any device, large or small, which can be evacuated, was announced by the *RCA* Scientific Instrument Section, Camden, N. J.

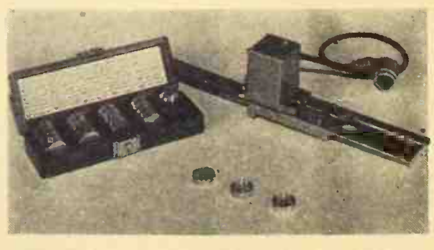
A hydrogen-sensitive, ionization-type instrument, the new Type EMV-7, weighs 31 pounds and is simple enough to be operated by non-technical person-

nel. The instrument measures 13¾" x 15" x 11", and operates from a 105-125 volt, 60 cycle, a.c. line. Heart of the unit is a sealed-off, high-vacuum-gauge tube, *RCA* type 1945, which responds only to hydrogen. It is complete with a high-stability d.c. amplifier, microammeter, self-contained power supply.

ABSORBER CHANGER

An automatic absorber changer attachment consisting of a slide and switch assembly and a set of 25 calibrated aluminum absorbers has been developed by *Tracerlab, Inc.*, 130 High St., Boston 10, Massachusetts.

The slide assembly mounts in the manual sample changer and allows the changer to position the absorbers over a source, thus making it possible to obtain



absorption curves automatically. This is of value in checking the purity of radioisotopes on a routine basis. Absorbers are 1" in diameter by 5/16" high and are made of aluminum foil cemented in aluminum rings.

TECHNICAL BOOKS

"BASIC ELECTRON TUBES" by Donovan V. Geppert. Published by *McGraw-Hill Book Company, Inc.*, 330 West 42nd St., New York 18, N. Y. 332 pages. $5.00.

This text covers the physical characteristics, electrical characteristics, theory, and mathematics of the eleven most basic types of electron tubes used in engineering. The book covers only the tubes themselves and not the circuit applications in which they are used.

In general the approach is from a practical, down-to-earth viewpoint; however, essential theory and mathematics are not sacrificed. Atomic theory and electron ballistics are covered as an integral part of the theory of each tube and gradually enlarged and developed as each chapter is added. The double cathode sheath theory in gas tubes, not covered in other texts of this nature, is here explained in detail.

The material in each chapter is divided into four sections, which makes for a particularly logical and comprehensible presentation. The first section covers the physical characteristics of the tube being considered; the second covers the electrical characteristics; the third contains the theoretical explanations of the electrical characteristics; and the fourth section gives the mathematics of the tube.

"ELEMENTS OF TELEVISION SYSTEMS" by George E. Anner. Published by *Prentice-Hall, Inc.*, 70 Fifth Avenue, New York, N. Y. 804 pages. $10.35.

This book begins with a study of closed systems, those that rely upon cable connections between sending and receiving apparatus. In this way the basic problems of any television system can be studied independently of the problems associated with broadcasting the signal by radio.

In the second part of the book, the point of view is expanded to include the complications introduced by using a radio link in place of interconnecting cables. The last part is concerned with methods of superimposing color-perception on a system which is inherently color blind.

Since details of a new art change rapidly, an attempt is made to concentrate on the basic principles involved. The new technique of dot interlace, which promises to become very important in the future, is covered in the appendix.

News Briefs

(*Continued from page 21*)

machines, other television receivers and occasionally incandescent lamps; and that caused by gaseous discharges such as atmospheric lightning, electric motors and the sustained discharge that is found in neon signs and fluorescent lamps.

Measurements of fluorescent lamp noise were made with tuned and wide-band receivers in conjunction with a cathode-ray oscilloscope. A direct viewing stroboscope and a stroboscope utilizing a rotating mirror were used to observe changes in the luminous gas of the lamp. Fluorescent lamps used were 20 watt T12 type, standard except for the omission of the phosphor coating. Lamp current was limited to a maximum of 350 milliamperes.

NEW LOCATION

Armour Research Foundation of Illinois Institute of Technology has signed a five-year lease for the two-story Irwin building at 3201 S. Michigan Ave., Chicago, to house its electrical engineering department. The department was formerly located at the Foundation's Physics Research building, 55 East 33rd St.

Dr. H. A. Leedy, director of the Foundation, said the new building will provide space needed to accommodate an expanded research program in electronics and will provide office and laboratory space for 40 scientists and engineers in the five sections of the electrical engineering department: control systems and communications, instrumentation, machines and devices, recording and computer systems, and materials and measurements.

RESEARCH SURVEY

A group of American scientific research authorities headed by Dr. Harold Vagtborg, president of Southwest Research Institute, has undertaken an exhaustive survey of West Germany's scientific research resources under ECA sponsorship. In addition to staff members from Southwest Research Institute, the group includes top research officials from Armour Research Foundation of Chicago, Battelle Memorial Institute of Columbus, Ohio, and Stanford Research Institute of Palo Alto.

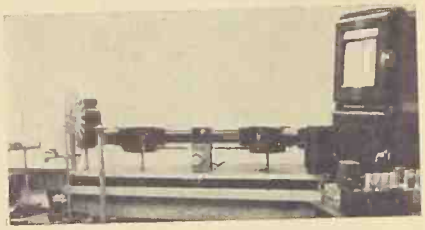
Primary objective of the group is to determine whether a need exists for establishment of applied research institutes to serve small and medium-sized manufacturers and processors in West Germany in the interest of national security, and if it does, how best to set up such laboratories.

In addition to West Germany, six

other democratic European countries have joined in requesting identical surveys sponsored by the Economic Cooperation Administration to be performed by the same or a similar American Group.

FLUORESCENCE

Within the past 15 years, the use of fluorescent lamps for general and



decorative lighting has increased to such an extent that the incandescent lamp now has a serious competitor. The spectral quality of the radiant energy from the lamp determines its usefulness in a particular application. Experiments at the National Bureau of Standards, conducted by Ralph Stair, have resulted in the development of a method and associated equipment for use in the precise evaluation of the spectral energy distribution of fluorescent lamps.

Radiant energy and wavelength are measured in the Bureau's studies on an NBS-modified Farrand double quartz-prism spectrometer. The light from a source is initially modulated at 510 cycles by a motor-driven sector disk. The modulated beam of light is split into its components as it passes through the motor-driven spectrometer and falls on a phototube at the end of the spectrometer path. As the spectrum is scanned the phototube detector is exposed to radiant energy of continuously changing wavelength. The output of the phototube, which responds to the magnitude of the energy of each narrow spectral region, is fed to a tuned amplifier designed for maximum linearity of response and negligible zero drift. Finally, the amplified signal is applied to a continuous-line recorder. The motor drive of the recorder is synchronized to the wavelength-selector drive on the spectrometer so that the wavelength of each narrow spectral region and the corresponding radiation magnitude detected by the phototube are recorded simultaneously.

PROMOTIONS

Three key engineering personnel have received promotions to top staff positions at *Emerson Radio & Phonograph Corp.*, 111 Eighth Ave., New York City. The promotions are made in connection with expansion of the engineering division for its increased research and development work both for electronic equipment for Government defense program and for civilian television and radio receivers.

The positions affected are those of chief television engineer, awarded to Mr. Walter Lukas; Mr. Francis J. Burger, chief radio engineer; and the post of chief mechanical engineer has been awarded to Mr. L. G. Zucker.

RADIO-FREQUENCY GENERATOR

The application of a *Westinghouse* two-kilowatt, 13.6 megacycle radio-frequency generator to the huge press shown in the illustration makes it possible to bond three pieces of plywood into a chime clock case in 90 seconds. Previously used animal glues, air-dried in the rotating rack in the background,

required a minimum setting time of four hours under ideal conditions.

DIRECT PROJECTION

A new departure in direct projection theatre television, the Simplex Theatre Television System, has been announced. Designed and manufactured by *General Precision Laboratory*, 63 Bedford Road, Pleasantville, N. Y., and sold through *National Theatre Supply*, the new system features an improved optical design said to produce higher over-all efficiency.

One feature of this *GPL* development is an improved mirror design for balanced light distribution over the entire screen. Illumination at the corners of the screen is 80 per-cent of that in the center. "Hot spot" glare is eliminated.

The projection tube has a suspension mounting that permits removal for cleaning without disturbing the positioning adjustment. The tube is suspended from the top of the barrel, and the tube mounting bracket may be removed through the top with the tube in place. All adjustments and controls for the barrel are at the top, easily accessible without using ladders or catwalks. With the throw distance of 65 feet, a picture 20 x 15 feet is obtained. However, the Simplex system may be operated over a wide range from 32 feet, an 8 x 10 picture on up to 80 feet when a picture approximately 25 x 19 feet is obtained.

NEW LITERATURE

Low Resistance Test Sets

A new bulletin L-12 describing its line of low resistance test sets and milli-ohmmeters, including several new models, has been issued by *Shallcross Mfg. Co.*, Collingdale, Pa. Originally developed for determining the quality of airplane and railway electrical welds or bonds by direct measurement or resistance and/or comparison with test standards, the instruments have since been used in many other applications.

Coil Winding Machines

The *George Stevens Mfg. Co., Inc.*, Pulaski Rd. at Peterson, Chicago 30, Ill. has issued a 32-page catalog illustrating and giving detailed descriptions of a line of coil winding machines which wind practically every kind of coil for laboratory or production line. One section deals with special and individual applications, another section lists accessories.

Mica Products

Descriptions, specifications, and applications of Macallen built-up mica electrical insulation products are fully covered in a new 20-page product bulletin issued by *Insulation Mfgrs. Corp.*, 565 W. Washington Blvd., Chicago 6, Ill. Built-up mica is used to insulate coils, commutators, armature slots, heating elements, and many other electrical and electronic units. Types included in the bulletin are commutator segment plate, plate for flat work, molding plate, mica combinations in sheet, tape, and roll forms, heaterplate and tubing.

CALENDAR of Coming Events

OCT. 29-31—Radio Fall Meeting, King Edward Hotel, Toronto, Ont., Canada.
NOV. 1-3—Audio Fair, Hotel New Yorker, New York City.
DEC. 10-12—Joint IRE-AIEE Computer Conference, Benjamin Franklin Hotel, Philadelphia, Pa.
NOV. 12-15—NEMA Convention, Haddon Hall, Atlantic City, N.J.
NOV. 16-17—Kansas City Section IRE Conference.
NOV. 29-DEC. 1—First JETEC General Conference, Absecon, N.J.
DEC. 6-7—AIEE Conference on Feedback Control Systems, Haddon Hall Hotel, Atlantic City, N.J.
JAN. 21-25, 1952—AIEE Winter General Meeting, Hotel Statler, New York.
JAN. 30—IAS-ION-IRE-RTCA Conference on Air Traffic Control, Astor Hotel, New York.
MAR. 3-6, 1952—IRE National Convention, Waldorf-Astoria Hotel and Grand Central Palace, New York, N.Y.

Carrier-Type Supply

(*Continued from page* 15)

tem. The slope of the curve at any point is essentially the slope of the transfer characteristic of the germanium diode (with about 30,000 ohms in series) multiplied by the gain of the a.c. amplifier.

When the regulator is delivering comparatively large load current, the bias on the series tube V_4 is low, and the control system is operating on the right-hand toe of the Fig. 1 curve Since this means poor regulation at high loads, it is desirable to supply an extra bias somewhere to keep the system operating on the high-slope portion of the curve. A very simple way to do this is by adding the compensating resistor R_1. This resistor tries to put a positive bias on the grid of series tube V_4, and the carrier output rectifier V_3 is forced to develop from 10 to 30 volts extra to counteract it.

Carrier amplification has been applied in many cases where a d.c. amplifier of unusual characteristics was needed. Besides the well-known chopper amplifiers for low-level d.c. measurements, Fleming[2] has described a unit capable of delivering 1 ampere to a 7 ohm load, from d.c. to 4000 cycles. A 30 kc. carrier was controlled at about 10 volts level by a linear plate-voltage modulator, then amplified, and passed through an output transformer and a large dry-disc rectifier. Over-all feedback was employed to get linearity.

A simple carrier-type d.c. amplifier was reported by Black and Scott,[6] using type 6L7 tubes in a conventional balanced modulator.

The problem of regulating a 50 kilovolt supply[3,4] has been solved by a scheme basically the same as that shown in the preceding pages. Transmitting tubes were used as series elements, controlled by a carrier d.c. amplifier having a tuned output transformer with high-voltage insulation.

An interesting application of a high-frequency carrier is indicated in Fig. 3. Oscillograph photography of transients requires that the oscilloscope beam be blanked off for long periods. The "Z" axis terminal in most instruments is capacitively coupled to the grid of the cathode-ray tube, and direct coupling to the grid is awkward because of the potentials involved. The addition of a suitable transformer and rectifier to the CRT grid circuit makes it possible to blank the beam by feeding an r.f. carrier to the transformer, and the operation of the oscilloscope for other purposes is not affected at all.

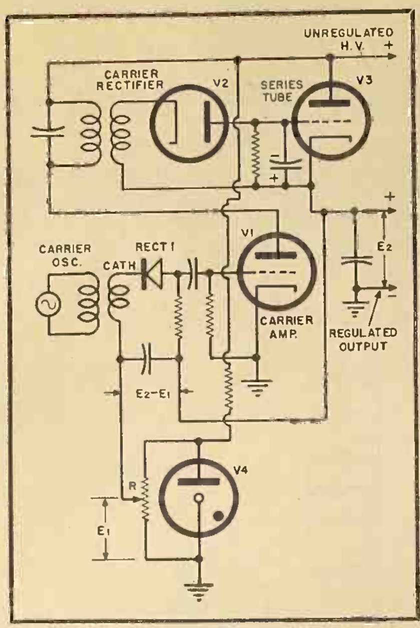


Fig. 5. Simplified schematic of a carrier-type regulated supply.

Germanium crystal diodes make more stable modulators than do thermionic tubes, as is evidenced by their use in the *Bell Telephone* system. The conduction of either a crystal or a thermionic diode for small carrier voltages depends essentially on the bias current. In applications where the input signal is essentially a current rather than a voltage, the carrier method of amplification is particularly suitable. On the basis of small-signal a.c. resistance versus bias current, even the characteristics of the 6H6 are remarkably stable. For low frequencies the mechanical chopper is the best, lacking the temperature sensitivity of the germanium diode.

By the use of transformers, both the input and the output of a carrier amplifier can be made free from any common connection with the intervening tubes. Differential amplification can thus be accomplished with no restrictions at all on the potentials existing between the signal sources and ground.

REFERENCES

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6. *Black, L. J. and Scott, H. J., "A D.C. and Audio Frequency Amplifier", Proc. I.R.E.,* (1940) *v.* 28, *p.* 269.

PHOTO CREDITS

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Pulse Standardizer

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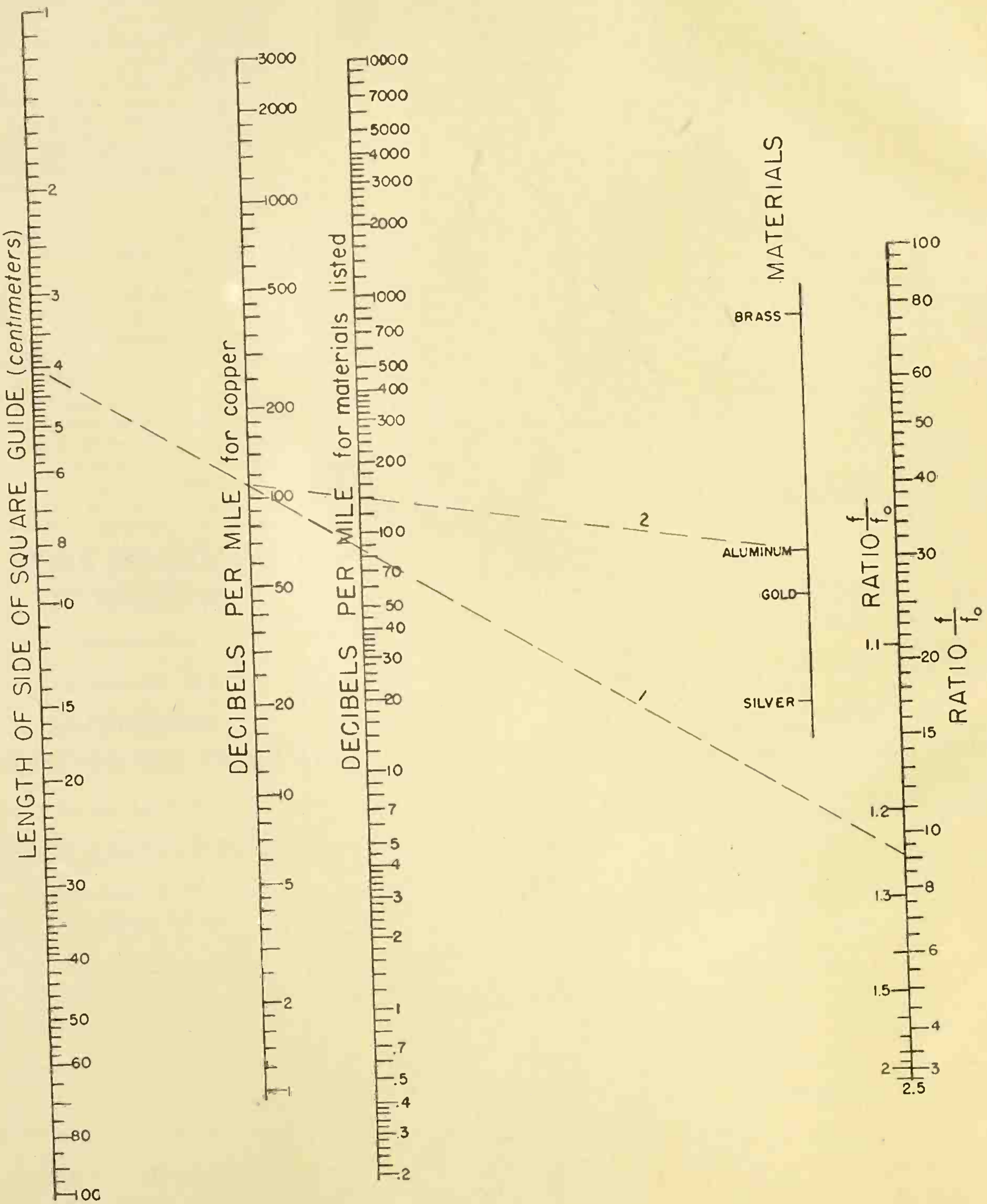
input. A noise level of under +4 volts will be attenuated by the unit, but noise at +6 volts will be standardized.

If both sections are used for a common operation, we may mix the two outputs by connecting a short 93 ohm cable from the output jack of one section to a tee connector on the output jack of the other and continuing with a single terminated line.

The pulse standardizer just described was built for test work on an electronic digital computer. The circuit constants which determine the arbitrary standard were selected to produce 0.1 μsec, half-sine-wave pulses, with a maximum output of 37 volts for +6 volts or more input. The equipment was purposely overdesigned to give maximum reliability at the computer's pulse-repetition frequency of 3 megacycles, and by test has been found to operate successfully up to 5 mc. with only a 10% reduction in maximum output. The unit does not contain its own power supply, but any reasonably stable external supply can be utilized. The dual-construction feature, in addition to saving rack space and installation time, enables the user to mix the outputs of the two sections and obtain a waiting time of less than 0.1 μsec between pulses.

SQUARE WAVE GUIDE ATTENUATION

A nomograph for determining the attenuation of the $TE_{1,1}$ mode in a square air-dielectric wave guide.



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