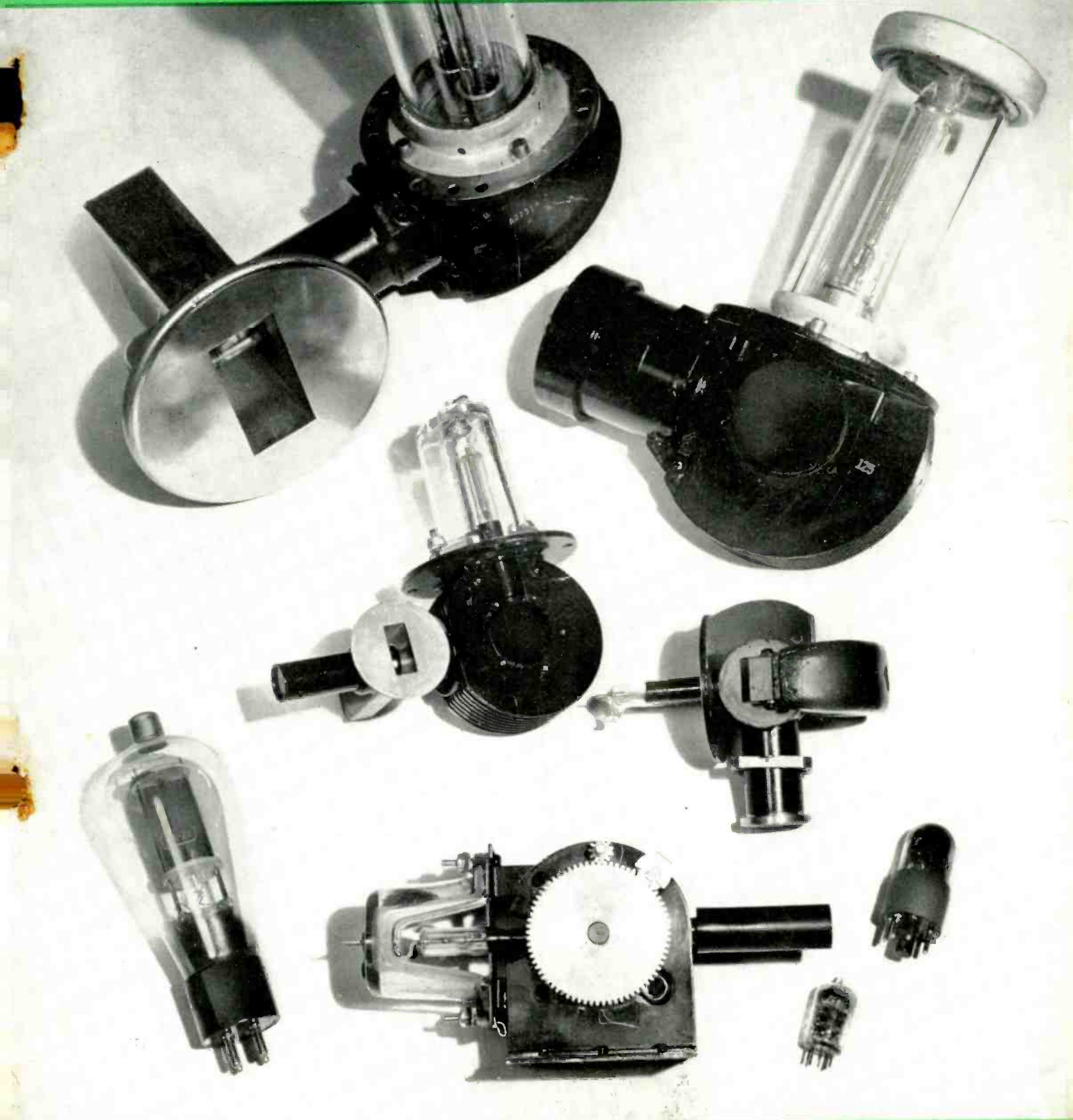
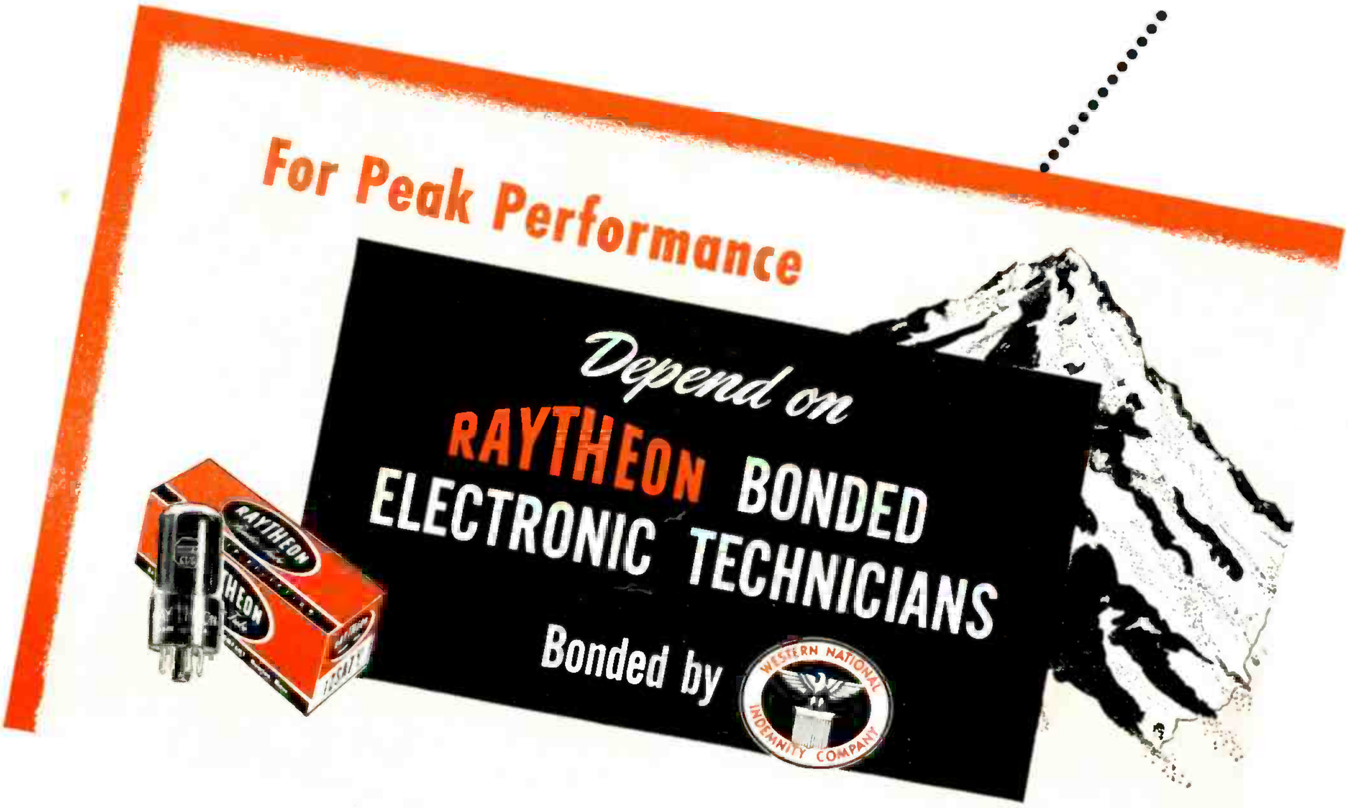
RADIO

FEBRUARY, 1946

Design • Production • Operation



The Journal for Radio & Electronic Engineers



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RADIO

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John H. Potts................Editor
Sanford R. Cowan...........Publisher

FEBRUARY, 1946 Vol. 30, No. 2

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COVER

Electron tubes for UHF and microwave applications, ranging from miniature receiving tube to high-power radar transmitting tubes. *(Raytheon Mfg. Co. photo)*

ARTICLES

MISCELLANEOUS

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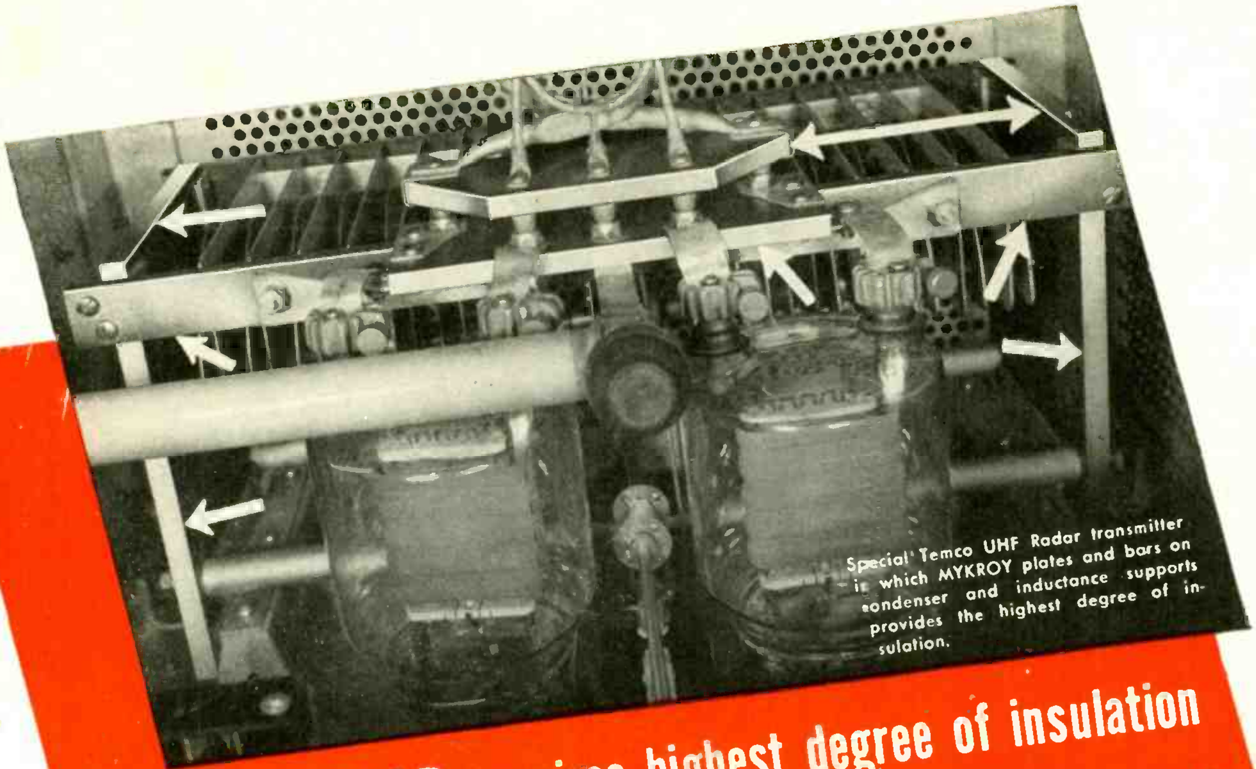


Special Temco UHF Radar transmitter in which MYKROY plates and bars on condenser and inductance supports provides the highest degree of insulation.

Because RADAR requires highest degree of insulation
MYKROY is specified at TEMCO

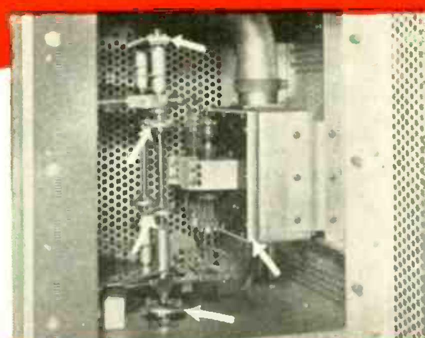
PERFECTED MICA CERAMIC INSULATION

"WHEN insulation of the highest order is specified you can always depend on MYKROY to fill the bill," says Morton B. Kahn, President of Transmitter Equipment Manufacturing Company, designers and builders of advanced Radar equipment, "and insulation requirements for Radar set an all-time high for the industry."

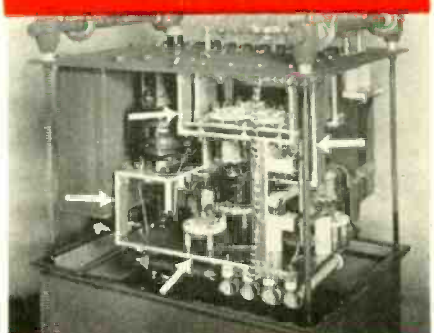
Mr. Kahn's opinion is shared by leading engineers and manufacturers everywhere who have also discovered that MYKROY is one of the best and most usable insulating materials ever developed for general and high frequency applications.

Mykroy is a perfected Glass-Bonded Mica Ceramic made entirely of inorganic ingredients, hence it cannot char or turn to carbon even when exposed to continuous arcs or flashovers. Its electrical characteristics are of the highest order and do not shift under any conditions short of actual destruction of the material itself. Furthermore it will not warp—holds its form permanently—molds to critical dimensions and is impervious to gas, oil and water.

Although MYKROY is a new and superior type of insulation it costs no more than many standard dielectrics of lower electrical and mechanical properties. It will pay you, therefore, to investigate MYKROY now in planning your new products. Write for Bulletins 101-104.



High powered Temco VHF Radar unit operates over wide frequency range utilizing forced air cooled tubes. MYKROY is used at all points requiring maximum insulations.



Temco 350KW Radar Pulse Modulator, all parts of which are completely immersed in oil, operates with a normal plate voltage of approximately 25000 volts. MYKROY is used at all critical high voltage points to assure maximum dependable insulation and particularly because it is impervious to oil.

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MYKROY IS SUPPLIED IN SHEETS AND RODS — MACHINED OR MOLDED TO SPECIFICATIONS

Transients

I. R. E. WINTER TECHNICAL MEETING

★ Accumulated engineering skill and hitherto secret developments were unveiled at the largest, most comprehensive showing of radio, radar, and electronics since the close of the war, at the I. R. E. technical meeting in New York. An unprecedented attendance of 7000 guests viewed the 170 exhibits and listened to the 87 technical papers which were crammed into the three-day meeting.

Highlighting tremendous strides made in electronics was the lunar contact announcement, heralding the technical world of tomorrow. This outstanding achievement constituted the central discussion at the annual banquet Thursday evening.

In the early days of radio, doubt existed that the new branch of engineering would become sufficiently important to justify establishment of an Institute. In retrospect it may be said that over a 34-year period the radio art developed to such an extent that it was able to decide a global war. The winter I. R. E. meeting brought home with tremendous impact the enormous contribution of radio to final victory.

Now it appears that radio has surpassed all its former achievements by effecting interplanetary contact. Where this path leads no one can accurately foresee, but interest in this and similar projects is at such an intense pitch that we may look forward to further spectacular achievements in the near future.

The I. R. E. can take sober pride in the part it has played in the development of radio to its present level, where it stands on the threshold of new and greater service to mankind.

PLENTY OF OPPORTUNITY

★ Having had an introduction to radio techniques in the armed forces, many discharged veterans now seek radio instruction in various technical schools. In most cases, the government is assisting them financially to obtain this training.

Established radio technicians frequently deplore this influx of new blood, contending that the field will soon become overcrowded. However, we venture to predict that, far from having too many skilled technicians within the next few years, the country will actually experience a shortage of trained radio men.

Vast new radio vistas are opening daily. We see technical opportunities expanding in electronic navigation, radio relay services, underwater electronic techniques, new personal and mobile applications, color television, air navigation and communication, and industrial electronics, to name a few of the more important. Only the reactionary-minded foresee an overabundance of technical ability in radio fields.

This influx of veterans to technical schools assures that high standards of workmanship will be maintained. These men are receiving fine instruction, both in theory and practice of their trade. When they graduate they are competent radio technicians who know how to do a job.

There is plenty of opportunity for them.

THIRTY YEARS AGO

★ Radio engineers did not dream of technical achievements during World War I which have now become commonplace. Yet a nostalgic glance at some of the technical papers published thirty years ago indicates that history repeats itself in technical fields, as elsewhere.

Haraden Pratt reported on "Long Range Reception with Combined Crystal Detection and Audion Amplifier." Today, this echo from the past finds parallel in crystal mixers used in microwave pulse techniques. We find miniature silicon detectors which measure only ¼ inch in diameter by ⅞ in length being manufactured specifically for that purpose. Without these non-linear mineral components, much microwave engineering would be impossible of accomplishment.

E. W. Marchant was likewise discussing the properties of the Heaviside layer at this time. Today, the ionosphere again looms as a topic of major interest. In fact, studies of wave propagation may be said to be entering an adolescent stage at this time.

In radio, as elsewhere, history appears to repeat itself.

ENGINEERING RESPONSIBILITY

★ Radio engineers, it may be observed, have a strong feeling of social responsibility. At a time when civilized society was threatened with a malignant and consuming fascist growth, American engineers worked at an accelerated pace to surpass all previous achievements.

Because this activity was successful, a liberated world is free to again walk the paths of social progress without fear or hindrance. Engineering progress is a two-edged sword which may be used to cut the bonds of the oppressed, but swung the other way it may likewise destroy civilization itself.

It is fortunate that engineers strive for enlightenment and social progress. By temperament and training, the engineer is a builder, not a destroyer.

Being in the foreground of public attention, the engineer is in a favored position to point the way to the world of tomorrow. His responsibilities are no longer confined to the laboratory, but extend to every corner of society—for society as we know it today cannot exist without the engineer.

His responsibility is grave. He will take it in his stride!

TECHNICANA

PULSE-WIDTH MODULATION

★ Pulse-width modulation has many practical applications, told by the editors of *Wireless World* in the December 1945 issue. An example of its use appears in the Army "10" set which is described in the same issue.

The pulse-width system is used in the Pye television sound apparatus, discussed on page 371. A width-modulated pulse carrying the sound signal is inserted within the line synch pulse as shown in the illustration.

A series of recurrent pulses may be used to carry information by varying the amplitude, duration, or interval between the pulses. When such a pulse train is modulated in duration, the width of individual pulses is varied in proportion to the amplitude of the modulating signal at that instant.

The television signal itself is unchanged. The line scanning frequency is 10,125 cps, and time available for scanning each line and transmitting the line synch pulse is 98.5 µs. The synch pulse itself occupies 10 µs. Within the period used for the line synch pulse, the duration-modulated signal is inserted, comprising a series of pulses with a mean duration of 3 µs, and varying from 1 µs to 5 µs.

With the 10,125 cps pulse frequency set by a 405-line picture, the sound frequency limit is about 5000 cps. With a 1000-line 25-frame system, there will be no difficulty in obtaining good response up to 10,000 cps.

It is pointed out that binaural sound systems may be designed about a dual pulse-width technique, and that in color television systems dual pulse systems may be used to transmit some of the additional information required.

While the normal blanking system must be modified in the pulse-width technique, this is said to incur no difficulties.

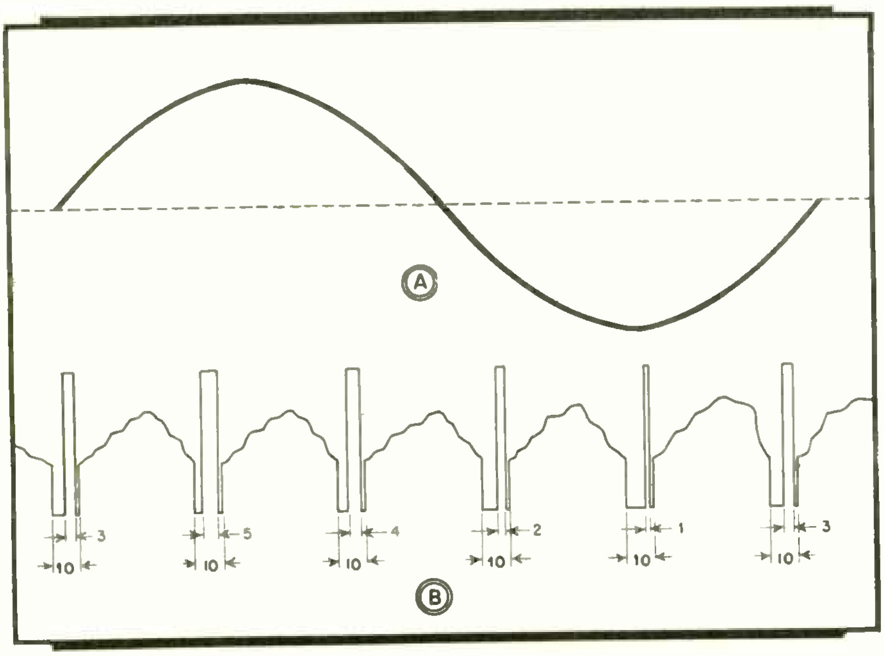


Figure 1

COAXIALS AT UHF

★ To design UHF cables using polyethylene as the dielectric, it was found necessary to also design measuring apparatus. Some of the factors involved are discussed by C. C. Fleming in an article entitled Measuring Coaxials at Ultra-High-Frequencies, in the January issue of the *Bell Laboratories Record*.

Attenuation is the characteristic measured, and while this could have been determined by observing standing waves with traveling detectors. it was found that greatest practical precision was obtained by measuring the insertion loss of a simple section of cable long enough to have considerable attenuation at the test frequency.

Insertion loss of a line section is defined as the loss of energy caused by inserting the line into the original circuit. A block form of typical circuit for measuring insertion loss is shown in *Fig. 2*.

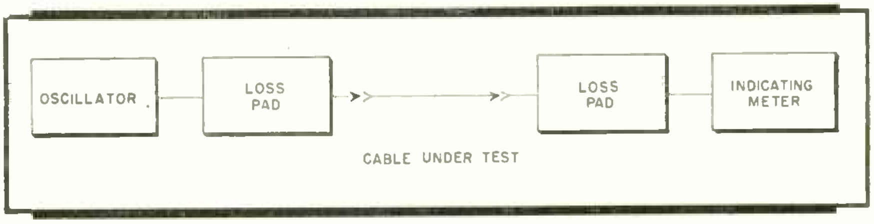


Figure 2

The loss pads are isolating pads which take the form of lengths of coaxial cable. "Measure" and "reference" readings are taken respectively with and without the test cable in the circuit, and the attenuation determined by subtraction.

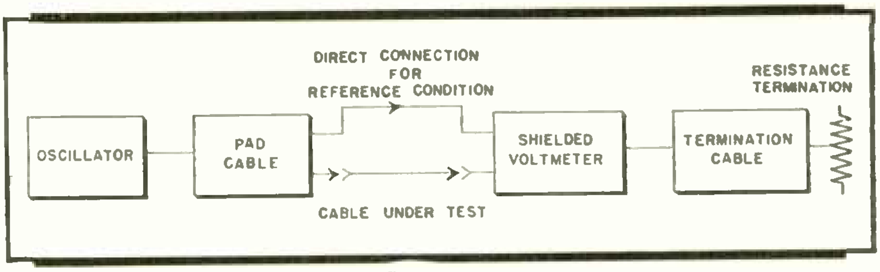


Figure 3

It is possible to place the indicating meter ahead of the second loss pad, for greater sensitivity. In *Fig. 3* is shown a block schematic of the shielded voltmeter method of measuring insertion loss.

The shielded voltmeter is usually operated in the range from 140 to 420 mc, thus including 400 mc as specified for attenuation measurements of production samples of polyethylene cables. It consists of a diode vacuum tube mounted on a short section of air-dielectric coaxial cable with Z_o about equal to that of the test cable. Tube and line are enclosed in a small copper box. The multiscale microammeter is calibrated in db.

The article also discusses measurements at 3000 megacycles and higher, likewise.

SINGLE SWEEP GENERATOR

★ Slave sweeps have not received as much attention as free-running sweeps, in spite of the fact that automatic synchronization and sweep expansion are definite advantages to be realized.

[*continued on page 8*]

Why this team could do

There are three reasons why the team of Bell Telephone Laboratories and Western Electric was able to handle big war jobs fast and well.

(1) It had the men — an integrated organization of scientists, engineers and shop workers, long trained to work together in designing and producing complex electronic equipment.

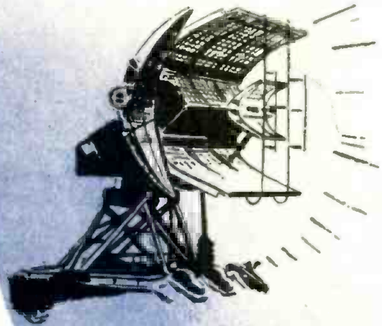
(2) It had unequalled physical facilities.

(3) Perhaps most important of all, it had a long-established and thoroughly tested method of attack on new problems.

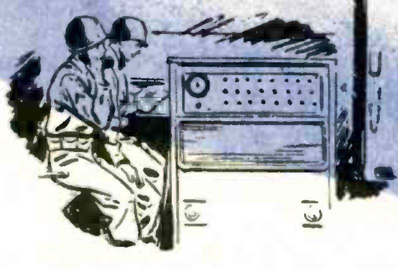
What is this method of attack?

In simple terms, it is this. Observe some phenomenon for which no explanation is known — wonder about its relationship to known phenomena—measure everything you can—fit the data together—and find in the answer how to make new and better equipment.

In the realm of *pure research*, Bell Laboratories have carried on continuing studies in all branches of science, with particular emphasis on physics, chemistry and mathematics. Often they have set out to gain new knowledge

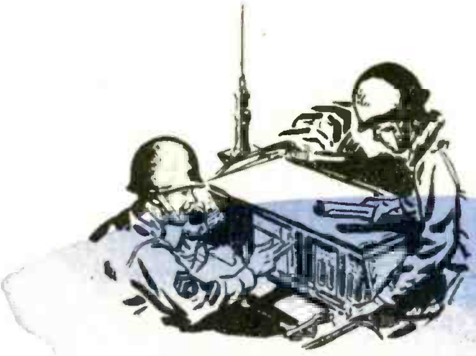


Bell Laboratories and Western Electric teamed up to supply more than 56,000 radars of 64 types—approximately 50% of the nation's radar production on a dollar volume basis.



Bell Laboratories designed and Western Electric produced more than 1600 electronic gun directors and gun data computers which greatly increased the accuracy of anti-aircraft and coast defense guns.

More than 1,000,000 airborne radio receivers and transmitters were furnished by Western Electric to help coordinate attack and defense in the air.



Bell Laboratories designed and Western Electric furnished more than 139,000 multichannel FM receivers and 74,000 multichannel FM transmitters for use by the Armored Forces and Artillery.

Bell Laboratories and Western Electric furnished revolutionary carrier telephone terminal equipment in great quantities—all "packaged" for quick installation in the field.

war jobs like these

with no immediate prospect of an application in the communications field. Time after time, their discoveries have eventually brought about fundamental scientific advances.

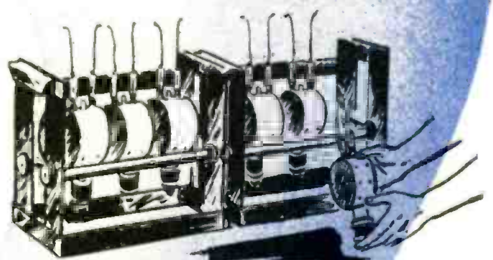
Applying new discoveries

As new discoveries have reached the stage of application, Western Electric manufacturing engineers have always worked closely with Bell Laboratories men to assure a final design suited to quantity production of highest quality equipment.

During the war, the capabilities of this unique research-production team expanded rapidly. New techniques were explored—new methods were developed—new ideas were born, rich with possibilities for the future.

What this means to YOU

Today Bell Laboratories and Western Electric are once more applying their facilities and their philosophy to the development and production of electronic and communications equipment for a world at peace. Depend on this team for continued leadership in AM, FM and Television broadcasting equipment.



Bell Laboratories and Western Electric played outstanding roles in the design and production of magnetrons and other essential vacuum tubes for use in radar and communications.

BELL TELEPHONE LABORATORIES

World's largest organization devoted exclusively to research and development in all phases of electrical communication.

Western Electric

Manufacturing unit of the Bell System and nation's largest producer of communications and electronic equipment.

TECHNICANA

[*from page 4*]

A single sweep generator particularly adapted to the investigation of transients is described by D. McMullan in an article entitled A Single Sweep Time Base which appears in the January 1946 issue of *Electronic Engineering*, published by Hulton Press, Ltd., 43-44 Shoe Lane, London, E.C.4.

The circuit of the sweep generator is shown in *Fig. 4*. In the static condition, V_4 is conducting and V_3 is cut off, causing V_2 to hold capacitor C_1 discharged. When a negative pulse is applied to the control grid of V_4, the trigger circuit immediately starts to change over to the other regime. As soon as plate current starts in V_3, the grid of V_2 is driven negative, and C_1 starts to charge through V_1, giving the working stroke.

When a negative pulse is applied to the tial approximately equal to the voltage drop across R_3, V_4 starts to conduct, and a negative pulse is applied to the grid of V_3 through C_2, causing the circuit to change back to its original condition.

Since the trigger circuit takes only a few microseconds to change from one regime to the other, and capacitor C_1 starts to charge as soon as plate current starts in V_3, the time delay between the application of the trigger pulse to V_4 and the starting of the working stroke requires only a fraction of a microsecond. As the length of the working stroke is unlikely to be less than a microsecond, this time delay is inappreciable.

The length of the trigger pulse is unimportant as long as its duration is less than that of the working stroke.

In order to expand one part of a cycle of a recurrent waveform, the generator must start at the proper point of the cycle. The amount of expansion depends on the length of the working stroke as compared with the length of the cycle.

The generator may be made to start at the correct time by arranging to trigger it with a peak of the signal waveform through a time-delay circuit. By adjusting the time delay, it is possible to start the sweep generator at the desired point of the cycle. In practice, this may be arranged by triggering the generator from an auxiliary generator which is operating in synchronism with the signal.

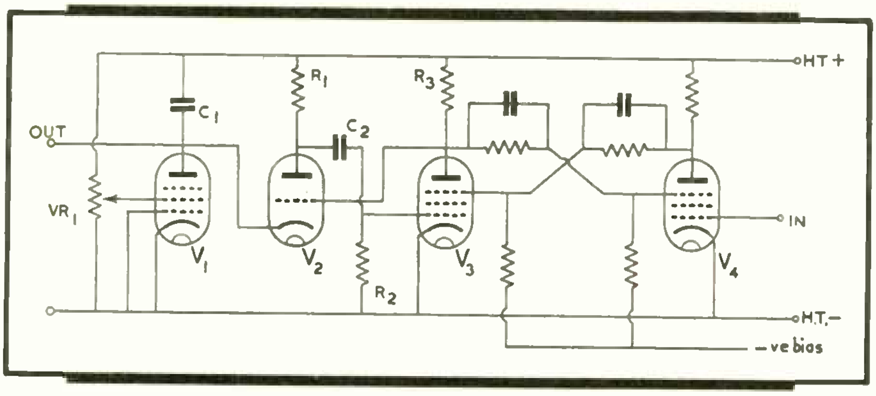


Figure 4

A circuit diagram for time-delay action is shown in *Fig. 5*, and a diagram illustrating the working of the sweep expansion circuit is shown in *Fig. 6*.

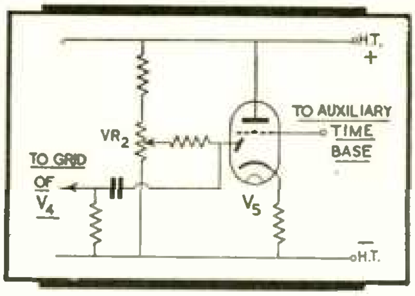


Figure 5

PRINTED WIRING AND RESISTORS

★ While the rugged miniature tube was the most important new development that made the proximity fuze possible, other important developments were a new type of miniature battery and a new method of circuit wiring.

By placing the battery electrolyte in a glass ampoule which was not broken until the shell was fired, the batteries could be stored indefinitely and not need to be replaced periodically as in the case of standard cells.

The method of circuit wiring was a radical departure from normal practice. This process, in which the circuit is "printed" on a ceramic plate, was but recently revealed at a meeting of the Institute of Radio Engineers at Marquette University by Dr. Cledo Bru-

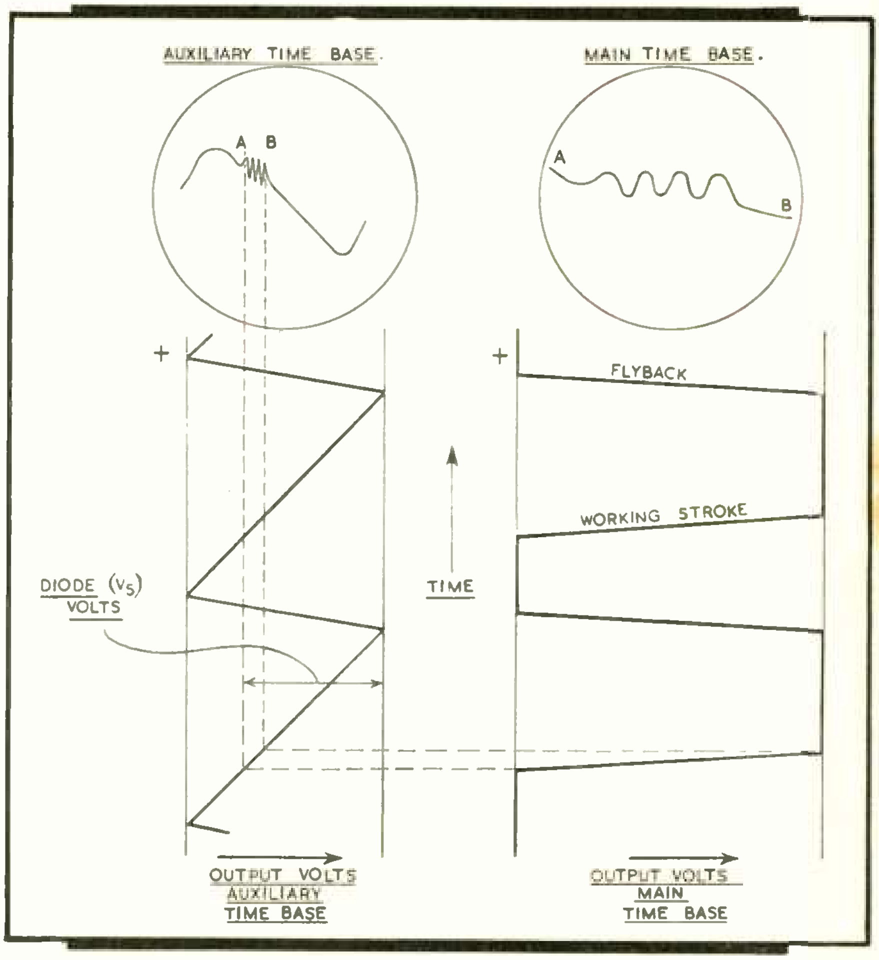


Figure 6

TECHNICANA

[*from page* 8]

netti of the National Bureau of Standards. The complete circuit can be formed in a simple process involving the use of suitable "stencils".

On the base plate is placed a silk mask with a pattern cut in it. A roller, like the inked roller of a printing press, is drawn over the mask. Instead of ink a thick silver paste is used. An impression of silver lines, which is the wiring of the circuit, is left on the plate.

Then another mask or stencil is placed over the plate and sprayed with carbon solution. This forms all the resistors in their proper positions in the circuit. Thin condensers are attached and other circuit elements connected in the proper places, and the wiring is completed.

SILICONE COATING FOR RESISTORS

★ The silicone resin family comes into its own again as a coating for power resistors intended for rigid military service. The development of a new coating for wire wound resistors was carried out under a WPB contract and is reported in the Dec. 1, 1945 issue of the *Journal of the American Ceramic Society* by Edward E. Marbaker, Senior Fellow of the Mellon Institute of Industrial Research.

The new coating enables the resistor to withstand the most severe thermal shock and water immersion tests of the Army-Navy specification, JAN-R-26. Operating at the maximum temperature of 275° C. the resistor qualifies as Grade 1, Class 1, in solder tab construction.

The silicone coating is highly elastic, compared with vitreous enamel coatings commercially used. Cracking, crazing, or peeling of the coating does not occur as a result of thermal shock due to differences in rates of expansion of the materials in contact, as occurs with vitreous coats. The criterion of the coating is the ability of the resistor to withstand thermal shock (from 275° C. to water at 0° C.) followed by operation again at 275° C. and immersion successively in concentrated salt water baths at 100° C. and 0° C., repeated for nine cycles.

The coating material has good dielectric strength, will not crack at −40° C., and is chemically inert and impervious to water.

The heavy white paint-like material is applied to the resistor in thin coatings. Baking for 15 minutes at 375° C. has produced satisfactory resistors. Curing must be carefully controlled to overcome tackiness and still not permit cracking. Several thin coatings are required to prevent the appearance of bubbles or pin holes. Abrasion resistance is inferior to that of vitreous enamel, but believed to be satisfactory.

The new coating can be removed from resistor which has failed in test, and this permits more accurate analysis of the causes of resistor failures than hitherto.

The author points out that in addition to failures due to porosity of the coating, those caused by porosity of the ceramic tube or cracking of the tube may be of equal importance.

For example, steatite or electrical grades of porcelain are not so likely to withstand thermal shock, these materials having fairly high coefficients of thermal expansion. Zircon porcelain, which has lower expansivity, may have higher water absorption and greater tendency to permit corrosion of the wire from the inside, due to salt water cycling.

Earlier in the development program several types of ceramic tubes, glazing materials, and wire were tried unsuccessfully. Differences in expansion rates and bunching of the wire during the glazing operations both contributed to the difficulties. A resistor using Kovar wire on a zircon porcelain tube was successfully glazed. However, the high thermal coefficient of resistance of Kovar, and its low resistivity, ruled out the use of this wire.

Another resistor, wound on a pre-enameled steel tube with Nichrome wire, passed the JAN qualification tests. Objections to the use of steel in high frequency applications, difficulty in winding on the glazed surface, and shorting of the terminal bands to the steel tube, contributed to the rejection of this design.

BOOK REVIEWS

Electronic Dictionary, by Nelson M. Cooke and John Marcus, published by McGraw-Hill Book Co., New York, 433 pages, leatherette binding, $5.00.

The field of electronics embraces that branch of science which concerns itself with the conduction of electricity through gases or in vacuum. Practical applications include radio communications, wire line telephones and telegraph facilities, television, facsimile, radio navigation, radar, industrial control and many others. The majority of these are highly technical in nature and the field is rapidly expanding. As a result, the radio engineer's vocabulary contains thousands of terms, many of which are not included even in the latest unabridged dictionaries. Rapid growth of electronics during the war has resulted in groups of engineers employing different colloquialisms for the same or similar terms. It is therefore timely that a dictionary of technical terms be published.

This book defines some 6,000 electronic terms in simple style. No mathematics is used although it is this reviewer's impression that a few simple equations would have served a useful purpose in clarifying and adequately defining some of the terms. The book is well illustrated, averaging several figures per page. Many terms, although originally company trademarks, have been popularized to the extent that they are now considered general usage; these are likewise defined.

A.S.A. standards of abbreviation and hyphenating are used throughout the text. This book appears to cover its field fully and to contain at least most of the generally useful electronic terms. It is highly recommended for the bookshelf of every communication engineer.

Two-Way Radio, by Samuel Freedman, published by Ziff-Davis Publishing Company, 185 North Wabash Avenue, Chicago 1, Ill., 506 pages, cloth binding, $5.00.

This book's avowed purpose is to describe the mechanics and applications of two-way radio for all forms of fixed, mobile and portable communications. It can be said that it succeeds in achieving this purpose.

Commander Freedman's philosophy is that "it is technically, financially, and legally possible for everyone to enjoy the advantages of two-way radio communication." His twenty chapters constitute a good case for his position. Half the book is concerned with planning and details of equipment. The latter half discusses the numerous fields of application for two-way radio, such as railroad, police, fire, forestry service, highway, public transportation, marine and aeronautical applications, and personalized use. The book is liberally illustrated.

A latter chapter discusses general sources of trouble and trouble-shooting. Another useful chapter points out applications requiring licenses, as well as those which do not.

The book ends with descriptions of typical installations used in various eastern localities such as Chatham, Mass., South Portland, Maine, the Cape Cod area, the states of Maine, Connecticut, and Michigan. The Border Patrol's two-way radio system is also described and illustrated.

Thus, Two-Way Radio is a book for planners and executives, rather than engineers. It is non-mathematical and semi-technical in treatment. The book has been written from a broad qualitative viewpoint, and is authoritative throughout.

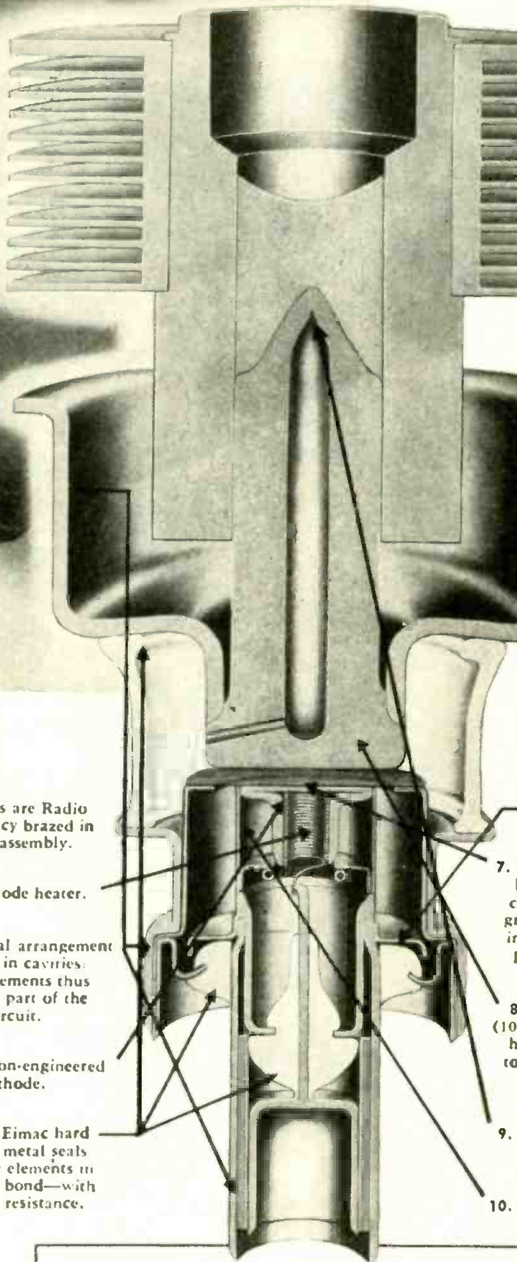
PRECISION ENGINEERING ON A MASS PRODUCTION SCALE

. . . that's the basic achievement of Eimac engineers in providing typically outstanding Eimac performance in these tiny triodes. Observe the many functions of the Eimac developed 3X100A11/2C39 triode—cross section view. Note actual size shown in photo above.

Designed for special military purposes—these tiny triodes will find valuable application in commercial fields. An indication of their high efficiency is their ability to operate on frequencies up to 2500 megacycles and their high plate dissipation (100 watts) despite the extremely small effective plate area—about the size of a dime.

By developing and improving the performance of this tiny triode Eimac has again demonstrated an extraordinary ability to accomplish outstanding results in Electronic vacuum tube engineering—an ability which has established Eimac as first choice of leading Electronics engineers throughout the world.

1148



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TYPE 3X100A11/2C39 EIMAC TRIODE

GENERAL CHARACTERISTICS

ELECTRICAL	
Cathode: Coated unipotential	
Heater Voltage	6.3 volts
Heater Current	1.1 amps
Amplification Factor (Average) 100	
Direct Interelectrode Capacitances (Average)	
Grid-Plate	1.95 μμfd
Grid-Cathode	6.50 μμfd
Plate-Cathode	0.030 μμfd
Transconductance (I_B=75 ma., E_B=600 v.) (Av.)	20,000 μmhos
Maximum Plate Dissipation	100 watts
MECHANICAL	
Maximum Overall Dimensions	
Length . 2.75 inches	Diameter . 1.26 inches

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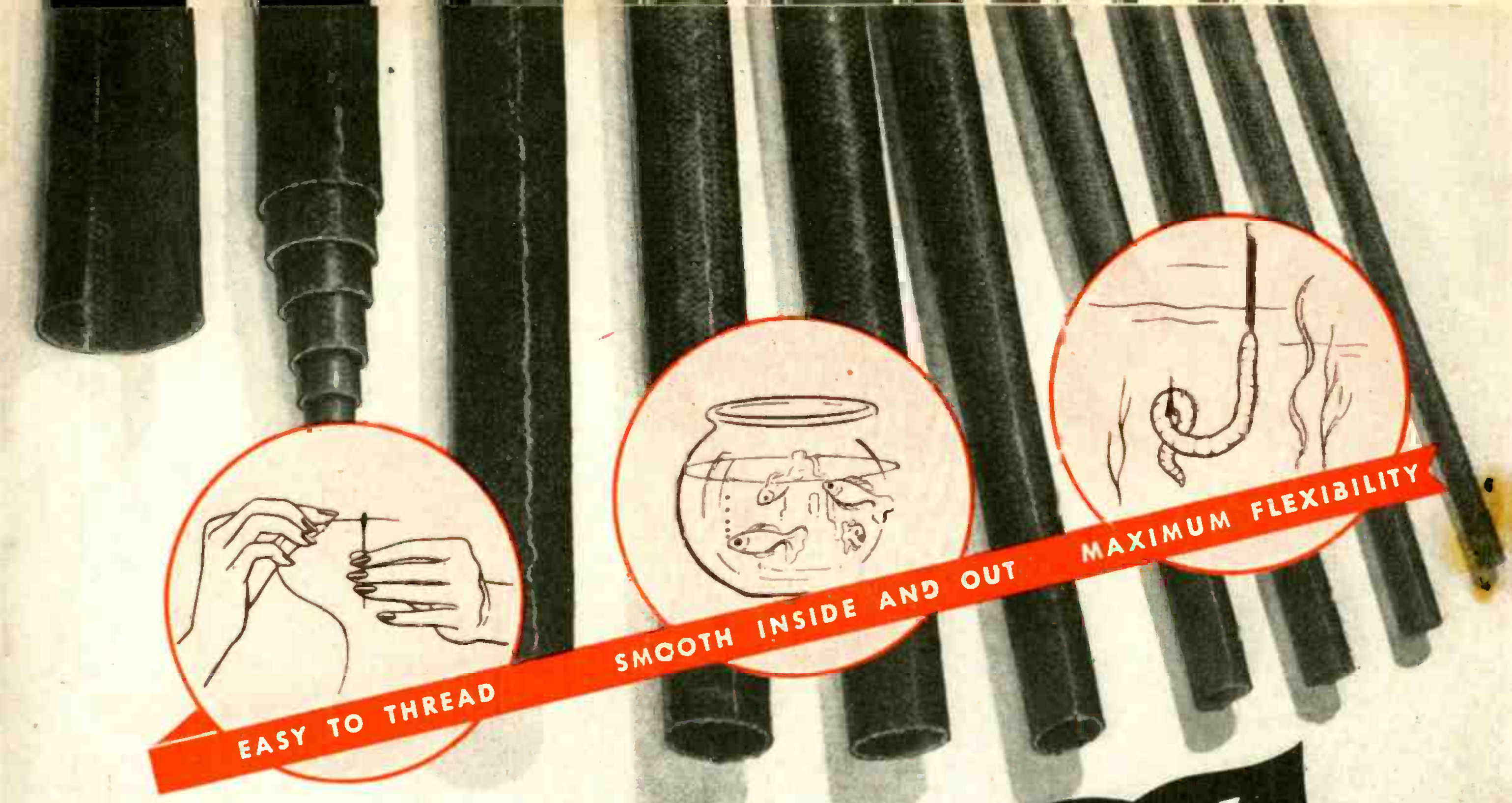

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Power Frequency Changers for Color Television

DR. D. L. JAFFE

Polarad Electronics Co.

Synchronization problems of color television circuits require an engineered 120-cycle power source for proper operation. CBS uses the supply described by Dr. Jaffe

COLOR TELEVISION SYSTEMS require a 120-cycle power source. The frame frequency in color television systems which utilize a disc with the three primary colors, is at the present time 40 cycles per second.

Within this interval, three rasters must be painted on the cathode-ray screen, corresponding to the three primary colors. Thus the time for each raster is 1/120 second. The field frequency is accordingly 120 cycles per second. In interlaced television systems, the field frequency must be in absolute synchronism with the power-line frequency, to avoid picture drift in the vertical direction.

A favorable solution to the problem has been found in synchronous induction frequency changers as discussed below. An experimental 5 kw installation designed and constructed by the writer has proven entirely satisfactory over an extended period of service, and is now in use by the Columbia Broadcasting System.

Theoretical Considerations Involved in Design of Equipment

When a wound-rotor three-phase induction motor is driven in a direction opposite to the electrically produced rotating field, the frequency of the rotor currents will be directly proportional to the relative speed between the field and moving conductors. If the stator is wound for p_1 poles and a three-phase voltage of frequency f_1 is applied, a revolving field will be produced in the air gap, the speed of which is related to frequency by

$$n_F = 120\, f_1/p_1 \text{ rpm}$$

Let the rotor be driven in a direction opposite to the rotating field, and if the rotor is wound for p_2 poles and its speed is n_R rpm, the rotor frequency will be

$$f_2 = (n_F + n_R)p_2/120 \text{ cps}$$

where $(n_F + n_R)$ is the relative speed between rotating field and rotor conductor. This equation for f_2 can be rewritten as

$$f_2 = s n_F p_2/120 \text{ cps}$$

where

$$s = (n_F + n_R)/n_F$$

For most commercial induction motors $p_1 = p_2$ so that $f_2 = sf_1$. If the rotor is driven at the same speed as the rotating field, the rotor frequency will be

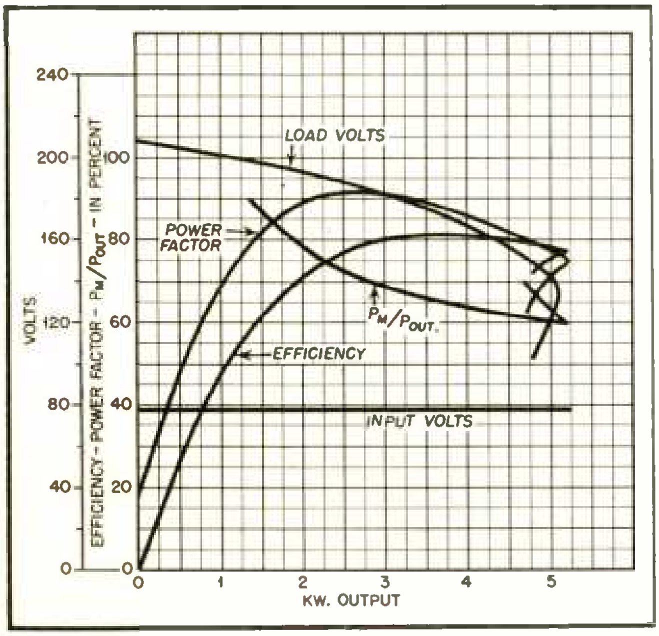


Fig. 2. Regulation, efficiency, power factor, and mechanical power input in terms of kw output; constant input voltage

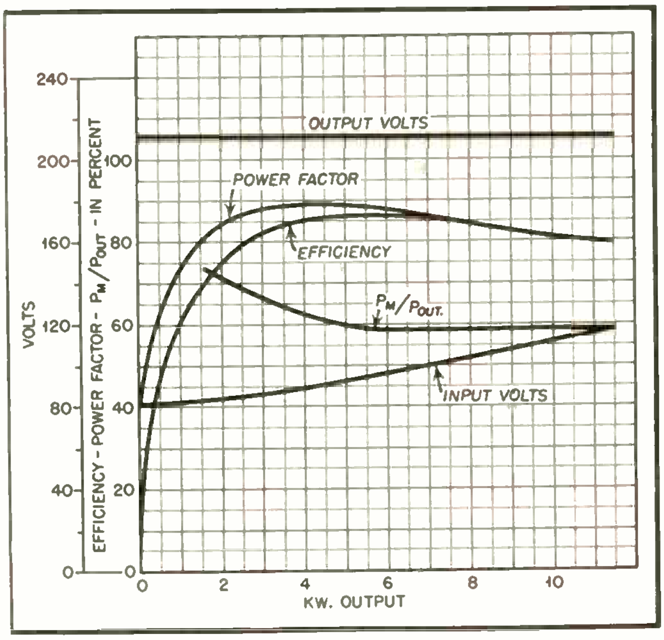


Fig. 3. Regulation, efficiency, power factor, and mechanical output to induction frequency changer; constant output voltage

twice the line frequency. For constant output frequency, the induction frequency changer should be driven by a suitable synchronous motor.

At standstill a voltage aV is induced in the rotor (assuming open-circuited rotor) where a is the ratio of transformation with respect to the stator winding and V the stator voltage. If the rotor is now driven into the rotating field, the rotor induced voltage is

$$V_R = saV$$

With a three-phase resistive load connected to the rotor, the power delivered to the load (neglecting losses) will be

$$P_L = 3^{1/2} \quad {}^{7}I\Lambda S$$

where I_R is the rotor current referred to the stator. The current I_L is reflected by transformer action into the stator so that the power input to the stator becomes

$$P_S = 3^{1/2}\, VI_L$$

Let P_m represent the mechanical power input so that

$$P_s + P_m = P_L$$

$$P_m = 3^{1/2}\, VI_L(S-1)$$

The ratio P_m/P_L is useful in that it yields the mechanical power necessary for a given load. It is

$$P_m/P_L = (S-1)/S$$

Experimental Investigation

To check the above theory and become familiar with this method of frequency conversion, a 15 kva three-phase induction motor driven by a d-c dynamometer was arranged as shown in *Fig. 1*. Two load tests were made, one at constant input voltage and one at constant output voltage. Characteristics are shown in *Figures 2* and *3*.

For constant voltage input the regulation is extremely poor and maximum power output occurs at 5.25 kw. This is explained by the fact that the machine under test was a more or less homemade induction motor. A slip-ring rotor had been inserted in an alternator frame without regard to air gap.

It has since been found that properly designed induction motors when run as frequency changers offer no regulation problem up to 125% overload. In spite of the excessive air gap, efficiency and power factor were surprisingly good, being about 80% at maximum power output. A properly designed 5 hp induction motor shows an efficiency and power factor of approximately 90% at full output.

The frequency changer was run at constant output voltage by increasing the input volts as load was applied. Without exceeding the primary current rating, the machine delivered 11.5 kw with an efficiency and power factor of 80%. Theoretically the ratio of mechanical power input to electrical power output is 50% as calculated with equation $P_m/P_L = (S-1)/S$. Actually it is 58%.

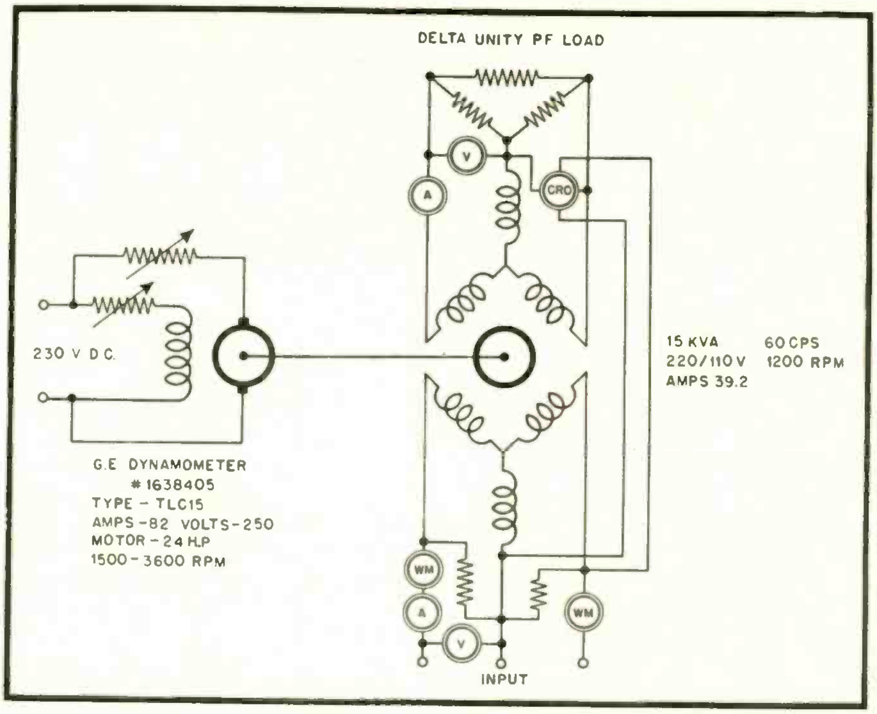


Fig. 1. Schematic wiring diagram of synchronous induction frequency changer

Practical Design

On the basis of the above experimental results a program was undertaken to construct such a motor-generator set. A five horse-power, three-phase wound-rotor induction motor was obtained, and the rotor rewound. Details of this process may be found in "Fractional Horsepower Machines", by Veidt (McGraw-Hill Book Co.). The rotor was rewound to deliver 115 volts at 120 cycles per second.

At the time, difficulty was experienced in obtaining a synchronous motor. However, a 15 horse-power Fynn-Wechsel self-synchronous motor was obtained and used in this project.

The two machines were mechanically coupled and rigidly fastened to a steel frame to form an integral unit, and no mechanical difficulties were encountered.

Ed. note—This system of power frequency conversion is the only practical means of obtaining a 120-cycle source at reasonable cost, which provides absolute synchronism with the 60-cycle line frequency.

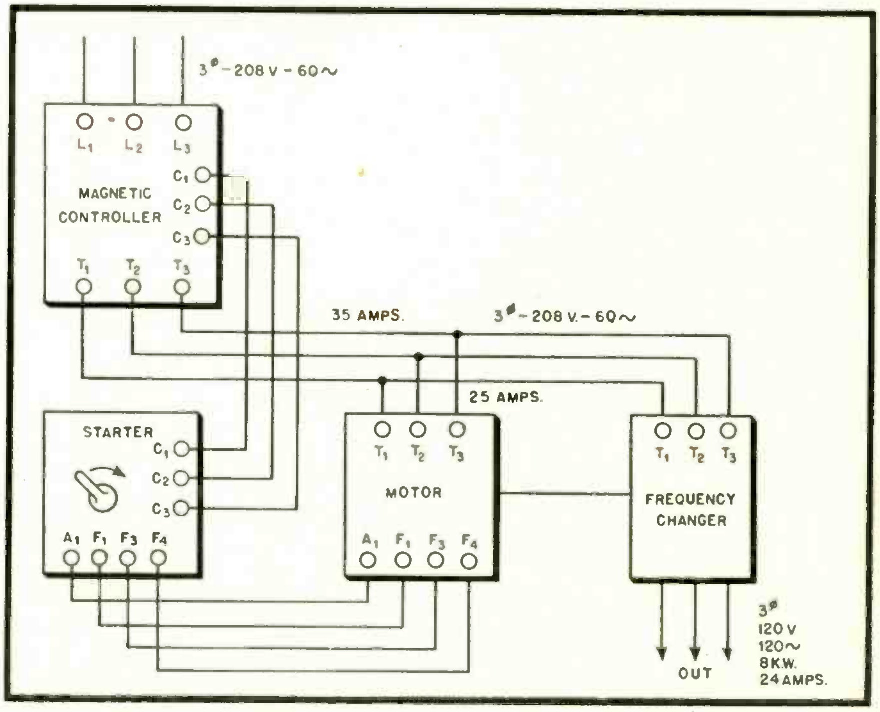


Fig. 4. Interconnections of synchronous induction frequency changer

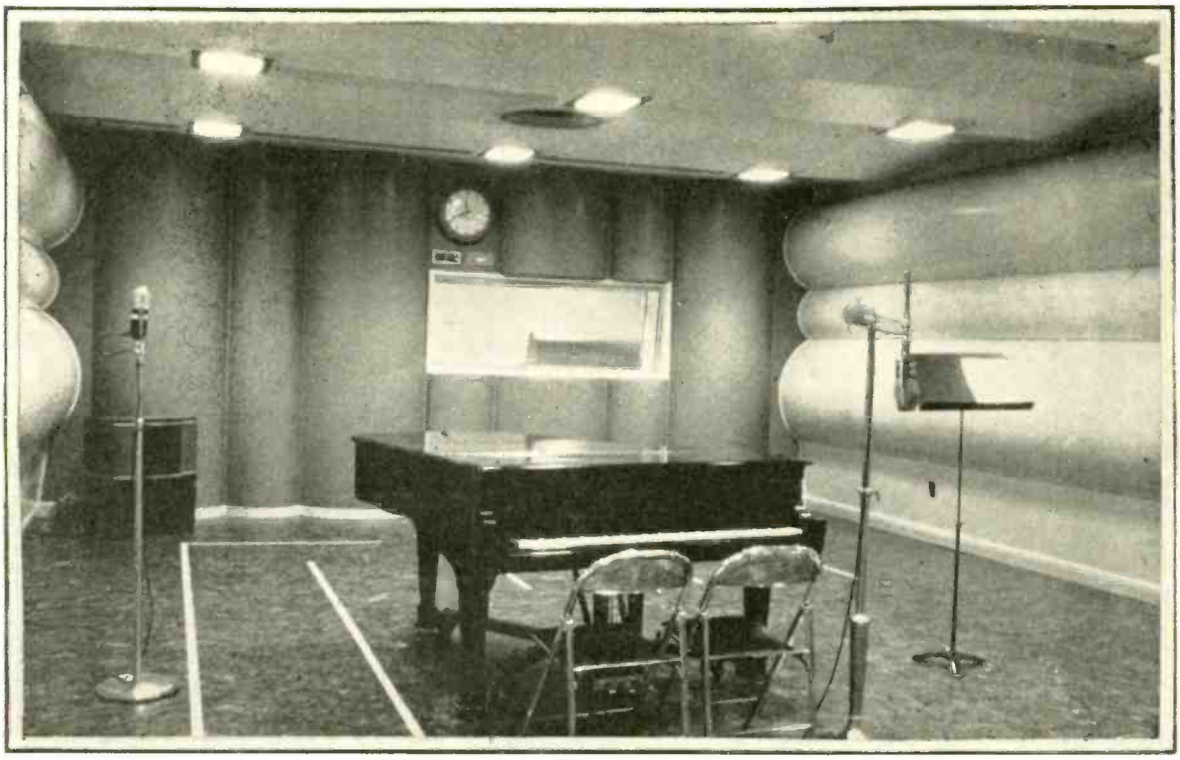


Fig. 1. The comparative improvement of the convex-panel structure over the conventional parallel-plane wall studio in beauty as well as operation, is illustrated in this view of Studio "C", WFAA, Dallas, Texas
[*RCA photo*]

Acoustical Treatment of BROADCAST STUDIOS

JOHN B. LEDBETTER

• **A review of acoustic engineering developments over the past ten years, with the quantitative analysis of studio design**

BEFORE A MICROPHONE can be placed to best advantage with reference to a given pickup, the engineer must be familiar not only with the directive pattern of the microphone but also with the acoustical characteristics or reverberative qualities of the studio and the extent to which they may be affected by such variable factors as the number of people in the audience and the angle of placement of microphone and talent in relation to the reflecting and absorbent surfaces.

Early forms of acoustical treatment consisted mainly of heavy drapes or curtains hung across one end of the room and augmented by various sound-absorbent panels attached to the walls. Although such methods of "dead room" treatment effectively eliminated objectionable echoes and wave distortion caused by excessive reverberation and multiple reflection from hard walls, it also eliminated most of the overtones by reducing to an excessive degree the period of reverberation at the higher and middle frequencies, with the result that program reproduction was entirely lacking in brilliance and timbre.

Reverberation Time

Reverberation is the reflection of an original sound back and forth a number of times between the various surfaces of a room, and when properly controlled results in adding a greater brilliance of overtones in music and a more vibrant quality to speech.

Reverberation time was first standardized by Dr. Wallace C. Sabine of Harvard University as the time in seconds required for a sound reverberating within a room to decay to one-millionth of its original intensity, or to decrease 60 db. Establishing $T = KV/a$ as the basic formula, Sabine determined the value of constant K as 0.05 and derived the formula

$$T = 0.05\ V/S\ \alpha a$$

where T is the reverberation time in seconds, V is the volume of the room in cubic feet, S is the total room surface and αa represents the average coefficient of absorption at a frequency of 512 cycles per second. Although this formula holds for large or live rooms, theaters, churches and auditoriums, a discrepancy exists in comparatively dead rooms such as broadcast studios where the average coefficient of absorption exceeds 0.05.

A modification of the original Sabine formula, developed by Carl F. Eyring, allows computations of greater precision and should be used in all broadcast studio analyses. Eyring's formula is

$$T = 0.05\ V/-S\ \log_e\ (1 - aa)$$

the value of components being identical to those used in Sabine's formula.

In determining the reverberation time and the amount of sound-absorbent material necessary for a particular studio, one must not lose sight of the fact that the average coefficient of absorption aa represents the sum of the absorption coefficients of not only the fixed surfaces of the studio including door and window areas, but also that of such variants as room furnishings, rugs, and the number of people in the studio.

Within an ordinary studio the length of reverberation is controlled to some extent by the size of the audience, a large number of people absorbing more sound and hence shortening the reverberation time, and a fewer number absorbing less sound and thereby lengthening the reverberation. This tendency may be corrected by fitting the auditorium section of the studio with generously upholstered oversize chairs so as to present essentially the same degree of frontal absorption regardless of the size of the audience.

Discussion of the evolution of determinant factors used in reverberation formulae has been given with reference to the rectangular parallelepiped type of structure. Eyring's formula may also be used in orthogonal applications of polycylindrical wave diffusing columns provided the proper coefficients of absorption are selected.

ROOM SHAPE	VOLUME CU.FT.	PURPOSE AND APPLICATIONS	DIMENSIONS (FT.)			RVB.* TIME
			H	W	L	
CUBICAL, SMALL	1,000 1,500	ANNOUNCE BOOTH; STAND-BY STUDIO	8.0 9.0	10.0 11.0	13.0 15.0	.59 .62
INTER-MEDIATE	2,000 3,000 4,000	SMALL GROUPS; SOLO WORK	10.0 11.5 13.0	12.5 14.5 15.5	16.0 18.5 20.0	.64 .67 .70
AVERAGE SIZE, AVERAGE SHAPE	5,000 10,000 15,000 20,000	SMALL PLAYS, ORCHESTRAS; AVERAGE GROUPS, GENERAL UTILITY	11.0 14.0 15.5 17.0	16.5 22.0 25.0 27.0	27.5 35.0 39.0 43.0	.72 .78 .83 .86
AVERAGE SIZE, LONG ENDS	5,000 10,000 15,000 20,000	SAME AS ABOVE	11.0 14.0 15.5 17.0	13.0 17.0 19.5 22.0	35.0 45.0 49.5 54.0	.72 .78 .83 .86
AVERAGE SIZE, LOW CEILING	5,000 10,000 15,000 20,000	SAME AS ABOVE	9.0 11.0 12.5 13.0	21.0 27.0 30.0 34.0	27.0 34.0 40.0 45.0	.72 .76 .83 .86
LARGE SIZE, AVERAGE SHAPE	50,000 90,000 250,000 500,000	LARGE AUDIENCES; CONGREGATIONS	23.0 25.0 30.0 40.0	37.0 45.0 75.0 100.0	59.0 80.0 105.0 128.0	.97 1.05 1.20 1.32

*OPTIMUM REVERBERATION TIME IN SECONDS (0.7 THAT OF AUDITORIUMS)

Typical dimensions and relative applications of various studios

Music vs. Speech

The optimum reverberation period of a broadcast studio is a function of its physical proportioning, its total coefficient of sound absorption, and the amount of acoustical treatment applied to its surfaces. The correct type and amount of acoustic material required to maintain an absolute optimum condition depends on the use for which the studio primarily was designed. A studio designed specifically for music, for example, does not necessarily contain the optimum reverberation characteristics required for perfect reproduction of speech.

In an auditorium or music studio the reproduction of orchestra or chamber music approaches an optimum condition when the overall reverberation time of the studio is allowed to assume a low-frequency period approximately 60 per cent greater than the reverberation period at 512 cycles and decreasing logarithmically until a period 3 to 5 per cent below the reference value is obtained in the frequency range between 1000 and 2000 cycles. The lower value is desirable because this range represents the period of maximum sensitivity of the human ear. From 2000 cycles the reverberation period rises gradually until at 8000 cycles an increase of approximately 10 per cent is attained.

For optimum *speech* conditions, however, the reverberation time curve is quite different. The period of reverberation through the lower and middle frequencies is practically uniform and is made rather low in order to eliminate excessive bass response or "boominess". Above 500 cycles the reverberation time is allowed to rise until at 8000 cycles an increase of approximately .25 per cent has been effected. This increase permits a greater degree of intelligibility in speech by high-frequency reinforcement and at the same time minimizes reverberation changes due to variance in audience size.

Corrective Treatment

The amount of reverberation increase or decrease at various frequencies caused by undesirable reflection or absorption at any point of the studio may be corrected or equalized by installing alternate panels of reflective and absorptive materials of the proper degree to provide compensation. The size and content of these panels are dependent on the various factors mentioned previously and vary with individual studios. In all cases treatment must be such as to avoid large areas of untreated or reflective surfaces, particularly when such surfaces lie in opposite or parallel planes.

In a room having excessive sound retardation or absorption characteristics, music and speech sound dead or "flat", while a room with too long a reverberation time gives a hollow or "cavity" effect. A distinct echo or "back-slap" may result from secondary wave reflection from the live or rear wall when the length of the studio has been excessively proportioned, and if sustained by successive reflections gives rise to "flutter" which results in confused and distorted sound.

Design Considerations

In a studio approximating a rectangular prism, a multiplicity of paths exist wherein distribution, reinforcement or cancellation of first-order waveforms takes place. As is evident, multiple reflection of even a sine wave produces phase distortion at the sound source, and because large numbers of secondary wave reflections occur between all parallel surfaces of opposing walls, ceiling and floor surfaces, a condition is often set up wherein a considerable portion of harmonic energy undergoes partial or complete cancellation.

When the primary sound energy consists of complex waveforms, such cancellation affects whole frequencies and results in the occurrence of "dead spots" or standing waves which produce considerable interference to frontal dissemination or dispersion of primary waves, causes serious distortion of sound pickup and extreme difficulty in accomplishing proper microphone placement.

It is apparent, therefore, that in studios designed for broadcast use equal consideration must be given to correct physical proportioning as well as to the methods to be used to attain proper acoustical control. Room design should incorporate surfaces having as few parallel planes as possible. Elimination of standing waves caused by parallel-wave reflection may be accomplished by "Vee-ing" or staggering sections of plane wall surfaces at an angle of approximately 10 degrees, or by employing various forms of either convex diffusive columns or alternate convex-plane panels, as will be discussed later in more detail.

Determining Studio Proportions

Studio dimensions are selected according to the purpose which the studio must serve, and are derived from the ratio of the cube root of two to one. This ratio corresponds to a fundamental separation of one-third octave between height, width and length. Other ratios may be derived from the fundamental if desired, provided the major dimensions remain separated by at least one integral octave. In the average studio, for example, physical dimensions are progressively separated by a *two-thirds* octave in order to prevent the accumulation of resonance or "standing waves".

The two-thirds octave separation, a derivation of the fundamental $\sqrt[3]{2}$, corresponds to the ratio $\sqrt[3]{4}$ and approximates the ratio 2:3:5, which, representing height, width, and length, respectively, has been selected and standardized by leading engineers as the ratio of proportioning essential for proper sound pickup and distribution, and for allowing economy in selecting studio space.

Typical dimensions and relative applications of broadcast studios of varying sizes are shown in the table. The figures as shown are intended only as examples and are based on a study of optimum conditions of several theoretically correct structures. The actual dimensions may be altered and made to comply with any form of architectural design as long as the integral-octave separation is maintained.

The overall reverberation time of transmitted programs is affected not only by the reverberation qualities of the broadcast studio but also by those of the room in which the receiver itself is located. For this reason the optimum reverberation time of the studio alone must be less than that of an auditorium of the same size in order to allow comparative results in overall reproduction. An optimum reverberation period approximating .7 that of auditoriums is preferable in broadcast studios of similar size and shape.

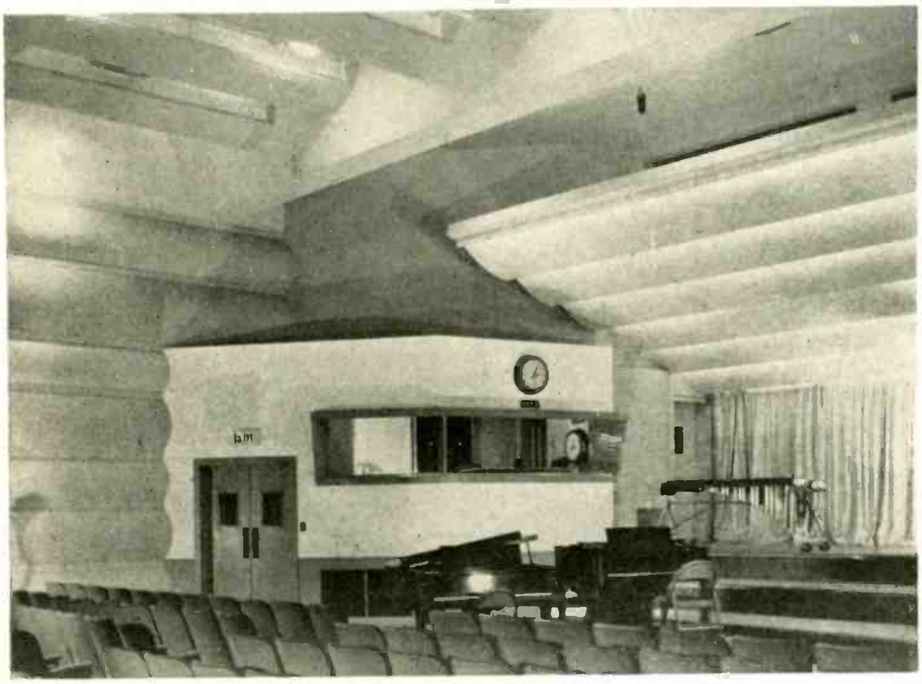
Determining Average Period Of Reverberation

The average period of reverberation is determined by taking the arithmetical mean of the reverberation times for frequencies of 128, 256, 512, 1024, 2048 and 4096 cycles per second. These frequencies are analogous to physical pitches of the key of C. 128 cycles, or low C, approximates the fundamental frequency of the male voice, while 256 cycles, middle C, represents the fundamental frequency of the average female voice. 512 cycles is used as the reference frequency in all reverberation measurements, while 2048 cycles represents the approximate period of maximum sensitivity of the human ear.

Measurements of reverberation time are made with a high-speed level recorder in conjunction with a microphone, amplifier and loudspeaker. The amplifier and speaker are placed at predetermined distances from the microphone and fed a warbled frequency either from a special decay-time record

[*continued on page* 60]

(Above) Front view of Studio "A", WLW, Cincinnati, Ohio



(Left) This unique method of combining polycylindrical diffusers and plane panels was designed exclusively and constructed by Crosley engineers under direction of R. J. Rockwell, technical supervisor. Shown is Studio "A" of WLW, Cincinnati. Another exclusive feature is an improved draftless, constant temperature air-conditioning system

FM FREQUENCY CONTROL

This article is the text of a paper delivered before the Institute of Radio Engineers, describing a new FM AFC design

Frequency modulated systems, particularly frequency modulated broadcast systems, present a number of problems. The system must be capable of modulation, but the center frequency must be accurately maintained. If the system is what is commonly called direct FM, the modulation is produced by varying the constants of the tank circuit of the primary oscillator at an audible rate. The extent of this frequency shift is approximately one tenth of one percent, at an audio frequency that may be as high as 15 kilocycles.

To build an oscillator that is capable of being modulated in this manner, it is necessary to keep the tank circuit capacity low and the inductance high. If a high C circuit is used, the oscillator will be so stable that it will be impossible to modulate it to the extent required, particularly at the higher audio frequencies.

On the other hand, the center frequency of the system must be maintained within approximately one five hundredth of one percent. Using the highest capacity and the lowest inductance practicable in the tank circuit, and using the best temperature compensation technique in building the oscillator, such stability is still not possible. The fact remains, also, that such an oscillator could not be frequency modulated even if it could be built.

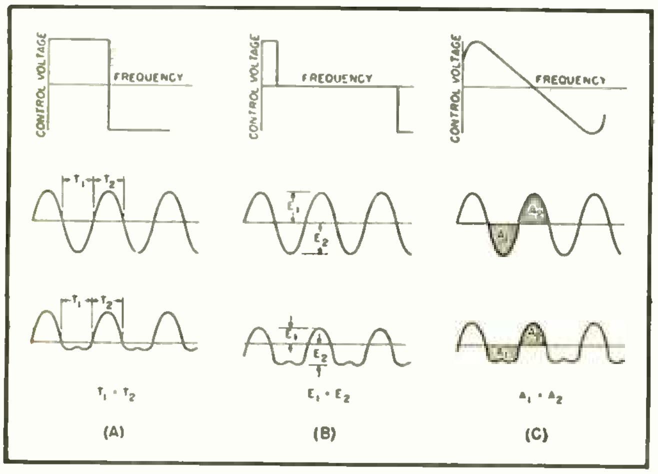
Since the required stability cannot be built into the oscillator, it becomes necessary to use some automatic frequency control system. There have been several such systems devised in the past, one of which utilized an LC discriminator to to maintain the center frequency a fixed number of kilocycles away from a reference frequency which was crystal controlled. Naturally, any drift or mistuning of the discriminator resulted in a corresponding shift of the transmitter center frequency. Another disadvantage was that it was difficult to realize a high control ratio. Control ratios in the order of 15 to 20 were generally used.

An improved system consists of dividing a sample of the oscillator frequency enough times so that the phase shift resulting from the frequency modulation is approximately one radian or less. This frequency, along with two waves in quadrature from a crystal oscillator, are applied to the grids of a pair of mixer tubes. The output of these mixer tubes is the difference between the divided oscillator frequency and the crystal frequency. This output, being two phase, is used to run a synchronous motor which turns the oscillator tuning capacitor in the direction to correct the oscillator frequency. This system presents the usual problems associated with a multiplicity of tuned circuit and moving parts.

Another system, known as indirect FM, uses a crystal oscillator. The output of this oscillator is phase-modulated and subsequently multiplied enough times to obtain the required frequency excursion. In order to end with the correct carrier frequency, this phase modulation must take place at quite low frequencies, which requires carefully shaped band pass multipliers. Also, audio distortion inherent to this system requires that extra precautions be taken to limit it to low values.

All of the above systems have the property of basing the control on the average frequency. If a plot is made of frequency versus time, a line is drawn equal to the frequency without modulation, the areas enclosed by the curve on each side of the line will be equal.

Several systems of frequency control have been suggested which would correct to a different point. One of these would correct to where the total time that the frequency was above the assigned frequency would be equal to the total time that it was below, *Fig. 1(A)*. If the modulation was a pure sine wave, such a system would correct to the



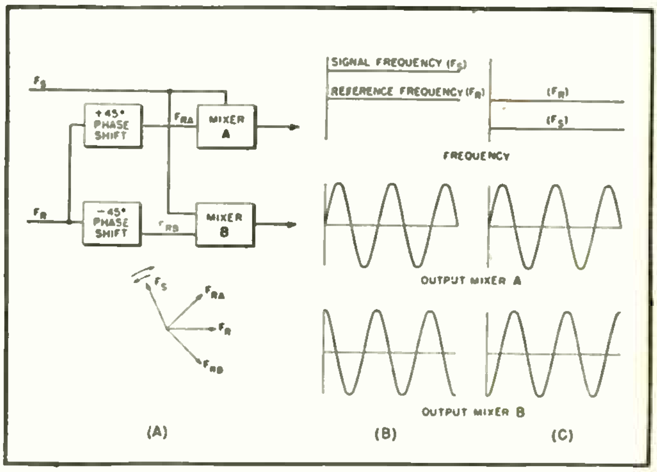
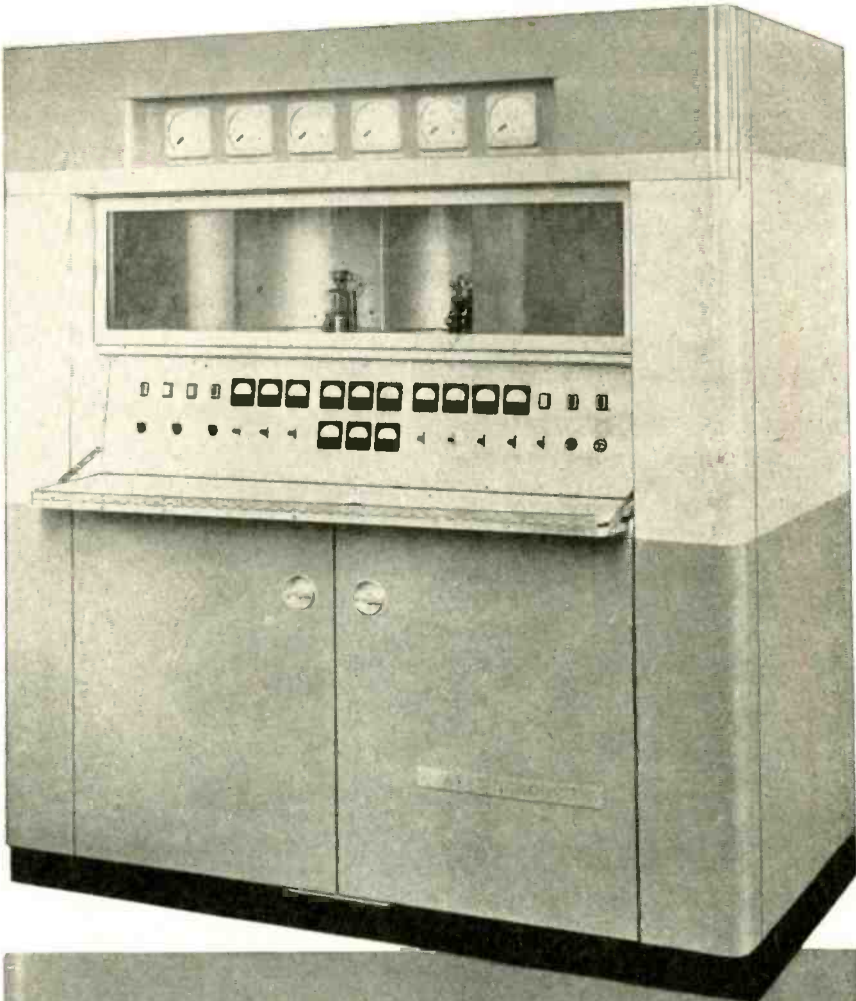
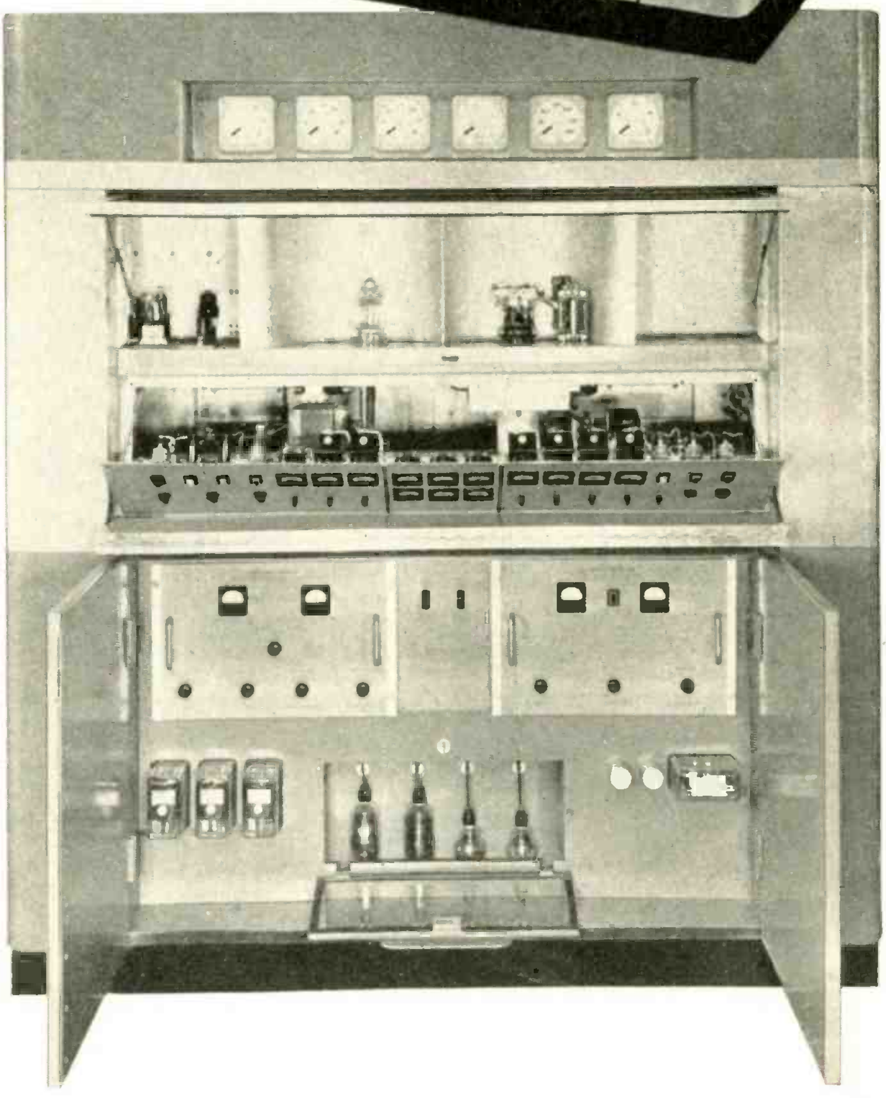


Fig. 1. (left) (A) Frequency control system may equalize total time that frequency is above and below assigned frequency (B) Maximum excursions above and below assigned frequency are equalized in another system (C) Areas on either side of assigned frequency may be equalized. Fig. 2. (right) (A) Vector relations in the phase-shift network (B) Relative mixer outputs with crystal frequency lower (C) Relative mixer outputs with crystal frequency higher

SYSTEM

J. R. BOYKIN





assigned frequency. With unsymmetrical modulation, however, some of the sidebands would often spill over into the adjacent channel. Another system proposed would adjust the frequency so that the maximum excursion above the assigned frequency was equal to the maximum excursion below the assigned frequency, *Fig. 1(B)*. Such a system would keep the sidebands within the assigned frequency spectrum under steady state conditions, even though the wave form of the modulation was not symmetrical. Under transient conditions, such as are encountered with program material where a non-symmetrical waveform may be quickly followed by another non-symmetrical waveform of opposite polarity, there would be considerable spilling over into the adjacent channels if the correction were slow, or unwanted frequencies introduced if the correction were fast enough to minimize the resulting adjacent channel interference.

Fig. 1(C) shows the correction based on the area enclosed on each side of the assigned frequency. If a crystal oscillator is built to operate on the assigned center frequency and mixed with the output of the modulated oscillator into a non-linear impedance, a beat note will be produced which has an instantaneous frequency equal to the instantaneous excursion of the modulated oscillator. The total number of cycles of beat note produced while the oscillator is on one side of the assigned frequency will be exactly proportional to the area enclosed by that part of the curve. It follows, therefore, that if the total number of cycles produced while the oscillator is on the high side of the assigned frequency is equal to the total number of cycles produced while the oscillator is low in frequency, then the transmitter is operating at the correct point, or the specified center frequency.

A new system of frequency control has been developed which takes advantage of this latter fact. Each cycle of beat frequency between the signal frequency and the reference frequency is used to generate a pulse. The pulses are separated into two circuits, one circuit receiving the pulses when the signal frequency is higher than the reference frequency and the other receiving the pulse when the reference frequency is the higher. A pulse counting circuit is so arranged that when a pulse appears on one of these circuits, a definite charge is transferred from a point of fixed potential to a storage capacitor. When a pulse appears on the other circuit, a charge of the same number of coulombs is transferred from the storage capacitor to a point of fixed potential. Since there is no bleeder resistor across the storage capacitor, the charge on the storage capacitor tends to remain constant during any period when there are no pulses. The voltage appearing across the capacitor, which is proportional to the charge stored in it, is used as a control on a reactance tube which controls the frequency of the master oscillator.

Referring to *Fig. 2(A)*, the signal from the modulated oscillator is designated by F_s, and the reference frequency from the crystal oscillator is F_r. This crystal frequency is fed through two 45 degree phase shift networks, each consisting of one resistor and one capacitor of approximately the same number of ohms. One of these networks shifts the phase forward by 45 degrees and the other retards the phase by the same amount. Mixer *A* and mixer *B* are used to mix these quadrature voltages with the signal frequency. *Fig. 2(B)* shows the relative output of the two mixers when the frequency of the modulated oscillator is higher than that of the crystal. It will be noticed that the output of mixer *B* leads the output of mixer *A* by 90 degrees. In *Fig. 2(C)*, the signal frequency is lower than the reference frequency and consequently the output of mixer *B* lags the output of mixer *A*.

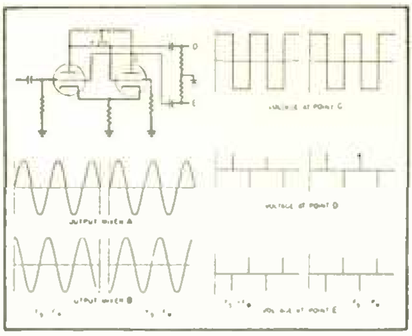


Fig. 3. Phase relationships of mixer outputs and multivibrator

The output of mixer *A* is used to trigger a direct coupled multivibrator. This multi serves as an electronic switch to make square waves from the sine wave input. Since the input to the multi is much greater than the amount required to trigger it, the time at which the multi turns over will be approximately the time at which the voltage of the output of a mixer *A* passes through zero. At this time the output of mixer *B* is at either a positive or negative peak. *Fig. 3.*

The voltage on each of the two multi plates is differentiated by a series capacitor and shunt resistor. The resultant two voltages appear as a series of pulses of opposite polarity. *Figs. 4A* and *4B* show the result when these pulses are superimposed on the output of mixer *B*. It will be noticed that when the pulses appearing at point *D* are superimposed on the output of mixer *B*, the pulses subtract from the sine wave if the signal frequency is higher than the reference frequency, and add to the sine wave if the signal frequency is lower than the reference frequency. In the case of the pulses appearing at point *E*, the pulses add to the sine wave if the signal frequency is higher and subtract if it is lower. These two signals, appearing at *F* and *G* of *Fig. 4* are passed through biased diodes which are used as pulse discriminators. The bias on these diodes is set just above the peak value of the output of mixer *B*. The result is that when the pulses add to the sine wave, the bias is overcome and the pulse is passed through the diode. When the pulse subtracts from the sine wave, the bias prevents the diodes from conducting and the pulse is not passed. This arrangement serves to separate the pulses onto two circuits. One circuit is energized one pulse for each cycle of beat frequency when the signal frequency is low.

Fig. 5 shows two pulse counters arrange in a balanced circuit to control the charge in the storage capacitor C_s. The votlage across the storage capacitor is used to actuate a cathode follower which in turn controls the bias on the modulator tube. Since the modulator tube controls the frequency of the modulated oscillator, the frequency is a direct function of the charge on the storage capacitor C_s. It will be noticed that there is no bleeder resistor across this storage capacitor, hence the system has no natural frequency which the frequency control must overcome. If the average frequency of the modulated oscillator is different from the reference frequency, the charge on the storage capacitor is continually changed in the direction to overcome the difference. When the difference has been overcome, the system becomes balanced, and the only tendency to pull off is due to stray leakages which cause negligible frequency drift.

The modulated oscillator is operated on one ninth of the assigned frequency of the transmitter. It has been found that simple tuned circuits in the multiplier stages provide adequate selectivity without cutting the sidebands when the modulation is applied in this region.

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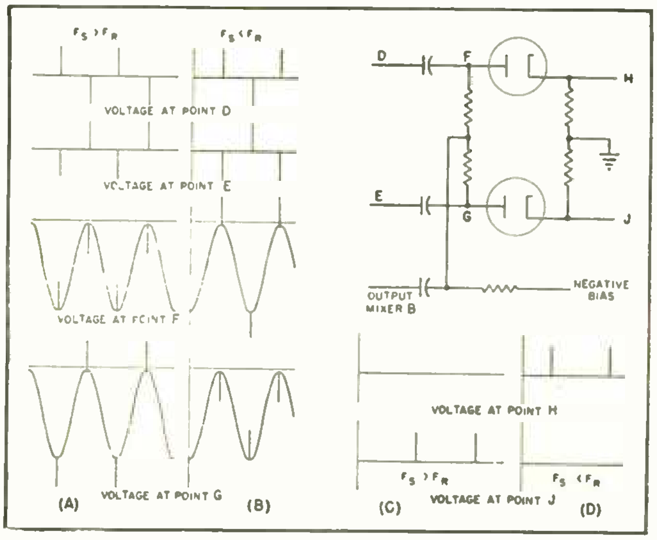


Fig. 4. Pulse outputs from multivibrator may add or subtract from mixer outputs, allowing pulse discrimination with diode circuit

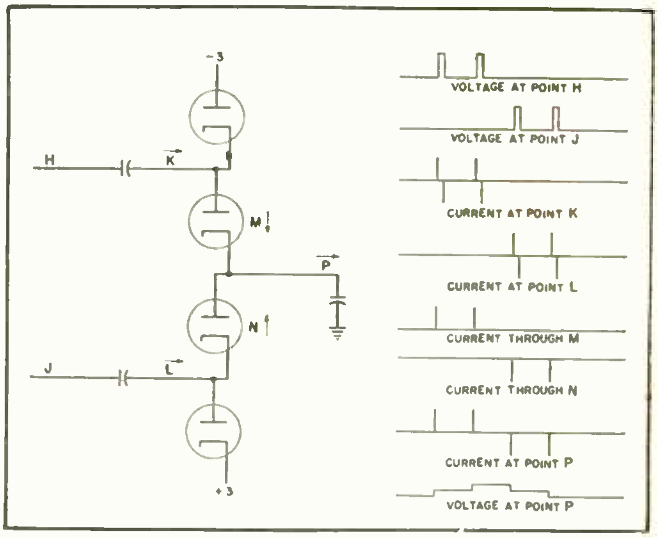


Fig. 5. Pulse-counter circuit yields frequency-controlling output voltage, utilized by modulator tube. No bleeder is used in circuit

Irregularities In RADIO TRANSMISSION

OLIVER P. FERRELL

Further useful engineering data on wave propagation

CONCLUSION

THE RADIO TRANSMISSION vagary of which the FM and television industry is most cognizant today, although mostly by name only, is sporadic E. Only the wholesale introduction of FM has been necessary to bring about this widespread interest. Yet under the pseudonym of "short-skip" it created little interest, beyond that of the 5 meter radio amateur, some 6 to 7 years ago. While the radio amateur awaits sporadic E as a possibility of contacting stations 400 to 1500 miles distant, the same amateur has discovered and formulated some very definite and worthwhile conclusions about this transmission irregularity.

Riddle of Sporadic E

Within the last 18 months we have heard much of the assignment of VHF as it pertains to the service areas of FM and television. This study as presented before the F.C.C. has consisted largely of recordings of the sporadic E virtual heights and critical frequencies. While undoubtedly this method will eventually solve the riddle of the formation of sporadic E, it leaves much to be desired in presenting a composite picture of the overall transmission effects. To heighten this understanding the irrelevant factors introduced during the war has brought many a disgusted engineer to the point of exclaiming, "How much do we actually know about this stuff?"

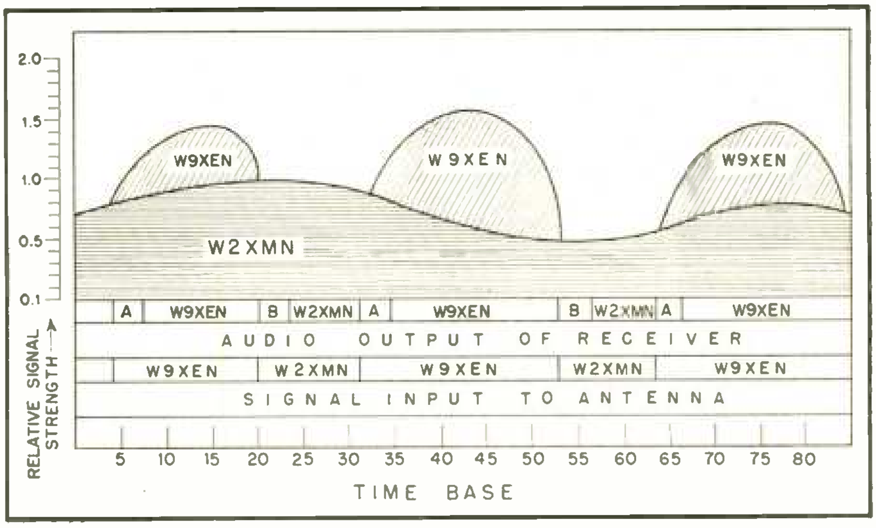
Although it may seem to depart somewhat from all too standardized engineering practice, the writer feels that an excellent attempt to mitigate this confusing situation can be made, by combining radio amateur data and liberal usage of papers dealing with sporadic E which have appeared in American and foreign publications.

Many engineers have found that the term "sporadic E" is not sufficiently descriptive and in many instances is apparently ambiguous. Actually in considering the normal ionosphere to consist of several well defined strata or "layers" the sporadic E will appear much like a very large cloud totally immersed in the E layer. Of course the term "cloud" is not employed in its meteorological sense, but is used to denote an area of definite proportions where the electron-density is abnormally high, compared with the remainder of the E region. The location of the sporadic E cloud, as a position in space is not particularly a matter of chance, but always appears to lodge at a certain height (about 110 km) at places where the general atmospheric circulation is probably downward. Wilson[1] proposes that this corresponds to a warp or dent in the E layer. Whether the sporadic E cloud is an isotropic medium or not remains to be discovered.

The limited lateral extent of the sporadic E clouds is fairly well known. Eyfrig[2] obtained a very definite indication of this by employing simultaneously two pulsed ionosphere sounding stations some distance apart. He writes, ". . . as regards the sporadic E layer the conditions at the two stations may be completely different which is a confirmation of the belief that the sporadic E cloud covers a comparatively limited extent in a horizontal direction. A large number of observations appeared to show that the cloud is in motion and possesses a high north/south component of velocity." Thus Eyfrig's records depict several cases when the cloud was observed over Berlin 1½-2½ hours earlier than observed directly overhead Kochel and disappeared ½-3¼ hours earlier. Motion of the sporadic E cloud has also been examined by Pierce[3] and recently by Ferrell.[4,5]

Aurora Correlation

The agency that creates the sporadic E cloud is still undetermined. One possibility offers the development of many different agencies all possible of producing sufficient ionization to affect radio signals above 40.0 mc. The region of maximum occurrence of sporadic E



Large-scale signal variations of W9XEN frequently exceeded the carrier strength and masking ratio of W2XMN. Delay echoes are audible at points A; program breaks occur at points B

apparently follows quite closely that of the aurora with very little sporadic E ever being recorded around the equator. Systematic ionosphere recording and radio amateur observations are confusing in two details. One is that the occurrence of sporadic E is more frequent at a given temperate latitude during the sunspot minimum. Amateur observations appear to correlate this, but show a trend where the occurrence of sporadic E during the sunspot maximum were less frequent, of greater intensity and of much longer duration than in 1941 when the sunspots were nearing a minimum. Five-meter tests also show that a possible latitude effect occurs during the sunspot cycle and the apparent skip distance increased yearly with the decreasing cycle.

The time duration of a sporadic E cloud is another problem which remains to be solved. Longer periods are recorded during the summer solstice, which also coincides with the yearly maximum activity. Actual prediction of sporadic E is a matter within sight of solution. Many of our readers newly discharged from the armed forces will have come into contact with excellent work that the I.R.P.L. has done on this vital subject. Preparations are now being made to publish formally much of the research and developmental work that was accomplished during the war. Until such material is available, very little that is of any consequence may be said in the matter of sporadic E prediction.

The propagation of FM signals in the 42.0-50.0 mc band has been almost invariably perfect. There have been few, if any, recorded instances of selective fading or distortion in FM skip reception which cannot be traced to low ionic-density in the sporadic E cloud, or reflection from the sides or edges of the cloud. or extension of the path by extraordinary means that might be mistaken for sporadic E propagation.

Multiple Paths

Although, theoretically, the propagation of a television video carrier (assuming 4.75 mc definition) is possible, we must consider that over such a band of frequencies, multiple paths will be formed and the velocity of propagation may vary. In such instances erratic phase combinations may be introduced if, viz., the truly direct path carrier (the shortest hop) were combined in phase with an indirect path carrier (singular or in multiple). The evident result would be an increase in carrier strength without change in sideband values from the respective received carriers (paths). While the apparent depth of modulation is somewhat reduced, time delay might or might not be great enough to affect the synchronizing pulses, but in either case would produce a displaced image. Ordinarily the polarity would be the same (upright image), and the image under ideal sporadic E reflection would be complete, but subject to complex sideband interference, however. Should the direct-path carrier be combined actively with superior out-of-phase indirect path components, the result would be a greatly reduced terminal field strength and a strong secondary image of reverse polarity.

FM Sporadic E Masking Effect

Possibility of the propagation of the old FM broadcast frequencies by sporadic E layer reflection was the outstanding factor necessitating the change to the 3-meter band. A typical example, as well as the first example, of the FM ratio masking effect of two FM transmitters operating on the same frequency, separated by 720 miles was observed by the writer on May 2, 1940. In this instance both W2XMN (Alpine, N. J.) and W9XEN (Chicago, Ill.) were rebroadcasting a CBS program originating in New York City.

In the accompanying diagram, the rapid large-scale signal variations of W9XEN can be seen exceeding the carrier strength and the masking ratio of W2XMN. At the writer's location 114 miles from W2XMN the receiver automatically shifted the program or the audio output in accordance with the input ratio of the two signal strengths. Since the program originated in New York City, the finite time delay on the wire lines to Chicago and the return signal path caused "repeats" or "echoes" of words or music previously heard a few hundredths of a second before from W2XMN (point *A*).

A signal lull from W9XEN caused a slight break or disappearance of the program previously broadcast over W2XMN and now "lost" in transit back to New Jersey, (points *B*).

References

1. M. S. Wilson; *Q.S.T.*, vol. 25, no. 8, August, 1941, p. 23
2. R. Eyfrig; *Hochf:tech. u. Elek:akus.* vol. 56, no. 6, Dec., 1940
3. J. A. Pierce; *Washington Meeting A.P.S.*, 1940
4. O. P. Ferrell; *Science and Culture*, vol. 9, June, 1944
5. O. P. Ferrell; To be published in *Journal of Franklin Institute.*
6. L. V. Berkner and H. W. Wells, *Terr. Mag.*, vol. 42, Mar. 1937

Appendix

It is necessary in reviewing the subject of sporadic E formation to favor those theories which at the present time appear most likely to be proven. For those interested in the back history of sporadic E, we review the following:

Vertical Movements of the Air in the Upper Atmosphere—L. Harang—*Terr. Mag.*; vol. 41, March, 1936, p. 143

Among other studies, the observations at Tronso indicate the formation of sporadic E coincides with auroral activity.

5-Meter Waves and the Dellinger Effect and Aurora—K. Stoye—*E.N.T.*; vol 15, no. 2, Feb., 1938, p. 35

The Dellinger effect of radio fadeouts is closely related to the abnormal long-range propagation of 5-meter signals with an apparent 28-29 day periodicity.

On Three Different Types of Fading and the Influence of Meteors—G. Leithauser—*Funktech. Monatshefte*; no 2, Feb., 1938, p. 33

A postulation that meteors and meteoric ionization in the E and F regions cause the Dellinger effect and possibly some sporadic E layer ionization.

Further Investigations on a Propagation Effect of U.S.W. to Distances of Some Hundreds of Kilometers—H. A. G. Hess —*Funktech. Monatshefte*; no. 4, April, 1938, p. 107

A discussion of the propagation of 5- and 8-meter waves in the United States and Germany by sporadic E layer. Some connection with large swarms of meteors.

Absorption of Corpuscles in the Ionosphere—H. D. Rathgeber—*Naturwiss*; vol. 26, no. 34, Aug., 1938, p. 563

A discussion of the possibility of cosmic rays or other high energy particles causing the sporadic E layer clouds.

The Transmission of U.S.W. Through Ionospheric Action—E. Fendler—*Hochf: tech. u. Elek:akus*; vol. 56, no. 2, Aug., 1940, p. 41

"Sporadic E seems to be produced by a combination of several layers due to different types of radiation . . . whether sporadic E reflects the waves directly or disperses them so that they fall on the F layer very obliquely and are then thrown back again is not certain."

The Formation of the Abnormal E Layer —K. Rawer—*Naturwiss*; vol. 28, no. 36, 1940, p. 577

In accepting the theory of the normal E layer by the dissociation of O_2 by daylight and recombination by triple collision during the night, it appears likely that pressure fluctuations and air circulation may create cloud-like patches of high density.

The Abnormal E Layer of the Ionosphere and an Unusual Long Distance Action of the U.S.W.—H. A. G. Hess—*E.T.Z.*; vol. 62, no. 17, April, 1941, p. 401

More information on the association of meteor swarms and the formation of the sporadic E layer. A correlation of the Perseid shower August 8th to August 15th, 1935 and 1937 is applied to sporadic E data.

Ionospheric Measurements in Connection with Thunderstorm Research—W. Stoffregegen—*Arkiv. f. Mat., Astr. und Fysik*, Bd. 30, Hft. 4. 1944

". . . the abnormal E layer is found to coincide with an increase in the frequency of thunderstorms. during the summer months."

Design of Counter Circuits

ELIHU R. JACOBSON

Counter circuits may be precisely analyzed on the basis of transient response. Circuits are easily linearized with positive bias

Counter circuits are of central importance to design engineers concerned with open servo systems. Whenever a physical variation can be transformed into a frequency change, which is almost always possible, this physical variation may be followed at a distant point with the aid of counter circuits.

To design an open servo system to transmit barometric pressure from a balloon to ground, for example, the engineer may couple a microtorque potentiometer to the shaft of an aneroid barometer. This potentiometer is made the frequency-controlling element of an RC oscillator, used to modulate an r-f carrier.

At the ground station, the demodulated signal is amplified, limited, and fed to the counter circuit. Evidently, many variations and applications of this basic system are possible.

Counter circuits are likewise coming into prominence for AFC in FM transmitter design.

Development of a Practical Counter Circuit

The counter circuit discussed in this article is of the type employed to transform an a-c input voltage to a d-c output voltage in such a manner that the value of the ouput is proportional to the frequency of the input. Since this counter circuit operates in conjunction with a preceding limiter stage, the d-c output voltage is made entirely independent of the amplitude of the input. For example, an input of 50 microvolts at 500 cycles will produce a much greater d-c output than would 100 microvolts at 200 cycles.

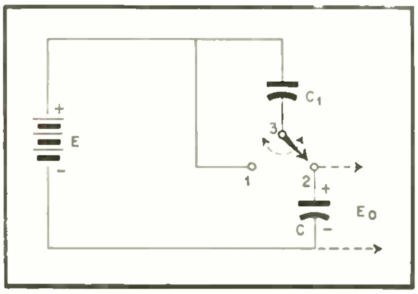


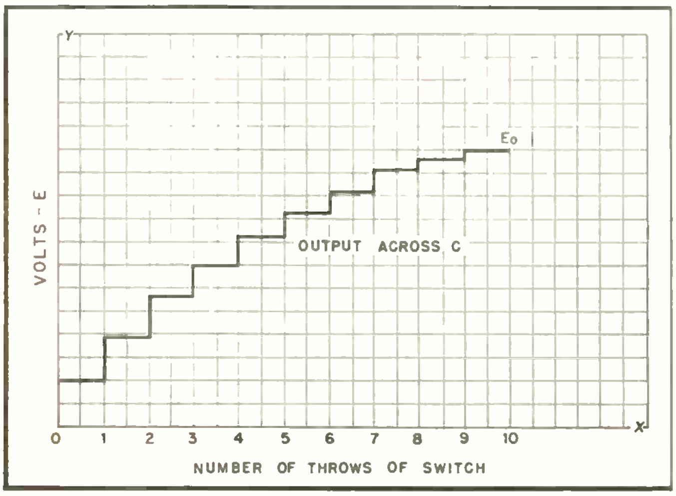
Fig. 1. Principle of operation of counter circuit

The first part of this discussion will deal with a qualitative analysis of this counter circuit using elementary ideas to simulate the actual circuit operation. A quantitative analysis is then presented and an equation for the output d-c voltage as a function of the input signal frequency is derived.

Analysis of Operation

Referring to the schematic in *Fig. 1*, let the action of the switch from *1* to *2* and back to *1* again represent one cycle. When the switch is closed at *2* the battery voltage, *E*, will be impressed across *C* and C_1 in series. This will be divided in such a manner that the voltage across *C*, or E_0, will be equal to $C_1E/(C_1+C)$. The switch is then returned from *2* to *1* completing the cycle. C_1 discharges through the short circuit path but *C* still retains its charge. The difference of potential between *3* and *2* will now be somewhat less than that of *E*, as the charge on *C* may be considered as a battery in series opposing that of *E*. As a result, on the second cycle, the charge added to *C* will be somewhat less than that of the previous cycle. A voltage less than *E* will now be similarly divided across *C* and C_1.

After a number of cycles the voltage across *C* will approach that of *E* and each increase in the charge on *C* will be slightly less than that of the preceding cycle. The graph of voltage across *C*, or E_0, will resemble that in *Fig. 2*, where E_0 approaches *E* as a limit. Assuming *C* to be a perfect capacitor, with no leakage, the amount of charge de-



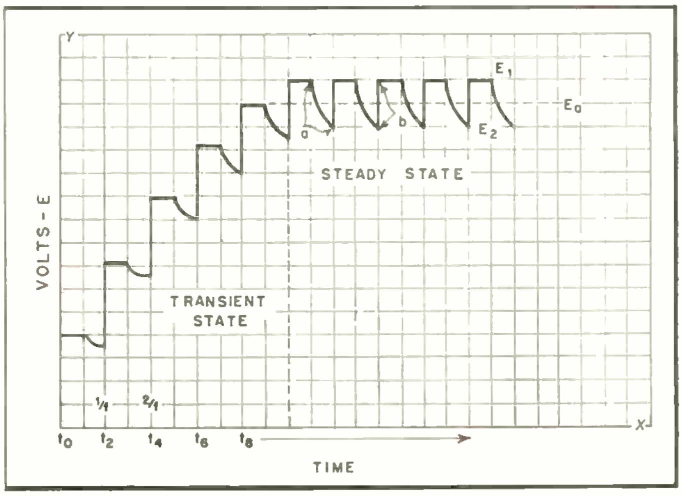


Fig. 2. (left) Exponential build-up of potential across C. Fig. 5. (right) Waveform of E_0, with transient build-up to steady state for a given frequency. (Final potential depends only on number of throws of switch).

veloped across it will be determined solely by the number of throws of the switch (cycles), and not upon how rapidly (frequency) the switching action takes place.

If a resistor were now shunted across C, (*Fig. 3*), during that period of time when the switch was open at *2*, a certain amount of the charge would leak out of C through R. The amount of the charge leaking out would be determined by the RC constants, the length of time that the switch remained open at *2*, and the initial charge on the capacitor at the instant the switch was opened. The voltage developed across C will now be determined by the frequency of the switching action. If the switch remains open at *2* for a short period of time, a small amount of the charge will leak out; if it remains open for a longer period of time, more of the charge will leak out. The percentage of the charge which leaks out each cycle will be fixed as long as the frequency of the switching action and the RC constants do not vary. However, as the voltage across C keeps increasing, the absolute value of the charge which leaks out each cycle will also increase.

From the discussion in the last paragraph it was shown that as the voltage across C increased, the increments decreased each cycle. Consequently, during the period of transition, there will be one point at which the amount of charge going into C will be equal to the amount of charge leaving C. It follows that the voltage across C will have reached a steady state d-c value with a small a-c ripple superposed. As long as all other parameters remain constant, this d-c voltage will depend only upon the frequency. Attention is again brought to the fact that as the frequency increases the decremental charge becomes smaller, and the incremental charge equal to this will occur when the voltage across C is of a greater value.

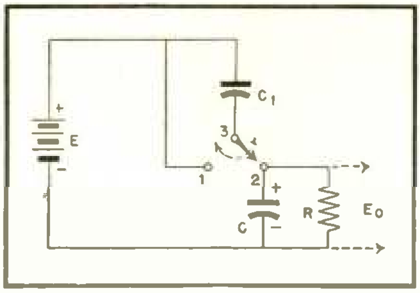


Fig. 3. Equilibrium point is determined by switching frequency; E_0 is always less than E and depends upon rate of capacitor discharge through R

Basic Counter Circuit

Fig. 4 is a schematic diagram of a basic electronic counter circuit. For the purpose of simplicity, the preceding limiter stage is represented by a square wave a-c + d-c generator of constant amplitude. The output wave of this generator will be similar to that of the output of the battery during the switching operation. The twin diode acts as an electronic switch replacing the single-pole double-throw switch in *Fig. 3*. A filter (R_1C_2) has been inserted to remove the a-c ripple. In all other respects the circuit is essentially the same as that of *Fig. 3*, and its action is identical.

As far as the a-c component of the generator is concerned, its zero axis is at the 50-volt line. Anything above this value the diodes will see as positive with respect to ground; anything below this value the diodes will see as negative with respect to ground. E represents the peak-to-peak value of the generated voltage and the ratio $C_1/(C_1+C)$ will be denoted by k. At the instant t_0, the circuit goes into action with the generator's voltage going positive. D_1 conducts and E is impressed across C and C_1 in series. The voltage across C will be equal to kE. At the time t_1, the generator's voltage becomes practically discontinuous with respect to time and drops to zero. D_2 is now conducting and C_1 discharges to zero.

The voltage does not go positive again until a time t_2. During the interval between t_1 and t_2, C will begin to discharge through R. At t_2 the voltage across C will be equal to $kEe^{-t/RC}$, where t is the interval between t_1 and t_2 or $1/2f$ of the generator's frequency. At t_2 the generator again goes positive and D_1 conducts. The voltage impressed across C and C_1 decreases to a value $E-kEe^{-t/RC}$ and the voltage across C becomes increased by k times this amount. This action continues until the voltage entering C is equal to that leaving C.

Up to this point the action may be considered as the transient of the counter circuit. Beyond this point the steady-state condition is reached where the average output voltage does not vary over any period of time. The graph in *Fig. 5* gives a clear picture of both the transient and the steady-state. Actually the steady-state may be considered as being composed of periodically recurring transients.

Steady-State Output

With the aid of *Fig. 5* we may now evaluate the steady-state output voltage, E_0, with respect to the generator's frequency—where $t = 1/2f$. The increments and decrements, b and a, as measured on the y axis, are equal. Each may be represented in terms of E_1 and E_2 and then equated.

$$a = E_1(1-e^{-t/RC}) = [E_2 + k(E-E_2)][(1-e^{-t/RC})] \quad (1)$$

$$b = k(E - E_1 \cdot e^{-t/RC}) = k(E-E_2) \quad (2)$$

Dividing equation (1) by $(1-e^{-t/RC})$ and equation (2) by k yields

$$E_1 = E_2(1-k) + kE \quad (3)$$

$$E_1 = E_2 e^{t/RC} \quad (4)$$

The solution of the simultaneous equations (3) and (4) is

$$E_1 = \frac{kEe^{t/RC}}{e^{t/RC} - 1 + k}$$

$$E_2 = \frac{kE}{e^{t/RC} - 1 + k}$$

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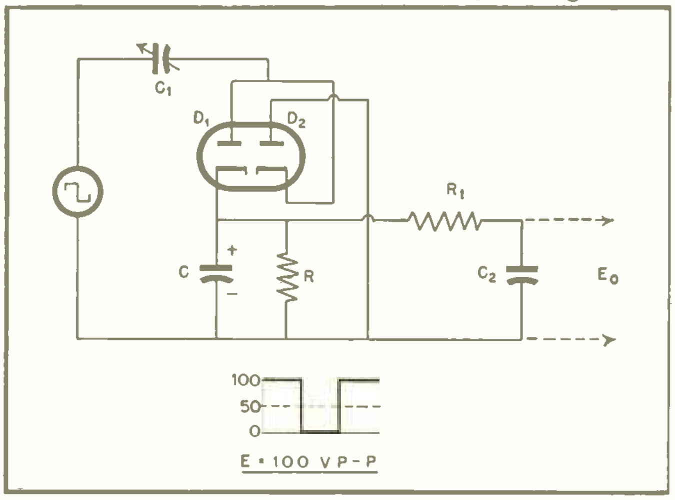


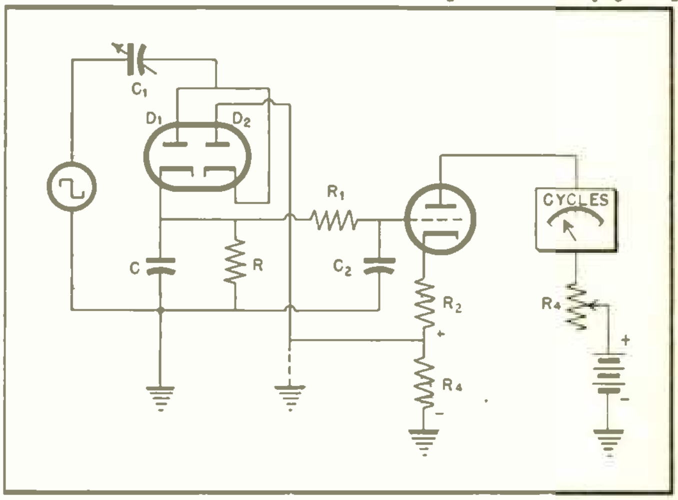


Fig. 4. (left) Fundamental electronic counter circuit. D_1 retains charge on C, while D_2 discharges C_1 on second half cycle. Fig. 6. (right) Linearized counter circuit returns anode of D_2 to positive bias source

Pulsing Circuits For
TIMING APPLICATIONS

ROBERT L. ROD

Pulsing technique, a lusty war baby, becomes of progressively greater importance to design engineers confronted with peacetime electronic problems

During the past few months considerable information has been released describing wartime developments in electronics. Many of the circuits incorporated into the complete systems, when viewed individually, are of interest to engineers engaged in the design of electronic timing, triggering, and synchronizing equipment. Some of these circuits are pulse generators, pulse width discriminators, variable delay systems, and gates and coincidence circuits.

In many cases, variations of these circuits may be adapted to applications involving synchronization or the measurement of small increments of time, generally with the aid of externally-triggered sweep oscilloscopes (i.e. "synchroscopes") which have time-calibrated sweeps of sufficient duration to facilitate the observation of periodic waveforms.

Therefore at this point, it is well to consider some of the methods by which pulses of various forms may be generated.

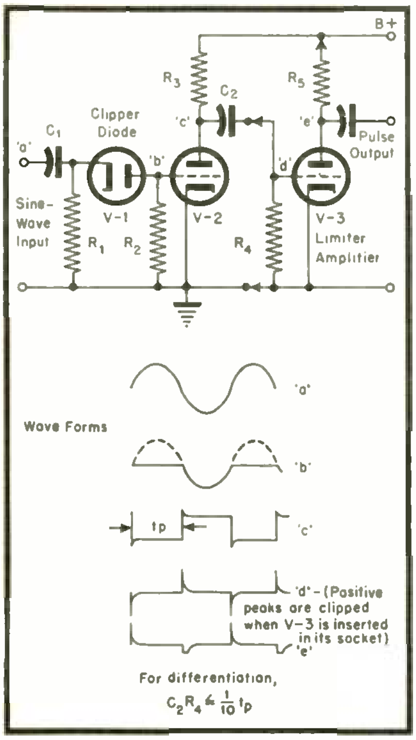


Fig. 1. Clipper-differentiator pulse generator, and significant waveforms

Pulse Generators

One method of obtaining a voltage pulse involves the amplification and clipping of a sine-wave with a view towards obtaining a square wave pulse having a pulse recurrence frequency (PRF) equal to the frequency of the sine-wave input signal. A non-amplified but "clipped" or rectified sine-wave is of little value in timing work, inasmuch as there is no convenient reference point which can be used to measure time intervals from a point on one of the "pulses" to a corresponding point on a pulse occurring some instant later in time. However, by amplifying the clipped sine-wave, the squared-up leading edge becomes an ideal time reference point. This clipping, squaring and amplification process can be performed by means of the circuit given in *Fig. 1.*

V-1, in *Fig. 1*, is a sine-wave clipper or limiter diode which is followed by *V-2*, an overdriven triode limiter. A much narrower pulse can be obtained from the negative-going square wave output at the plate of *V-2* by means of a differentiating circuit, C_2 and R_4. Differentiation can be obtained by making the product of C_2 and R_4 one-tenth (or less) the value of the pulse width input to the *CR* circuit, or stated differently, $t_p \geq 10\ C_2R_4$. The limiter amplifier, *V-3*, following the differentiator clips off the positive pulses formed in the differentiating action by virtue of grid current flow and thereby provides an output at its plate consisting of a series of narrow positive pulses having a PRF equal to that of the sine-wave input to *V-1*.

A diode detector placed across the output of *V-3* provides a d-c voltage proportional to the PRF or sine-wave input frequency so long as the pulse width of the differentiating circuit's output remains constant. This method is convenient for use as a sine-wave (or for that matter, any periodic wave) frequency indicator.

The squaring and clipping method of obtaining square waves from sine-waves is rather uneconomical, if only from the standpoint of the number of tubes required to accomplish the task, hence use is made of many simpler circuits which obtain the same results. The following pulse generators are representative, many offering several types of output pulse lengths and PRFs, depending upon the requirements to be met.

Multivibrator Pulse Generator

Multivibrators, for example, generate excellent pulses over a wide range of recurrence frequencies using but one twin-triode of the 6SN7 type. *Fig. 2a* depicts a balanced multivibrator which will produce a square wave having equal positive and negative pulse durations. Two triode amplifiers in cascade have, in effect, the output of the device reconnected back to the input in order to sustain the oscillations that will occur by the feedback action ensuing.

In the multivibrator, either one tube or the other normally conducts for the period of time needed for the grid voltage of the non-conducting triode to rise from some low negative value to cutoff. When this latter condition occurs, the non-conducting tube commences heavy conduction, passing a negative pulse from its plate to the grid of the formerly conducting tube. Therefore, a "flip-flop" action takes place as first one tube, then the other conducts.

The time of non-conduction of both tubes need not be equal, in fact in the asymmetrical case, the two tubes conduct for different lengths of time in order to provide a certain type of output (taken at either plate).

The period of one complete oscillation, T, is equal to the sum of the non-conducting times of both tubes, or:

$$T = T_1 + T_2$$

This equation is valid only if the changeover time between conduction and non-conduction of both tubes is infinitesimal. For most analyses, the changeover time is considered to be instantaneous. Knowing the output pulse requirements, i.e., the PRF and the durations of the negative and positive pulses, the multivibrator is analyzed by considering an equivalent circuit of the coupling condenser discharge path of either of the tubes. This resolution will aid in determining the magnitudes of the voltages existing throughout the multivibrator so that the correct CR combination can be fixed. In steps, the process takes the following form.

Circuit Analysis

1. Resolve the discharge path of C_1, for example, into an equivalent circuit, as shown in *Fig. 2b*. By the aid of Thévenin's Theorem a further simplification, shown in *Fig. 2c*, can be made from that shown in *2b*. Assuming that at $t = 0$, *V-1* has just been cut off by the receipt of a negative grid pulse, the voltage across C_1 will equal E_{bb}. Therefore, the equivalent circuit can again be simplified by establishing only one voltage source, labeled "Net Active Voltage" in *Fig. 2d*. This voltage is the difference between the voltage across C_1 and the voltage applied to the circuit at $t = 0$ and is of the polarity shown.

The voltage developed across R_1 can be determined from an expansion of the basic equation for any series C-R circuit having a square-wave voltage

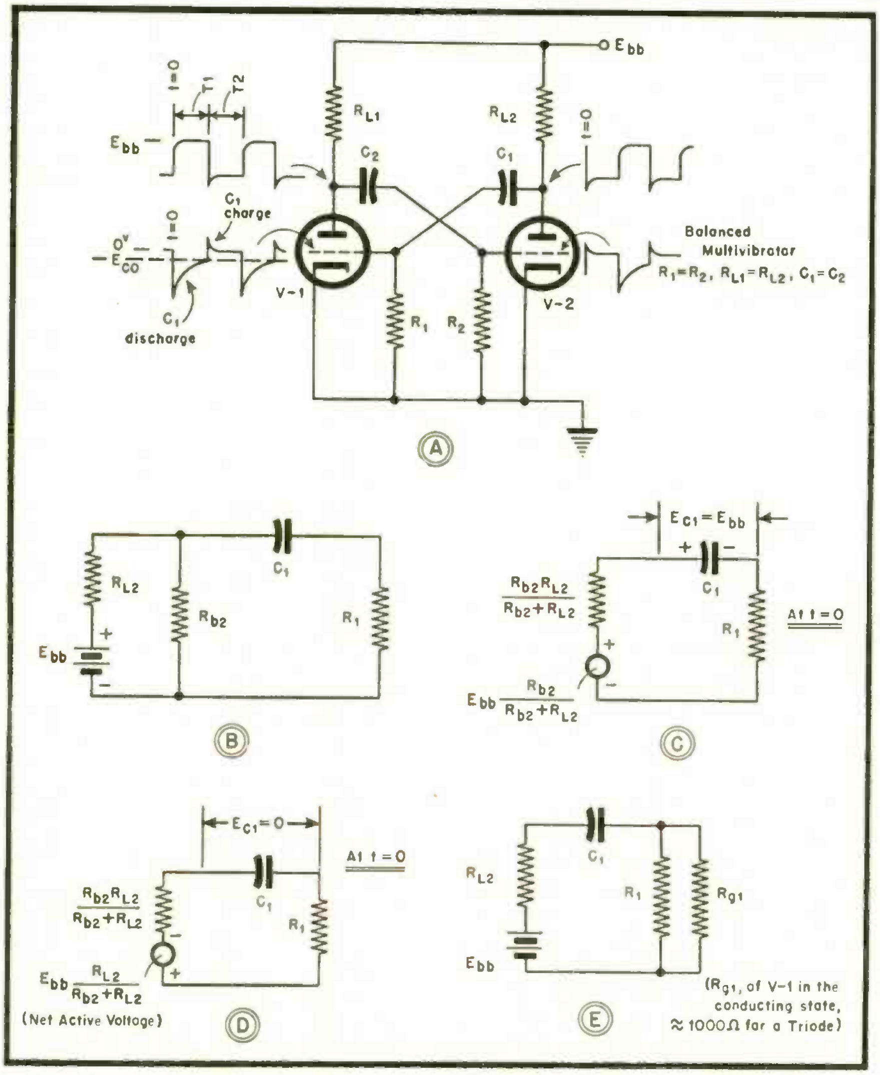


Fig. 2A. Multivibrator circuit, with waveforms. Fig. 2B. Equivalent circuit of C_1 discharge paths. Fig. 2C. Simplified equivalent circuit. Fig. 2D. Final equivalent circuit. Fig. 2E. Equivalent charge path of C_1

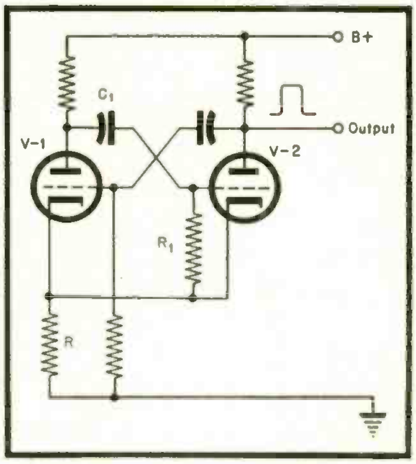


Fig. 3. Triggered one-shot multivibrator

source, E, in series with r, the internal impedance of the generator, and CR:

$$E_{R1} = \frac{ER}{R+r} \exp\left(-t/C(R+r)\right)$$

2. Substituting for the values of E and r, as given in *Fig. 2d*, the equation for the voltage developed across R_1 is:

$$E_{R1} = -E_{bb}\left[\frac{R_{L2}}{R_{L2}+R_{b2}}\right]\left[\frac{R_1}{R_t}\right]\exp(-t/C_1R_t) \qquad (1)$$

$$\text{where } R_t = R_1 + \left[\frac{R_{b2}R_{L2}}{R_{b2}+R_{L2}}\right]$$

Equation (1), above, can be further simplified by the following:

$$E_{R1} = -a_2 E_{bb} \exp(-v_1 t) \qquad (2)$$

$$\text{where } v_1 = 1/C_1R_t$$

$$a_2 = \left[\frac{1}{1+\frac{R_{b2}}{R_{L2}}}\right]\left[\frac{1}{1+\left[\frac{R_{b2}R_{L2}}{R_1(R_{b2}+R_{L2})}\right]}\right]$$

3. Substituting T_1, the time *V-1* is to remain non-conducting, for t and the cutoff voltage, $-E_{co1}$, for E_{R1} in equation (2), it is possible to solve for v_1T_1:

$$v_1T_1 = \log_e(a_2\mu_{co1}) = 2.3\log_{10}(a_2\mu_{co1}) \qquad (3)$$

$$\text{where } \mu_{co1} = E_{bb}/E_{co1}$$

If $R_1 >> \frac{R_{b2}R_{L2}}{R_{b2}+R_{L2}}$, as is usual, a_2 simplifies and approximates $1/[1 + (R_{b2}/R_{L2})]$. Therefore, it is possible to solve for v_1T_1 by knowing E_{bb}; the load resistance, R_L; the plate resistance of the triode, R_{b2}, and $-E_{co1}$.

4. The assumption has been made in equations (1) through (3) that C_1 is fully charged prior to $t = 0$. Before R_1 can be determined, it is necessary to limit the size of C_1 to meet this assumption by noting the charging equivalent circuit, *Fig. 2e*. As C_1 will be fully charged in about five times T_2, it is necessary to fix the maximum capacity of C_1 by:

$$C_{1max} = \frac{T_2}{5\{R_{L2}+(R_1R_{g1}/R_1+R_{g1})\}} \qquad (4)$$

where $R_{g1} = 1000$ ohms or so for a triode.

The above equations will yield a solution which provides the correct values R_1 and C_1 to approximately fix the value of T_1. T_2 circuit values may be obtained similarly.* In *Fig. 2a,* since $R_1 = R_2$, $C_1 = C_2$, etc.; $T_1 = T_2$, and the multivibrator is considered to be balanced.

A variation of the multivibrator just discussed is known as a biased multivibrator in which either or both the grid resistances are tied not to ground from the grids but rather to E_{bb}. Thus the discharge times are shortened and frequency is increased without decreasing the values, let us say, of C_1 or R_1 (assuming only *V-1* is so connected). The charging equivalent circuit is identical to that given in *Fig. 2c*, but the discharging circuit is altered somewhat from that given in *Fig. 2c*, as a similar analysis will prove.

Frequently, only a short trigger pulse is available in particular applications, and it is necessary to generate another pulse having leading edge coincidence but greater pulse duration than the trigger. A "one-shot" or "flip-flop" multivibrator is often used to advantage in this case. In *Fig. 3*, a typical circuit is shown wherein *V-1* is cut off by the action of the plate current of *V-2* flowing through the common cathode resistance, *R*. No multivibrator action occurs until one of the following steps is taken:

1. A positive pulse is applied to grid, *V-1*
2. A positive pulse is applied to plate, *V-2*
3. A negative pulse is applied to plate, *V-1*
4. A negative pulse is applied to grid, *V-2*

Any one of the above measures will cause *V-1* to conduct heavily, cutting off conduction in *V-2* until such a time as the grid of *V-2* is positive with respect to its cutoff voltage. The analysis of this circuit can be performed in a similar manner to that discussed in the previous case of a free-running multivibrator. C_1 and $(R + R_1)$ form the discharge path in this case in conjunction with the other circuit parameters mentioned previously. In the case of *Fig. 3*, the output is taken off the plate of *V-2* giving a positive-going pulse; for a negative output the plate of *V-1* can be utilized.

An interesting version of the familiar transitron oscillator finds application as a "one-shot" multivibrator, wherein one pentode and a minimum number of components will provide two outputs, which are opposite in polarity but which have leading-edge coincidence, for each positive trigger. When applied to the grid of the transitron circuit given in *Fig. 4*, the positive trigger will at first cause an increase in plate and screen currents and a decrease in plate and screen voltages. However, C_1 has an effect which causes the suppressor grid to follow the screen in the latter's negative-going excursion and which also results in plate current decreasing at the instant screen current is increasing. An increase in screen current at the same time the screen voltage is falling is an effect of negative resistance between the screen and suppressor grids.

The overall effect of this unconventional process is that plate voltage rises almost instantaneously once the trigger is applied, and the suppressor voltage quickly drops until all plate current flow ceases and screen current stabilizes at some low value. C_1, at this point, then discharges through R_1 until the potential difference existing across the capacitor is low enough to allow conduction to resume. When conduction again resumes, the plate voltage drops, the screen current falls off, and the screen and suppressor voltages rise. The output across the plate, therefore, will be a positive going pulse, while the output at the screen will be a negative-going waveform. The pulse width of the output pulses is almost exclusively a function of the time constant of R_1 and C_1, while the actual output pulse shapes are governed by the type of load being used. By experimentation with the loads, the desired pulse shapes can be obtained.

The last of the pulse forming circuits to be discussed is the "blocking" oscillator which finds numerous applications in systems requiring the generation of short pulses or the reliable division of frequency. With but one triode, it is possible to generate pulses over a wide range of PRFs which vary in width from less than one to more than twenty microseconds. The basic blocking oscillator is given in *Fig. 5a*, wherein regenerative action causes the circuit to oscillate whenever the grid is made slightly positive. When the grid allows the tube to conduct, a reinforcing action drives the circuit into heavier conduction by virtue of the polarity connections between the primary and secondary windings of the "pulse" transformer, *T*. As the grid draws current, condenser, *C*, charges to a voltage, *E*, given by:

$$E = \frac{1}{C}\int_0^T i\,dt$$

where, i = charging current through C
T = pulse duration
C = capacity of condenser

The circuit ceases conduction when plate current reaches saturation and when the large charge accumulated on *C* brings the grid to cutoff potential. The width of the output pulse, which normally is taken off a third transformer winding, 3, is a function of the capacity of *C* and also the resonant frequency of the transformer windings, while the PRF of the oscillator in the free-running condition is governed by the time constant of the discharge circuit of *C* through *R*.

The pulse transformers used in blocking oscillators are generally small in size having approximately one hundred turns on each leg, and they now are

*A further expansion of multivibrator design procedure is given by E. R. Shenk, "The Multivibrator", *Electronics*, January, 1944.

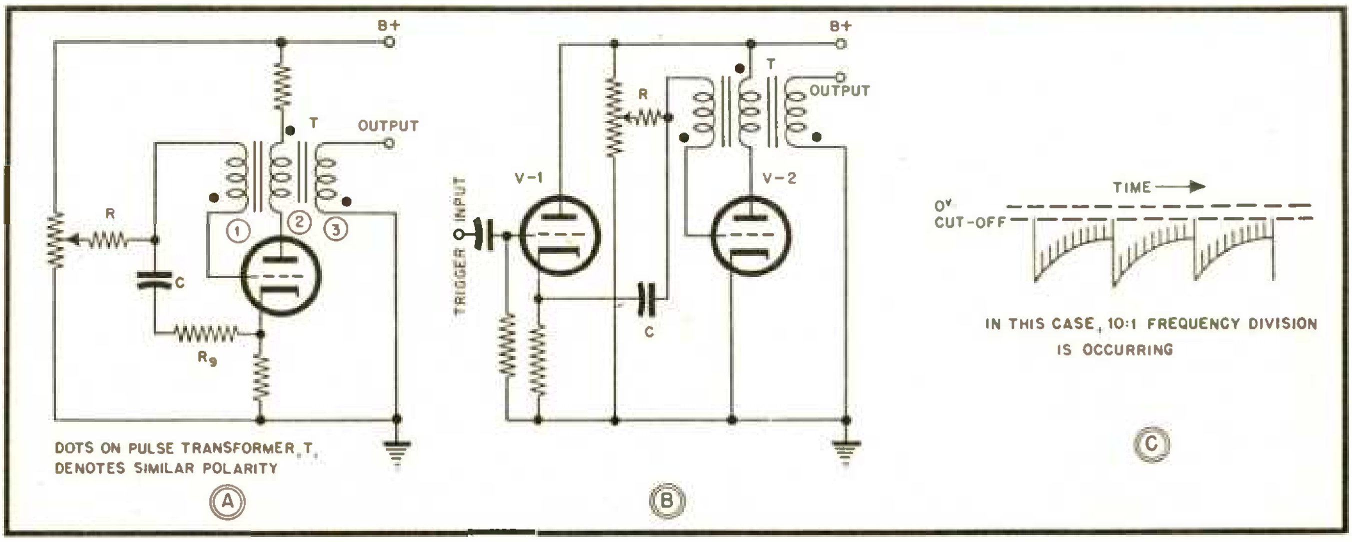


Fig. 5A. Circuit of blocking oscillator. Fig. 5B. Triggered blocking oscillator. Fig. 5C. Grid voltage waveform of 5B circuit

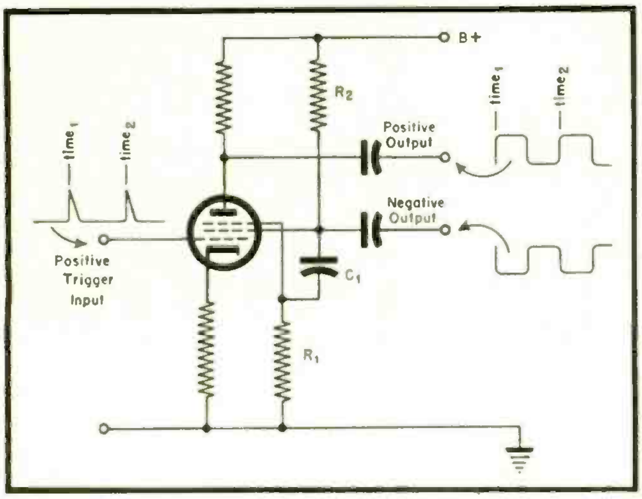


Fig. 4. Transitron one-shot multivibrator

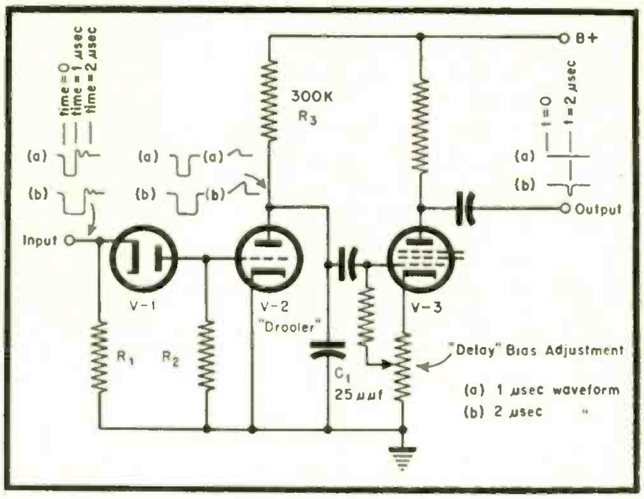


Fig. 6. Pulse width discriminator

commercially available for general use. Resistor, R_g, is a grid current limiter having a value of a thousand ohms or so, while C is generally selected to be greater than several hundred micro-microfarads. Both C and R are critical, and the two components are best selected experimentally to give maximum circuit stability.

The blocking oscillator just described is of the free-running variety. *Fig. 5b* gives a circuit which allows the blocking oscillator to be triggered by some external pulse and which generally finds application in frequency division. The trigger pulse should be of the sharp leading edge variety and oftentimes is actually a squared-up sine-wave. *V-1* is a cathode follower providing circuit oscillation as well as a low impedance path for the blocking oscillator's grid current. If, for example, it is desired to obtain one blocking oscillator pulse for every ten trigger pulses, i.e. 10 to 1 frequency division, the dormant time of the oscillator is made slightly longer than the time interval between ten successive trigger pulses. The trigger pulses, fed in to the grid of the cathode follower, are then superimposed upon the exponential grid discharging curve, as shown in *Fig. 5c*, so that the tenth trigger arrives at the grid of the blocking oscillator just before the instant the circuit would normally fire in the free-running condition. The tenth trigger pulse then fires the oscillator "prematurely". For accurate frequency division, the peak amplitude of each trigger superimposed upon the discharging curve of C should be about 20% above the base of the next trigger to the right (See *Fig. 5c*).

Sufficient plate resistance, adequately bypassed, must be included to prevent damage to the blocking oscillator tube.

Pulse Width Discriminator and Variable Delay Circuit

In many applications, radar beacon techniques in particular, it is necessary to discriminate between two pulses, one having less than a specified duration and the other having a longer duration, with a view to rejecting the shorter of the two. A complete circuit which is capable of performing this function is shown in *Fig. 6*. An input pulse when applied to *V-1* must be in the form of a two microsecond pulse in order to obtain an output from the discriminator. Shorter input pulses result in no response by the circuit. *V-1* is merely a clipping stage which insures that the signal placed on the grid of the so-called "drooler", *V-2*, is a good negative pulse. Operated at zero-bias, the drooler is conducting heavily, and its plate voltage is therefore low. C_1 is charged to this plate voltage until a trigger arrives to cut off *V-2*. At this instant, the plate voltage of *V-2* rises to B+, and C_1 begins charging up to the supply voltage. The longer *V-2* remains cut off, the greater the charge accumulated on C_1, therefore, the circuit is designed so that *V-3*, which is biased beyond cutoff by a voltage divider, conducts when C_1 has charged for two or more microseconds. In practice, several pulse amplifiers follow *V-3* in order to obtain a pulse of sufficient magnitude to be of practical use.

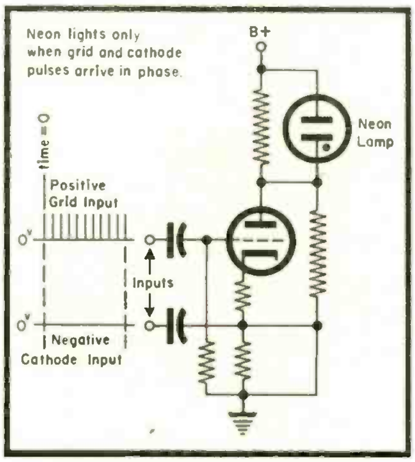


Fig. 7. Coincidence tube circuit

A variation of the circuit can be used as an electronic time delay, merely replacing *V-2* with a switch. Various delays, or variations of the discrimination quality of the circuit given in *Fig. 6*, can be created by the proper choice of the delay bias adjustment, C_1 and R_3. The time necessary for C_1 to charge up to any voltage, E_1, through R_3 is equal to $C_1R_3\log_e \frac{E_1}{E_2}$, where E_2 is the voltage at the beginning of the charging period.

Gates and Coincidence Circuits

A pentode can be successfully squelched by placing a negative voltage of large amplitude on the suppressor grid, and oftentimes this is done to "gate" or "blank" an amplifier for a selected period of time. A similar result can be obtained by driving the grid negative or by placing a positive voltage on the cathode, however the advantage of gating the suppressor is that other circuit elements are generally undisturbed. A cathode-ray tube, for example, can be "unblanked" during the forward part of the sweep by placing a positive pulse of a duration equal to the sweep duration on the first anode. The 'scope is then blanked on the fly-back portion of the sweep by the termination of the gate.

The gating technique can be expanded to include "coincidence" circuits which depend upon gating and which find application in determining the accuracy of electronic counting and frequency division circuits. In *Fig. 7*, the coincidence tube is a triode having two signal inputs, one on the cathode and the other on the grid. Let us assume that the grid input is the higher frequency trigger applied to the blocking oscillator frequency divider shown earlier in *Fig. 5b*, and the cathode signal is the blocking oscillator output (which is one-tenth the PRF of the trigger). The grid input consists of a series of

[*continued on page 60*]

CBS Color or Fine Line TELEVISION TRANSMITTER

Having uniform modulation from 0 to 10 mc, this transmitter developed by Federal engineers represents fine engineering technique

THE COLOR TELEVISION transmitter in use by CBS is essentially a wide-band transmitter operating on a carrier frequency of 490 mc with a peak output power of 1 kw. The output can be modulated uniformly from 0 to 10 mc, and represents the highest power transmitter of its type to date.

Ten bays are occupied by the transmitter, power units, and cooling equipment, which weigh approximately six tons. The bays are 30 inches in width, and appear as shown in *Fig. 1*.

RF Problems

The r-f portion of the transmitter consists of a conventional chain of amplifiers and frequency multipliers, following a crystal oscillator. The oscillator stage uses a type 6V6/GT tube in a tri-tet circuit, with a crystal frequency of 6.805 mc. The oscillator stage is arranged to double the crystal frequency in the plate circuit, so the output of this stage is approximately three watts at 13.611 mc.

The following stage uses a type 815 tube in a push-pull frequency tripler circuit. This tube, which is a dual beam tetrode, delivers approximately ten watts at 40.833 megacycles. The following stage is another type 815 in a tripler circuit, delivering approximately ten watts at 122.5 megacycles.

This stage is followed by an amplifier stage using a type 4-125 power tetrode, operating without neutralization, but with the reactance of the screen lead series resonated to bring the screen to ground potential more effectively. This arrangement has proved entirely stable, and the stage delivers approximately 120 watts at 122.5 megacycles.

The remaining stages of the radio-frequency chain make use of the type 6C22 tube. This tube, which is a triode of high mutual conductance and low plate resistance, uses the ring-seal technique to reduce the inductance of the leads to the electrodes, and to make the tube suitable for operation in the ultra-

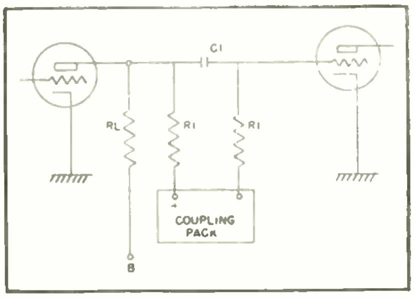


Fig. 2. Method of low-frequency coupling

high frequency portion of the spectrum. The anode is a solid block of copper filled with a water jacket for cooling. With a water flow of one gallon per minute the tube may be used for plate dissipations up to one kilowatt in radio-frequency service. In applications where no grid dissipation is encountered, as is common in video-frequency amplifiers, somewhat greater dissipation is permissible, and with a water flow of two gallons per minute, a dissipation of two kilowatts is reasonable.

The fifth stage of the radio-frequency chain consists of a type 6C22 tube in a coaxial circuit operating as a frequency doubler at high power level. With an input of 120 watts at 122.5 megacycles, the stage delivers 250 watts output at 245 megacycles. In this stage the cathode of the tube is by-passed to ground, and the grid circuit is excited with driving energy. The anode circuit of this stage is a quarter-wave line shorted at the end farthest from the tube. Tuning is by a movable piston.

The sixth stage of the radio-frequency chain also uses a type 6C22 tube in a frequency doubler circuit, but in this

Fig. 1. Color or fine-line television transmitter operating at 490 mc and output of 1 kw

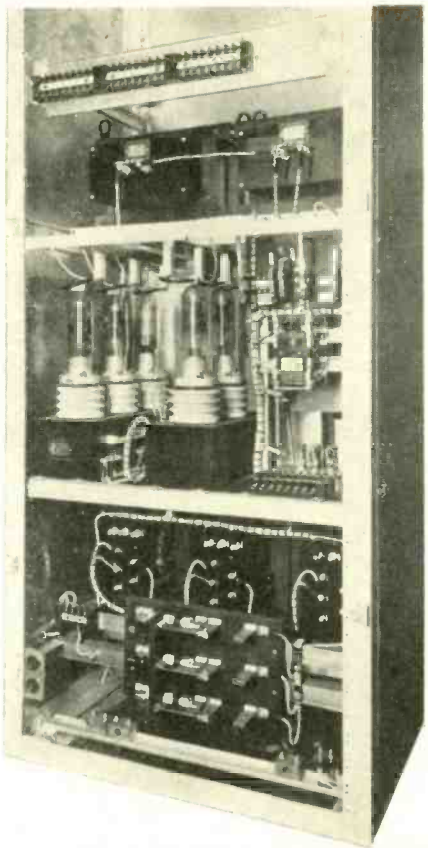
case it is no longer possible to ground the cathode, because of the cathode lead inductance. In this case the grid is grounded, and the drive energy fed into the cathode circuit. With 250 watts of drive, this stage delivers 300 watts output at the final carrier frequency of 490 megacycles.

The seventh stage is a neutralized amplifier, using the type 6C22 in a grounded-grid circuit. With 300 watts of drive it delivers approximately 700 watts output at 490 megacycles. This is considerably more than is required to drive the final stage of the transmitter to its rated output of one kilowatt peak, but the excess power is dissipated in a damping resistor attached to the coupling line between the driver stage and the modulated amplifier stage. The load imposed by this resistor acts to maintain constant output voltage from the driver stage in spite of changing load imposed by the output stage as its bias is varied through the modulation cycle. This improves the linearity of the modulation characteristic, and somewhat reduces the voltage required from the modulator stage.

The eighth stage of the radio frequency chain is the final, or modulated amplifier stage. This stage also uses a type 6C22 tube in a neutralized, grounded-grid circuit. With a drive of 350 watts from the preceding stage it will deliver any output from zero to one kilowatt depending on the grid bias at the time. (For dissipation reasons it is not possible to deliver one kilowatt continuously; one kilowatt peak, or 600 watts average, is the rated output of the stage.)

The Video Frequency Modulator

The modulator system consists of a five-stage video frequency amplifier having uniform response from d.c. to ten megacycles. The method of high-frequency compensation is quite conventional, being based on principles of design arrived at from filter theory, using both two terminal and four terminal networks. One unusual feature of the amplifier system is the absence of any system of dc restoration. Since the dc



Modulator power supply for the transmitter

component of the signal is retained throughout the chain, restoration is not required.

The method of low-frequency coupling is shown in *Fig. 2.* (No high-frequency compensation is shown in this figure, but, of course, any type desired may be used without affecting the principles discussed.) A condenser C_1 is connected from the plate of the first stage to the grid of the second. From each side of this condenser isolating resistors R_1 are connected to the terminals of a regulated power supply, referred to as a coupling pack. No other path from the grid of the second stage to ground is provided. The cathode of the second stage is directly grounded. The isolating resistors are made very much larger than the first stage load resistor R_1 so that the capacitance of the coupling pack to ground will not impose a shunt on the first stage at high frequencies, but for such frequencies the coupling condenser carries the signal without any appreciable change in the potential to ground of either terminal of the coupling pack. For very slow changes in potential of the plate of the first stage it will be apparent that both terminals of the coupling pack are raised or lowered in potential by the same amount as the plate of the first stage, thus transferring the signal to the second stage through a path consisting of the isolating resistors and the pack itself. When the coupling condenser greatly exceeds the capacitance to ground of the coupling pack, the region of transfer of signal from one path to the other is gradual and smooth, and the response of the amplifier is uniform from a moderate frequency which passes through the condenser, to d.c., which is transferred through the pack.

This system of coupling is used throughout the video-frequency system to retain the d c component of the signal and to insure good response at the very low frequencies. In spite of the possibility of a small instability in one of the early stages being magnified to cause "bounce" or flicker in the output, no such troubles have been encountered, principally due to thorough attention to the proper regulation of the coupling packs in the low-level stages of the system.

The first stage of the modulator system uses a type 6AG7 tube. Normal input for the stage is approximately 2 volts peak-to-peak. (All signal voltages discussed in the video frequency portion of the system will be referred to in terms of their peak-to-peak amplitude). The stage gain is 7, giving an output of 14 volts.

The following stage uses a type 807 tube, giving a gain of 2.8 and an output of 40 volts.

The third stage uses three type 807 tubes in parallel. This is necessitated by the relatively large input capacity of the following stage. The stage gain is 4.5 and the normal output 180 volts.

The fourth stage uses a type 6C22 tube as a conventional triode amplifier. Although the tube interelectrode capacitances are not large, the Miller effect increases the apparent input capacity of the stage to a considerable degree. With a suitable driver stage no other detrimental effects are found. The gain of this stage is 3.5 and its output is 700 volts.

The fifth stage is a cathode-follower using two type 6C22 tubes. The principal purpose of this stage is to supply a driving signal from a source of sufficiently low impedance that the effects of the changing load imposed by the output stage grid circuit will be neg-

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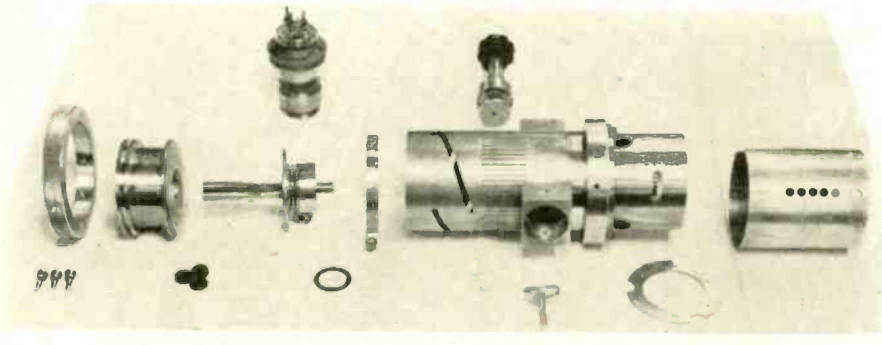


Exploded view of coaxial amplifier using 6C22 tube at 500 mc

RADIO DESIGN WORKSHEET

NO. 45 – NON-LINEAR RESISTANCES; AMPLIFIER COUPLING

NON-LINEAR RESISTANCES

When a linear resistance is connected in series with a non-linear resistance, the properties of the circuit are intermediate to those of linear and non-linear circuits. *Fig. 1* illustrates a constant resistance in series with a diode whose terminal characteristic may be given by $i = kv^{1.5}$. A magnetic field of $\frac{1}{2} Li_0^2$ watt-seconds has been established within L. It is desired to know the nature of current flow as the flux collapses.

The circuit equation is:

$$L\,di/dt + Ri + v(i) = 0$$

Or

$$1.5Lkv^{\frac{1}{2}}\,dv/dt + Rkv^{1.5} + v = 0$$

Whence

$$dt = -1.5Lk\frac{dv}{Rkv + v^{\frac{1}{2}}}$$

And

$$t = -1.5Lk\int_{v_0}^{v}\frac{dv}{Rkv + v^{\frac{1}{2}}}$$

The equation may be integrated for current:

$$t = -L\int\frac{di}{i(R + i^{-\frac{1}{3}}k^{-\frac{2}{3}})}$$

Whence

$$i = (a\epsilon^{-Rt/3L} - b)^3$$

Where $\epsilon = 2.718+$, $a = i_0^{3} + R^{-1}k^{-\frac{2}{3}}$, $b = R^{-1}k^{-\frac{2}{3}}$

With R small compared to R_{in}, the curve of current decay is shown in *Fig. 2* for $i_0 = 0.02$, $R = 300$, $L = 1$, $k = 2\times10^{-5}$. It is interesting to compare the equation for the LR-diode circuit with the equations for L-diode and LR circuits: The LR equation contains an exponential term, $\epsilon^{-Rt/L}$, while the L-diode equation involves a cubic function of time. The LR-diode equation displays a cubic function of an exponential term, $\epsilon^{-Rt/3L}$, exhibiting mathematically the intermediate properties which this circuit possesses with respect to the other two. The current reaches zero in 0.59 ms.

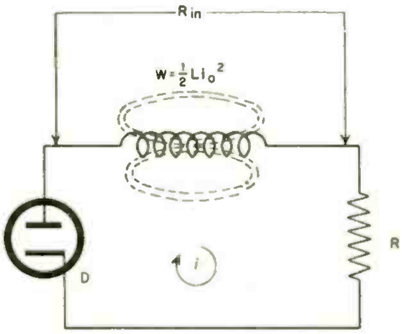


Figure 1

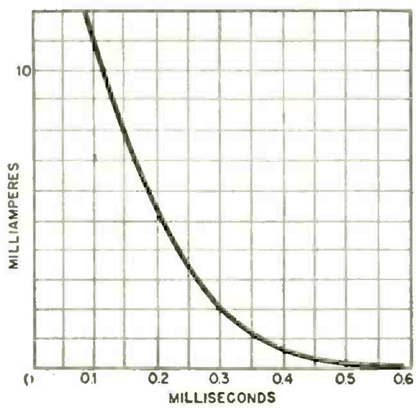


Figure 2

With R large compared to R_{in} (R_{in} = input resistance of circuit seen by E_L), the curve of current decay is shown in *Fig. 3* for $i_0 = 0.02$; $R = 6000$; $L = 1$, $k = 1$. The solid line plot shows the complete decay, which reaches zero at approximately 38 ms. The dotted line shows the initial decay period down to 0.5 ma. on an expanded scale. The solid curve illustrates clearly that in the initial decay period the linear resistance governs, but in the final period the diode governs. Thus if the final period is replotted on an expanded scale, the curve appears similar to *Fig. 1.*

It is seen that in any LR-diode circuit, the curve of current decay must reach zero in some finite time, irrespective of values of circuit parameters; this is because the internal resistance of the diode must finally govern as the current decays without limit, and the diode will ultimately pinch off the asymptote.

Unless tables of exponential functions for small values of x are available, it is frequently preferable to convert the above equation into logarithmic form. The logarithms of large numbers are then sought, and readily found.

It was seen that when a sinusoidal wave of voltage is applied to an unbiased diode, the current conduction angle is pi and the current waveform is non-sinusoidal. Should the diode be negatively biased to half the peak value of the a-c voltage, the conduction angle is 2/3 pi as shown in *Fig. 4*. If the diode is positively biased to the peak value of the a-c voltage, it is apparent that the conduction angle will be 2 pi. Again, because of the non-linear internal resistance of the diode, the current waveform will be non-sinusoidal, and will contain harmonics of the source frequency. The magnitudes of these harmonics become less as the positive bias

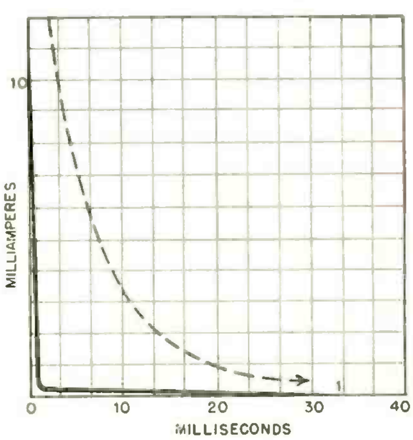


Figure 3

is increased in value, since dv/di is thereby caused to assume a higher order of tangency with the terminal characteristic of the diode.

When a sinusoidal voltage wave is applied to an unbiased diode, the current which flows is given by:

$$i = k\ (E\ \sin\omega t)^{1.5}$$

with the condition that negative current does not flow.

With positive bias, the two voltages may be superposed, and

$$i = k\ (E_b + E\ \sin\omega t)^{1.5}$$

with the condition that negative current does not flow.

Current flow may not be obtained by superposing direct current upon alternating current, since the two are not independent of the presence of each other. This is one of the basic differences between non-linear and linear circuits.

Harmonics present in the current waveform may be evaluated by expanding the terminal characteristic of the diode in a Taylor's series and computing the harmonic coefficient at the given operating point. Taylor's series may be written: $(E_b > 2E)$

$$f(x+a) = f(a) + af'(x) + a^2f''(x)/2! + a^3f'''(x)/3! + \ldots$$

and since

$$i = kv^{1.5},\ di/dv = 1.5kv^{0.5},\ d^2i/dv^2 = .75kv^{-.5},$$
$$d^3i/dv^3 = .375kv^{-1.5},$$
$$i = I_b + 1.5kE_b^{1/2}E\sin\omega t + .375kE_b^{-1/2}E^2\sin^2\omega t - .0625kE_b^{-1.5}E^3\sin^3\omega t + \ldots$$

also,

$$\sin^2\omega t = \tfrac{1}{2}(1 - \cos 2\omega t);$$
$$\sin^3\omega t = \tfrac{1}{4}(3\sin\omega t - \sin 3\omega t),$$

wherefore the amplitudes of the second and third harmonics are:

$$H_2 = 0.1875kE_b^{-1/2}E^2;\ H_3 = 0.015625kE_b^{-1.5}E^3$$
$$DC = I_b + 0.1875kE_b^{-1/2}E^2$$

amperes.

Amplitudes of higher harmonics may be computed similarly. The smaller that E/E_b is, the fewer significant harmonics exist.

With two a-c voltages present and positive bias, the current waveform is given by:

$$i = k\ (E_b + E\ \sin\omega t + E_1\ \sin\omega_1 t)^{1.5}$$

Harmonics present in the current wave may be evaluated as before by expanding the terminal characteristic of the diode in a Taylor's series:

$$i = I_b + 1.5kE_b^{1/2}\ (E\ \sin\omega t + E_1\sin\omega_1 t) + .375kE_b^{-1/2}(E\sin\omega t + E_1\sin\omega_1 t)^2 - .0625kE_b^{-1.5}(E\sin\omega t + E_1\sin\omega_1 t)^3 + \ldots$$

The square term may be expanded:

$$(E\sin\omega t + E_1\sin\omega_1 t)^2 = E^2\sin^2\omega t + 2EE_1\sin\omega t \cdot \sin\omega_1 t + E_1^2\sin^2\omega_1 t$$

also,

$$\sin\omega t \cdot \sin\omega_1 t = \tfrac{1}{2}\ (\cos\ (\omega - \omega_1)t - \cos\ (\omega + \omega_1)t]$$

wherefore the harmonics of the square term are:

$$0.375kE_b^{-1/2}E^2\cos 2\omega t;\ 0.75kE_b^{-1/2}EE_1\cos\ (\omega - \omega_1)t;\ 0.75kE_b^{-1/2}EE_1\ (\omega + \omega_1)t;\ 0.375kE_b^{-1/2}E_1^2\cos 2\omega_1 t.$$
$$DC = I_b + 0.375kE_b^{-1/2}E^2 + 0.375kE_b^{-1/2}E_1^2.$$

An interesting aspect of this result is that sum and difference frequencies appear when two a-c voltages are applied to a positively biased diode. This is the condition of a modulated carrier wave. If one frequency is 1 megacycle, and the other frequency is 1000 cycles, the output will contain frequencies of 1 megacycle (the carrier), $f + f_1$ (the upper sideband), $f - f_1$ (the lower sideband), as well as a 2 megacycle and a 2000 cycle component. The frequencies of 1,001,000, 1,000,000, and 999,000 cps constitute the modulated wave, which is usually of interest and which may be filtered out from the other components by means of a bandpass tuned circuit.

If the curvature of the characteristic at the point of operation is sufficient to make the cube term of significance, further modulation products are obtained in the output. These are discussed in the following installment.

Note that the presence of the a-c voltage caused a d-c current over and above I_b to appear in the output. This current increase is a measure of the curvature of the terminal characteristic of the diode. If dv/di coincided with the characteristic, no d-c rise would be noted in the output with a-c voltage applied. The increase of d.c. in the circuit represents rectification, and will take place even with a conduction angle of 2 pi.

Thus the current which flows in a non-linear circuit is not the sum of the currents which would be produced by each voltage acting separately. Instead, each current is influenced by the presence of all other currents, and interaction takes place resulting in the generation of currents which are unexpected from the standpoint of linear circuit analysis.

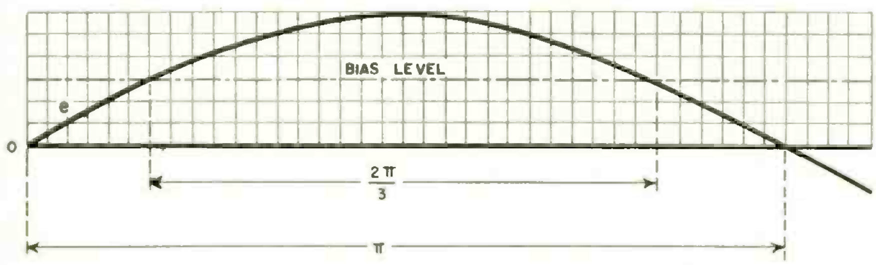


Figure 4

AMPLIFIER COUPLING

Fig. 5 illustrates a resistance coupled circuit in which:

R_0 = plate resistance of the tube
μ = amplification factor of the tube
ϵ = input grid voltage

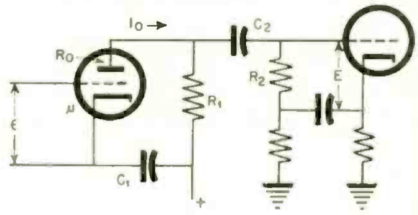


Figure 5

Let R_1 be much greater than R_0

$$I_0 = \frac{\mu\epsilon}{R_0 + R_1}$$

$$E = I_0 R_1 = \frac{\mu\epsilon R_1}{R_0 + R_1}$$

$$\frac{E}{\epsilon} = \frac{\mu R_1}{R_0 + R_1}$$

Obviously the gain increases with R_1 and will be a maximum when R_1 is so large that R_0 may be neglected by comparison. Whence

Maximum gain $= \mu$

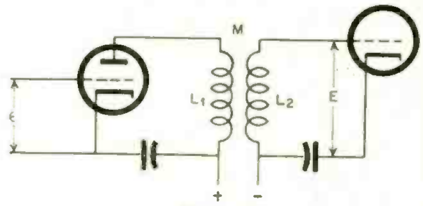


Figure 6

Fig. 6 illustrates a transformer coupled amplifier in which $K\ (= \frac{M}{L_1L_2})$ is the coupling coefficient of the transformer and M its mutual inductance.

$$E = 2\pi f M I_0 = 2\pi f I_0 K\sqrt{L_1 L_2}$$

$$I_0 = \frac{\mu\epsilon}{\sqrt{4\pi^2 f^2 L_1^2 + R_0^2}}$$

$$E = \frac{2\pi f \mu\epsilon K\sqrt{L_1 L_2}}{\sqrt{4\pi^2 f^2 L_1^2 + R_0^2}}$$

$$\frac{E}{\epsilon} = \frac{2\pi f \mu K\sqrt{L_1 L_2}}{\sqrt{4\pi^2 f^2 L_1^2 + R_0^2}}$$

To find the relation between R_0 and $2\pi f L_1$ for maximum gain:

$$\frac{\delta}{\delta L_1}\left(\frac{E}{\epsilon}\right) = 0$$

$$\sqrt{4\pi^2 f^2 L_1^2 + R_0^2}\ \frac{2\pi\mu f K\sqrt{L_2}}{2\sqrt{L_1}}\ \delta L_1$$

$$= \frac{2\pi\mu f K\sqrt{L_1 L_2}}{2\sqrt{4\pi^2 f^2 L_1^2 + R_0^2}}\ (4\pi^2 f^2 L_1^2 \times 2L \frac{\delta}{\delta L_1})$$

$$4\pi^2 f^2 L_1^2 + R_0^2 = 2L_1^2\ (4\pi^2 f^2)$$

$$R_0^2 = 4\pi^2 f^2 L_1^2$$

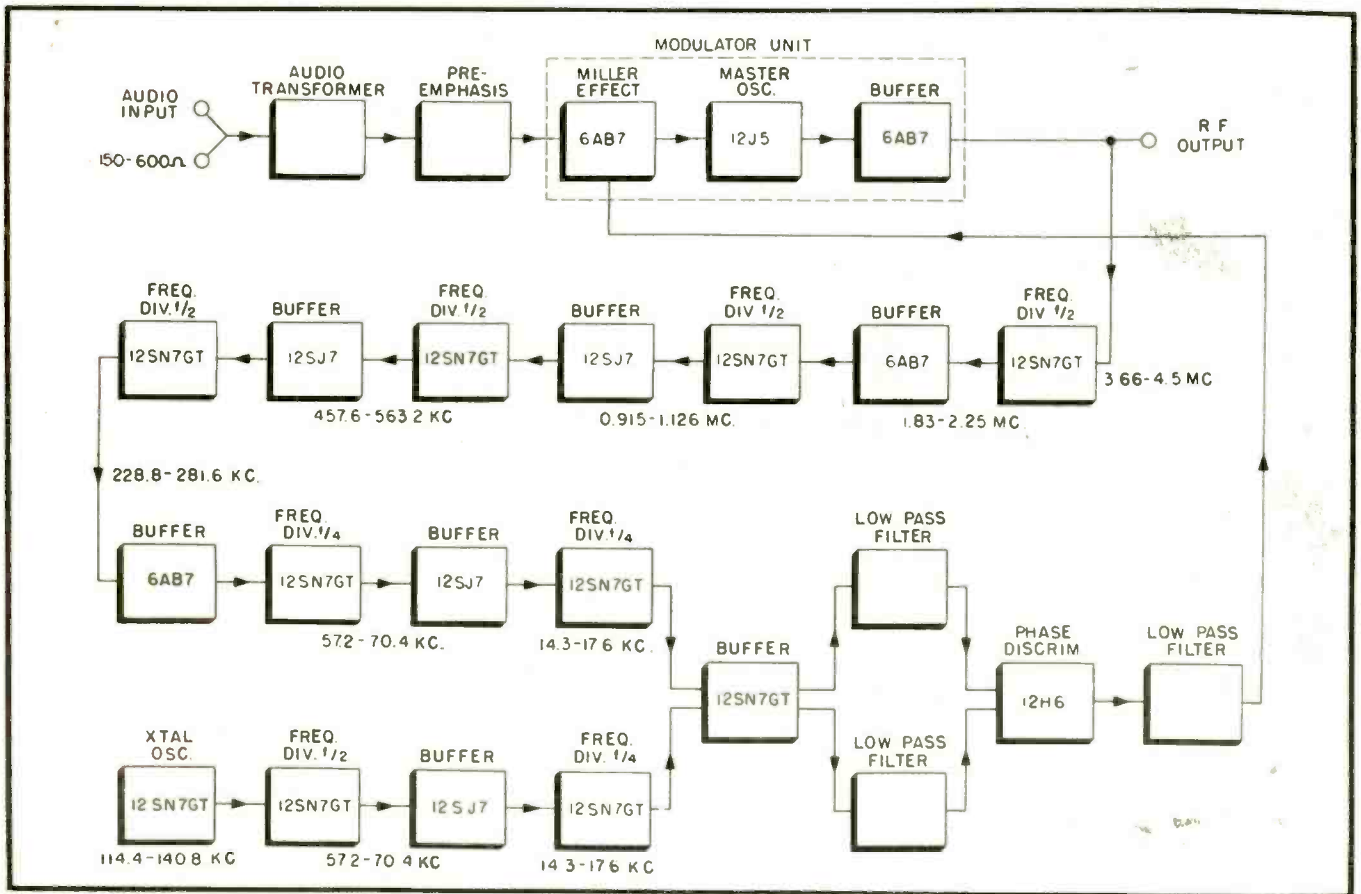
$$R_0 = 2\pi f L_1$$

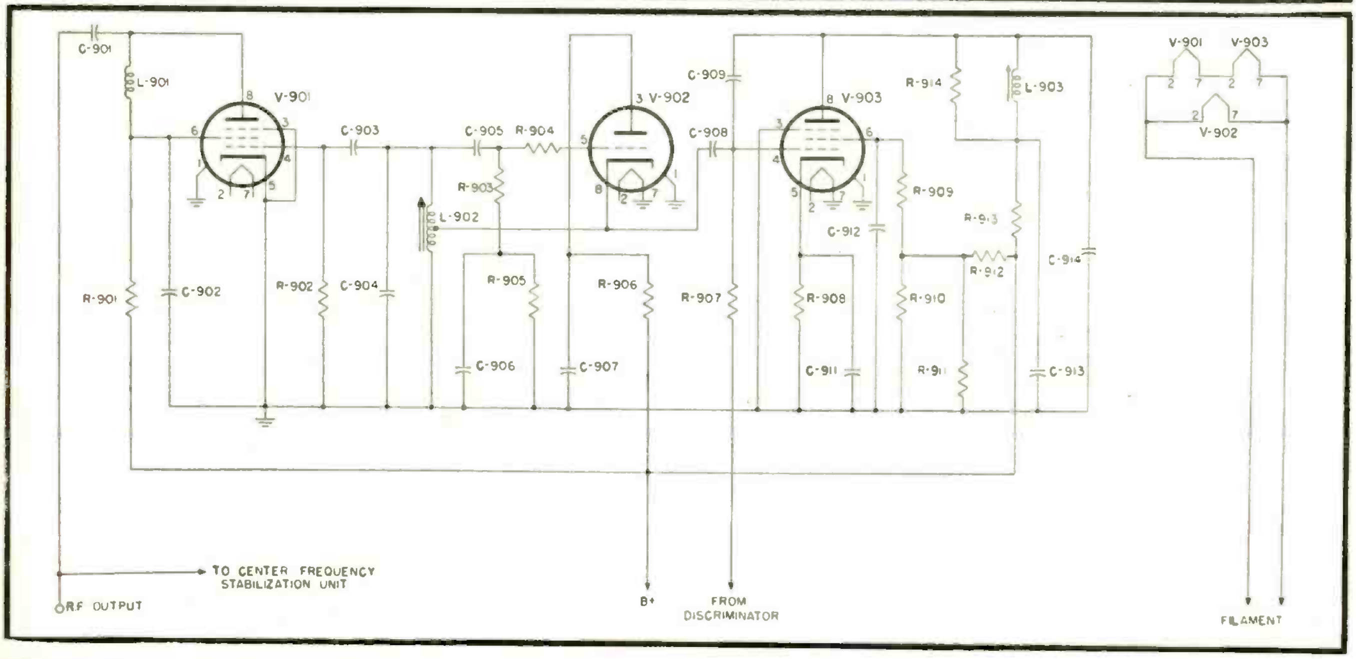
Whence it appears that $\frac{E}{\epsilon}$ varies directly with K and $\sqrt{L_2}$. Voltage gain will be maximum when $K = 1$.

NEW TRANSMITTER CIRCUITS

Block diagram of a center frequency stabilization and modulator unit which maintains carrier frequency within 0.001%. Below, schematic diagram of modulator unit with audio distortion of less than 0.5%, and noise level of — 75 db. The essential feature in the operation of Federal's stabilization system is that when two coupled oscillators are operated at nearly identical frequencies, they will "lock-in" at the frequency of the more stable oscillator with a phase, relative to the stable frequency, dependent on the difference in natural frequency of the two oscillators.

[Federal circuit]





This Month

Dr. Robert Adler of Zenith, with original laboratory sample of the phasitron tube and modulator circuit

I.R.E. SHOW

Presenting a panoramic view of the new world of electronics, the Institute of Radio Engineer's mammoth radio engineering show, held in connection with its annual winter technical meeting, was the largest exhibit of its type ever shown. More than 7000 radio and electronic engineers attended this 3-day gathering.

As a preview of an electronic "world of tomorrow," the 170 exhibits of new devices by 135 companies included everything from latest developments in radio receivers to the latest frequency modulation and television transmitters, from a preproduction model of a camera for the photographic recording of patterns which may appear on a cathode ray oscilloscope screen to "packaged" antennas, easy-to-erect 30-foot antenna towers and 150-foot masts.

Radars and radar devices for peacetime use, AM and FM radio, television, sound recording, communications, photography, vacuum tubes, magnetic recording, remote control devices, testing devices, time and heat control devices, rectifiers and converters, electronic navigation and direction finding instruments, X-ray equipment are a few of the many categories of electronic equipment featured in the exhibit.

SUMMARIES OF RADIO PAPERS

Radio engineers unable to attend the winter technical meting of the I. R. E. will be interested in the official summaries of important papers which were presented:

A New System of Angular Velocity-Modulation Employing Pulse Techniques

James F. Gordon

A frequency-modulation system was described in which a crystal-controlled pulse triggers a multi-vibrator. This pulse establishes a reference time for the system. The asymmetry of the multivibrator cycle varies with modulation. Clipping the reference pulse and differentiating the intelligence pulse which is generated at the cross-over point of the multivibrator cycle produces a source of time-modulated intelligence. These pulses are used to control the phase of a continuous-wave carrier.

Noise Spectrum of Crystal Mixers

P. H. Miller

Studies of the noise spectrum of crystal mixers were made over the frequency range of 50 to 1,000,000 cycles per second. In the audio range a band pass filter employing a three terminal Wien bridge was used to perform the analysis. For analysis at higher frequencies 7 megacycles was added to the noise spectrum and a communications receiver employed. It was found that regardless of the type of power applied to the crystal the noise temperature varies inversely with the frequency. The noise in the audio range is always large, a noise temperature ratio of 10^6 being typical. A mechanism responsible for the observed noise has not yet been suggested.

The General Problem of Crystal Rectifiers

K. Lark-Horovitz

A blocking layer at the boundary of a semi-conductor and a metal is assumed. Discrepancies between theory and experiments are explained on the basis of multi-contact potential theory. The radio-frequency behavior, studied on the basis of a contact resistance and contact capacitance in parallel, with a spreading resistance in series, indicates that different assumptions are necessary for different semiconductors.

Theories of contact rectification assume a blocking layer at the boundary semi-conductor (SC)— metal with a ratio of its thickness t to mean free paths l of electrons in SC determined by the number n of = electrons and their mobility b as determined from Hall effect and conductivity: $t \{ 1$ diffusion theory, $t \{ 1$ diode theory. The DC characteristic is then given by an equation of the type $i = i_0 (a^V - 1) \left(a = \frac{e}{kT} \right)$

Discrepancy between theory and experiment $a_{obs} \{ a_{th}$ is explained on the basis of multi-contactpotential theory. (Applications: Surface treatment and absorption). The RF behavior studied on the basis of the usual model: contact resistance in parallel to contact capacity and in series with a spreading resistance indicates the necessity to assume different models for different semi-conductors.

Microwave Converters

C. F. Edwards

Microwave converters using point-contact silicon rectifiers as the nonlinear element were discussed with particular emphasis on the effect of the impedance-frequency characteristics of the input and output networks on the converter performance. Several converters which have been developed during recent years for use at wavelengths between 3 and 30 centimeters were described, A balanced converter having uniform conversion efficiency over a frequency band 15 megacycles wide was described in detail, and experimental results are given which show that the performance is influenced by the input-network impedance at both the image frequency and frequencies in the second harmonic range.

A Medium-Power Triode for Frequencies Around 600 Megacycles

S. Frankel, J. J. Glauber, and J. Wallenstein

A tube was described which was originally designed for pulse operation to deliver approximately 50 kilowatts peak power output at 600 megacycles with good efficiency.

Design considerations were discussed which include, as the most important factor, problems of transit time, peak emission, cooling, and circuit properties of the internal tube structure.

A detailed description of this tube structure was given which includes design considerations of the electrodes, operating conditions, and static characteristics. Uniformity of characteristics was also discussed.

Methods of testing and using the tube as an oscillator, amplifier, and frequency multiplier were described and the results obtained were given. These results include data and curves of power output versus frequency; efficiency versus frequency; power gains as an amplifier and multiplier; and life-test results.

Directional Couplers

W. W. Mumford

The directional coupler is a device which samples separately the direct and the reflected waves in a transmission line. A simple theory of its operation was derived. Design data and operating characteristics for a typical unit were presented. Several applications which utilize the directional coupler were discussed.

Phase and Frequency Modulation—A New Method

Robert Adler, F. M. Bailey and H. P. Thomas

The design of frequency-modulation transmitters has been simplified and their performance improved by the development of a new phase modulator tube. In a concentric structure of conventional dimensions, a radial electron stream is shaped into a wave-like pattern which progresses continuously around the cathode. The development of the tube was reviewed. A description was also given of a commercial frequency-modulation broadcast transmitter making use of this tube together with a discussion of the design features involved.

Two New Miniature Tubes for Frequency-Modulation Conversion

R. M. Cohen, R. C. Fortin, and C. M. Morris

The use of a new miniature converter tube and a new miniature radio-frequency amplifier tube in the head end unit of a frequency-modulation receiver covering the 88- to 108-megacycle band was described. The unit employs a radio-frequency stage, a converter stage, and two intermediate-frequency stages. Pertinent data covering construction and performance including circuit constants, stage gain, over-all gain, signal-to-noise ratios, image rejection, and oscillator-frequency drift was presented.

Generation of CW Power at VHF

W. G. Dow, J. N. Dyer, W. W. Salisbury, and E. A. Yunker

Techniques for the generation of continuous-wave power at high frequencies have advanced greatly in recent years, both with respect to the amount of power that can be generated and the frequencies that can be reached. This paper describes a number of oscillator and amplifier techniques for the generation of continuous-wave power in the range of frequencies used for radar. These power sources are tunable over considerable frequency ranges such as 1:5 to 1, and can be modulated over relatively wide frequency bands. Arrangements employed include open-wire resonant lines with conventional tubes, concentric oscillators employing parallel-plane triodes, resnatrons, and magnetrons. Powers range from 10 watts upward, depending on the tubes employed, and the frequencies. The art has been advanced sufficiently to permit generation of at least 1 kilowatt of continuous-wave power up to the lower frequencies used in microwave radar, and powers as great as 30 kilowatts can be obtained at somewhat lower frequencies.

Peter C. Goldmark, Morris Liebmann 1945 Memorial Prize Winner, "for his contribution to the development of television systems, particularly in the field of color"

Ralph Vinton Lyon Hartley, 1946 Medal of Honor Winner, "for his work on oscillating circuits employing triode tubes and likewise for his early recognition and clear exposition of the fundamental relationships between the total amount of information which may be transmitted over a transmission system of limited bandwidth and the time required"

The Role of Atmospheric Ducts in the Propagation of Short Radio Waves

J. E. Freehafer

Experience gained during the war has shown that strong fields, at frequencies greatly exceeding the penetration frequency of the ionosphere, are often observed at several times the horizon distance. Experimental and theoretical investigations in this country and in England indicated that these effects are associated with the presence of layers in the troposphere in which the vertical gradient of refractive index exceeds numerically the reciprocal of the earth's radius. Under these conditions, a duct is formed which for sufficiently high frequencies both reduces the rate at which the field is attenuated with range and also disturbs the normal height-gain effect.

Electronic-Frequency Stabilization of Microwave Oscillators

R. V. Pound

For many purposes, microwave signal generators of very-high-frequency stability are desirable. Two methods of electronic frequency control relative to the resonant frequency of an isolated microwave cavity resonator were discussed. The relative frequency can be maintained to better than one part in 10^8 and the absolute frequency stability is that of the cavity. High-fidelity frequency modulation with deviations of the order of f/14Q about the stabilized frequency is possible. Several uses were mentioned.

Field Intensities Beyond Line of Sight at 45.5 and 91 Megacycles

C. W. Carnahan, N. W. Aram, and E. F. Classen

This paper presented the results of a field-intensity monitoring project initiated by the Federal Communications Commission during the summer of 1945. Signal strengths from WMFM, a frequency-modulation broadcast transmitter at 45.5 megacycles, and an experimental 91-megacycle transmitter, both located at Richfield Wisconsin, were continuously monitored for a period of two months at Deerfield, Illinois, a distance of about 80 miles. The data were analyzed in terms of the average field strengths at the two frequencies, and individual characteristics, such as the range and prevalence of fading and diurnal variation of average field strength. Comparison was made with field strengths predicted from Federal Communications Commissions curves, and the ratio of the 91-

megacycle field strength to that at 45.5 megacycles is found to be considerably lower than expected.

From Wiring to Plumbing

E. M. Purcell

At microwave frequencies circuit components are needed which, although comparable to a wavelength in size, provide the functional flexibility of ordinary radio-frequency circuit elements. Connectors, rotating joints, tee-junctions, transformers, filters, variable reactors, attenuators, etc., must be manufacturable, durable, and in electrical behavior accurately predictable. In some respects microwave circuits are simpler than their low-frequency counterparts. Line length transformations are conveniently and freely employed. Also, the symmetry properties of waveguide transmission modes permit the realization, in simple form, of networks with interesting and useful properties. With a few notable exceptions microwave circuit design has been reduced to an engineering science.

Propagation of Six-Millimeter Waves

G. E. Mueller

The effects of rainfall and atmospheric absorption on the propagation of microwaves and the methods employed for measuring them were described. The attenuation of 3.2-centimeter waves is slight for moderate and light rainfall. During a cloudburst, the attenuation may approach a value of 5 decibels per mile. At 1.09 centimeters, the waves are appreciably attenuated even by a moderate rain. Attenuations in excess of 25 decibels per mile have been observed during a cloudburst. The losses are still higher at 0.62 centimeters reaching a value of 42 decibels per mile for a cloudburst. The gas attenuation at this wavelength is probably less than 0.2 decibles per mile.

Measurement of the Angle of Arrival of Microwaves

W. M. Sharpless

This paper describes a method of measuring the direction from which microwaves arrive at a given receiving site. Data which have been collected on two short optical paths using a wavelength of 3¼ centimeters were presented to illustrate the use of the method. Angles of arrival as large as ½ degree above the true angle of elevation have been observed in the vertical plane while no variations greater than ± 1/10 degree have been found in the horizontal plane. More recent work, using a lens-type scanning antenna operated at a wavelength of 1¼ centimeters revealed that, at times, as many as four distinct transmission paths were present simultaneously on a 12.6-mile circuit. Simultaneous meteorological soundings were made near both terminals of the circuit.

Stagger-Tuned Wide-Band Amplifiers

H. Wallman

In radar and television receivers, the simplicity of single-tuned circuits strongly commends itself to the designer of wide-band, band-pass amplifiers. Unfortunately, with present tubes, one cannot make a high-gain amplifier wider than about 4 megacycles; the principal reason is the rapidity with which bandwidth decreases as identical single-tuned stages are cascaded. This paper described the scheme of stagger-tuning the individual single-turned circuits, which essentially eliminates the shrinking of over-all bandwidth and thus makes possible very simple 10- and 15-megacycle-wide amplifiers. Stagger-tuning appears to be much less well known than it deserves. Graphs wre presented condensing the whole basic design of a wide-band amplifier into the work of a few minutes; actual examples of amplifiers were shown.

Metallized-Glass Attenuators for R-F Applications

E. Weber

Based on special techniques of precision metallizing of glass plates and tubes, power-absorbing elements have been developed suitable for use in calibrated attenuators in coaxial as well as waveguide R-F power transmission systems of moderate power level. Particular attention had to be given to proper matching of the attenuating sections to the practically lossless transmission lines by means of impedance transformers which themselves are part of the metallized-glass elements. Several models with precision measuring drives were developed for use as reference standards.

Microwave Power Measurement

T. Moreno and O. C. Lundstrom

Possible methods of microwave power measurement were reviewed. The design requirements for bolometric wattmeters were outlined, and examples were given of bolometer elements that have been developed to meet these requirements. A recently developed bolometer element that may be used over an exceedingly wide band of frequencies is included. The results of experiments to determine the accuracy of these wattmeters were summarized; these experiments indicate that errors may be held to within a few per cent.

Beam-Shaping Methods in Antenna Design

L. C. Van Atta

The angular width of an optical searchlight beam is determined by the extended light source placed at the focal point of the paraboloid reflector and by inaccuracies in the reflector shape. The beam width of a microwave paraboloid antenna, however, is due to diffraction of the radiation at the aperture. For sharp beams, it is desirable, frequently, to distribute the radiation in some manner other than that determined by diffraction. The focusing property of the antenna system can be modified either by providing an extended antenna feed or distorting the paraboloid shape. Straightforward experimental and theoretical approaches are available to the antenna designer in achieving a wide variety of beam shapes for special application.

Theory of Impulse Noise in Ideal Frequency-Modulation Receivers

David B. Smith and W. E. Bradley

An analytical treatment of noise in frequency-modulation receivers was given for the case when a mixture of noise and useful signals is applied to the receiver input. Methods of measuring the performance of receivers with respect to frequency-modulation noise were discussed.

TV SYNCH GENERATOR

Telequip Radio Co. exhibited an interesting TV synch generator.

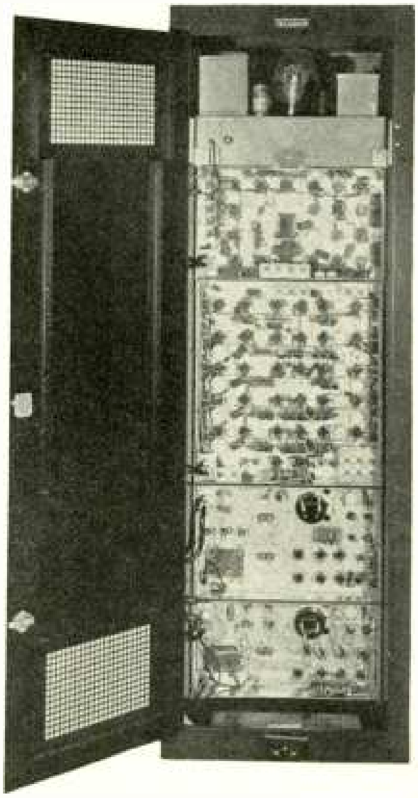
This equipment is designed to produce a standard FCC-RMA signal. It is housed in a 19 inch rack with black crackle finish having outside dimensions of 68" by 22" by 18" deep. A seven inch cathode ray tube is mounted in the top center of the rack. Front and rear doors are provided on the rack. The complete equipment comprises five units as follows:

Two electronically regulated power supplies, for timer and shaper units. One timer unit. One shaper unit. One monitoring oscilloscope.

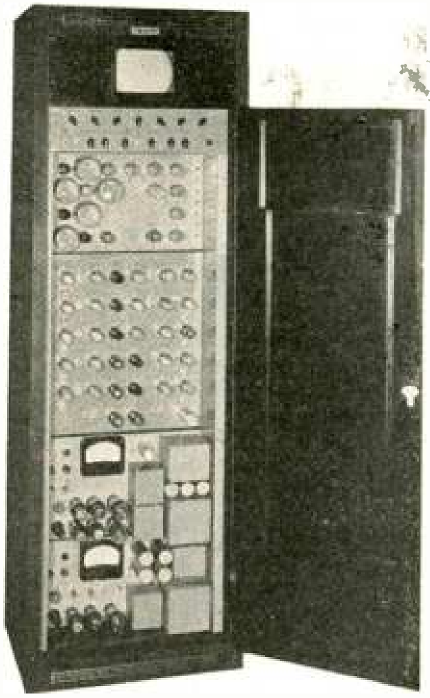
Approximate weight of the complete unit is four hundred pounds. All except the monitoring oscilloscope are vertically mounted and are completely serviceable within the rack.

The timer and shaper units are provided with test outputs from the front to facilitate test and adjustment. Normal outputs for television camera, and monoscope operations are available from the rear of the shaper unit.

The timer unit includes thirteen tubes, and uses Eccles-Jordan multivibrators for the production of the proper timer signals. The 31,500 and 15,750 cycle signals have output amplitudes of approximately 20 volts RMS sine wave. The sixty cycle signal is a pulse of approximately 30% duration with a peak amplitude of approximately 20 volts. All multivibrators are adjustable from the front of the unit. A phasing control which adjusts the phase between the sixty cycle line and sixty cycle multivibrator is provided. A reactance control tube is provided to properly lock



Interior view of Telequip television synch generator, producing a standard FCC-RMA signal. Tests outputs are available from the front panel for the timer and shaper units



Front view of Telequip synch generator and monitoring oscilloscope which consists of a 7" C-R tube with either low or high speed presentation

the sixty cycle multivibrator to the a.c. line frequency.

The shaper unit includes thirty-two tubes for properly shaping, locating and mixing the required signals. Controls are provided to adjust the width and position of the various pulses required for the final formation of signals. This unit has output connections to the following signals: Kinescope or super-synch, Kinescope pedestals, iconoscope or monoscope pedestals, iconoscope or monoscope vertical synch, iconoscope or monoscope horizontal synch. These signals are each available at two points: one at about 200 ohms 2 volts peak to peak, and the other 5000 ohms at 30 volts peak to peak. The high level output of kinescope synch is available across 2500 ohms at 30 volts peak to peak.

The monitoring oscilloscope includes fifteen tubes. It uses a short seven inch electrostatic deflection cathode ray tube for display. The high voltage for the cathode ray tube is supplied from a radio frequency high voltage oscillator. The time axis is sixty cycles, which can be made either low speed for examination of the complete signal, or high speed where it may be used for the examination of only a few lines in the complete signal. Phasing controls are provided for the horizontal time axis to allow examination of any portion of the complete signal. A thirty cycle square wave is injected into the vertical amplifier to allow trace separation for more detailed examination of the signal. Controls are provided for horizontal attenuation (fine and in steps), horizontal gain, centering, both vertical and horizontal, intensity control, focus, block-out on-off, block-out, width, phase 0-180°, phase fine, trace separation on-off, trace separation "fine", sweep origin, input selector, on-off switch.

The power supply for the shaper normally operates at 250 volts, 200 ma. It is electronically regulated. It is provided with on-off switch, and a meter which reads either volts or current through the operation of a toggle switch. The a.c. primary and high voltage d.c. is also fused.

The power supply for the timer is similar to the shaper power supply except for a slightly lower power output.

CAVITY MAGNETRON

The mighty cavity magnetron—the electronic tube that gave American radar its powerful wallop—led the Western Electric vacuum tube parade at the I.R.E. Convention.

Consisting of a cylindrical unipotential-heater cathode surrounded by a massive copper anode, the cavity magnetron falls into a two element classification. Each anode contains a number of resonant cavities shaped in cross-section like keyholes with the thin stems or slots of each feeding into the central cathode chamber. The cavities—in effect resonant circuits— become excited, as electrons emitted by the cathode, are whirled in the cathode chamber past the slots by the action of an exial magnetic field.

Among the magnetrons shown was the famous 706AY-EY series in the S-Band. These tubes are essentially an improved version of the original magnetron secretly brought to the United States by the British in 1940. In a matter of less than five weeks this tube was completely tested and constructed. Another cavity magnetron on display with an equally glamorous history was the 700A-D series—the earliest of the L-Band magnetrons that proved itself aboard the cruiser Boise when the gallant craft broke up a Jap battle flotilla in a night engagement in the South Pacific.

Others in the L-Band group are the 728AY-GY series with their tunable counterpart the 4J51; also, the 4J21-25 and 4J26-30 groups of the fixed frequency variety and the 4J42 and 5J26 of the tunable variety. The 4J42 is a tunable replacement for the 700A-D series while the 5J26 acts as a tunable replacement for the fixed 4J21-25 and 4J26-30 groups.

In the S-Band, besides the previously mentioned 706AY-EY series, there was displayed the 714AY, 718AY-GY, 720AY-GY series, and the 4J45-47 series. The 4J45-47 type is intended for pulsed operation in systems where peak r-f power output up to a million watts is desired.

Standard peacetime tubes included the 298A, a 4 ft. 3⅞ inch high, water-cooled, filamentary triode which may be used as an audio frequency amplifier or radio frequency oscillator, amplifier or modulator. Others were the 342A filamentary, water-cooled triode oscillator which may be used at full rating up to 100 mc, and the 240B, 320A, and 389AA types used in transmitters for broadcasting.

Representative samples of the dozens of other special purpose and radar tubes produced during the war years also formed an interesting part of the exhibit. Included were gas switches, T/R tubes, spark gaps, pulsing tubes, an L-Band tunable high power triode, miniatures and Klystrons.

PULSE-TIME MULTIPLEX SYSTEM

Federal Telecommunication Laboratories presented a motion picture of their "Pulse-Time Modulation Radio Relay System" at the meeting.

The development affords a system whereby twenty-four or more conversations can be carried on the same radio frequency simultaneously without interference with each other.

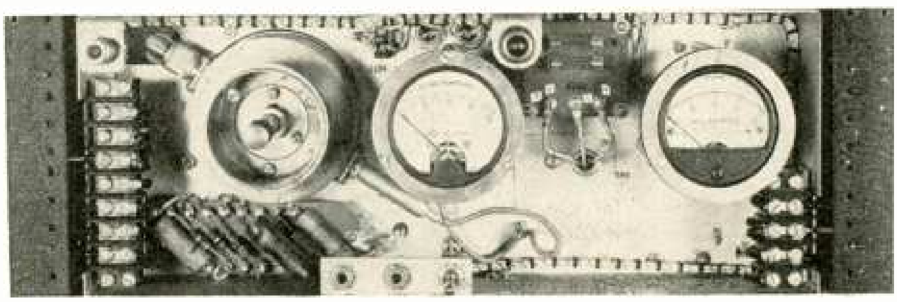
An outstanding telephonic feature of PTM is that telephone exchanges employing the system are automatically operated, reducing operational costs to the minimum and thus providing cheaper service. Absence of wires means low maintenance cost, and little hazard of interruption of service due to floods, wind and ice storms.

The PTM system is the culmination of years of work in the I.T.T. laboratories here and abroad and stems from the successful experiments of more than a decade ago by the system's laboratories in France and England with the micro-ray across the English channel.

The repeater stations boost the strength of the micro-wave energy without causing the distortion that sometimes results from wire-line repeaters. The repeater stations operate automatically and are entirely without human attendance. Those at Telegraph Hill and at Nutley are located atop huge towers.

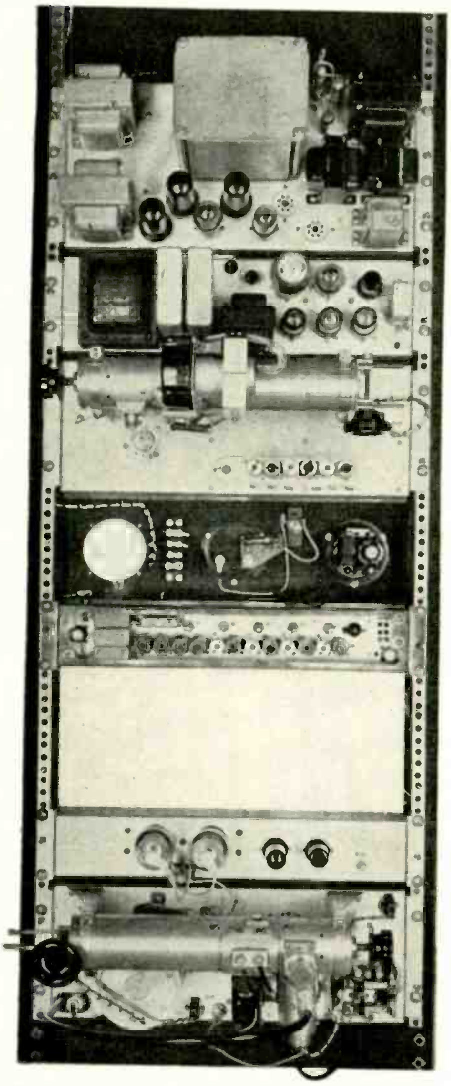
In effect, the PTM system samples the conversation and integrates them again at the point of reception. The transmitter beams the signals out over the microwave link on 1,300 mc. The pulses are so rapid and the bits of conversation fitted so compactly in time intervals that when they are filtered at the receiving end and each conversation is re-integrated, the human ear is incapable of detecting the process. A faithful reproduction of each of the twenty-four speakers' voices is produced, each one being selected automatically for the receiving station individually called.

The key to the filtering process is the cyclophon tube. The audible results which



Interior view of the multi-channel repeater transmitter chassis used in the PTM Multiplex Radio Relay System

PTM presents to the ear is compared with visual effects which the motion picture presents to the eye. Although the screen in a motion picture theatre is completely dark much of the time that a film is being shown, the eye is not quick enough to detect the dark intervals. The effect of PTM



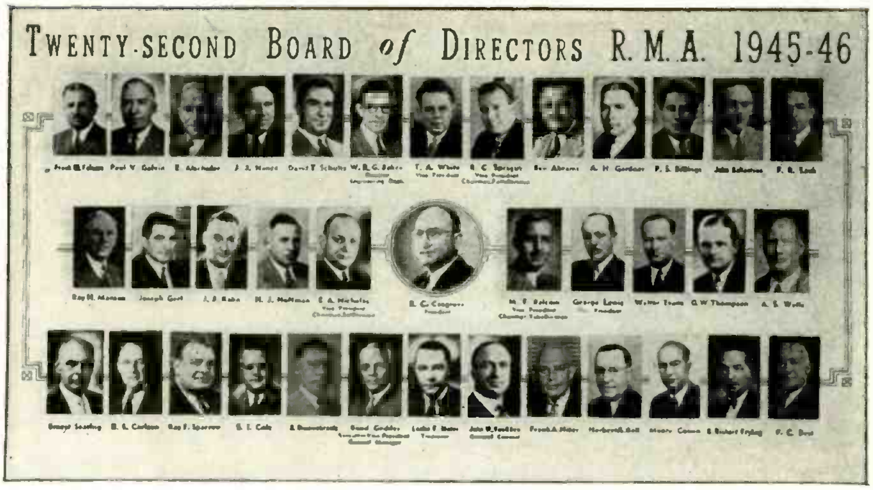
Detail of the Pulse Time Multi-channel Repeater assembly, a part of the PTM Multiplex Radio Relay System

on the ear is as flawless as the effect presented to the eye by the modern movie.

The PTM system is also applicable to the transmission of color television with sound on the same microwave channel. If used for radio broadcasting, it would make possible the simultaneous transmissions of twelve different programs from the same station. Public demonstration of PTM in color television transmission awaits further refinements in the art of full color broadcasting, which are expected "any day."

TV TEST GENERATOR FM TRANSMITTER

Two complex and amazingly accurate mathematical "magic brains" for television, an FM transmitter of the latest design, and a complete operating television station in miniature were among the new electronic equipments exhibited by the Engineering Products Division of the Radio Corporation of America.



So that we may know the leaders of the radio industry, serving us on the RMA Board of Directors

One of the mathematical units is an electronic time-interval counter, developed by Igor E. Grosdoff, RCA research engineer, which will measure time intervals a fraction of a second long in millionths of a second. Originally developed for military use at the Army's Aberdeen Proving Ground in Maryland, it is capable of measuring extremely short time intervals or velocity of swiftly moving objects in a wide variety of applications and is expected to find many uses in peacetime industry and commerce. At Aberdeen, the muzzle velocity of guns was determined by arranging two electrical coils so that a magnetized projectile, when fired, would pass through them in succession, setting up a small electrical current in each coil as it passed though. These small currents started and stopped the counter, thus measuring the time interval between the two signals. At the I. R. E. exhibit, pushbuttons were provided to permit the visitor to start and stop the counter and observe the measured interval.

The FM transmitter (RCA-1C) incorporates RCA'c newly developed "Direct FM" modulator circuits, and a new frequency control circuit which assures precision crystal control. Frequency modulation is accomplished directly by push-pull reactance tubes, connected across the frequency-determining circuit of the modulated oscillator. Grounded-grid amplifiers, a new feature in FM transmitter design, provide improved efficiency and result in greater stability in the new 100 megacycle FM band.

The miniature TV test generator is actually a compact set of television test equipment designed to eliminate bottlenecks in television receiver testing. With it, a complete video signal can be produced, making it possible to measure and adjust accurately the focus, contrast, resolution, and scanning linearity of television receivers.

It includes a monoscope camera, which produces a fixed television signal, and a distribution amplifier (RCA Type TA-1A), which, when used with the camera and a synchronizing generator, permits transmission of pictures and synchronizing signals over coaxial lines to various locations, or the feeding of signals from program lines

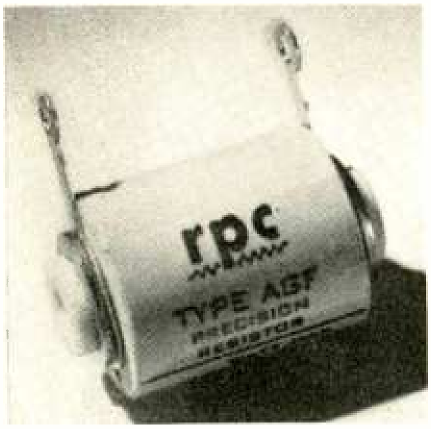
[*continued on page 42*]

FIGURES IN LUNAR RADAR CONTACT
Standing, left to right: Herbert P. Kauffman, Jack Mofenson, Dr. Harold D. Webb

New Products

WIRE WOUND PRECISION RESISTORS

RPC Precision Resistors, made in five sizes, have been developed to meet the needs of manufacturers and users of elec-



tronic equipment, meters and scientific instruments for applications where extreme accuracy and stability are required.

Steatite winding forms are used to insure highest insulating qualities, mechanical strength and permanence. Terminal lugs of brass, hot tin dipped, are securely fastened to the winding form. Resistance wire is of nickel-chrome or copper-nickel alloy. The enamel insulation on each spool of wire is tested for dielectric strength. The wire is non-inductively section-wound by especially developed machines having means for correctly maintaining wire tension. The ends of the winding are soldered directly to a special tab on the terminals.

These resistors are manufactured by Resistance Products Co., 140 South Second St., Harrisburg, Pa.

VOLTASCOPE

The Voltascope is a small self-contained instrument (3" x 4" x 5") which is used to calibrate an oscilloscope under operating conditions. This instrument has been designed by Polarad Electronics Co., 135 Liberty Street, New York, for the purpose of extending the usefulness of an oscilloscope in making quantitative measurements where

previously only qualitative measurements were practical.

The Voltascope provides three standard signals whose values are .1, 1.0, and 10.0 volts measured from peak to peak. By means of a selector switch, any one of these standard signals may be compared to an unknown signal on the screen of the oscilloscope for any setting of the amplifier gain control.

Thus, the magnitude of the unknown signal may be determined rapidly and accurately. The Voltascope operates from a-c mains, and its accuracy is one percent at a line voltage of 115 volts. There is no warm-up time, and the instrument may be used with any make of oscilloscope.

DUAL REGULATED DC POWER SUPPLY

Television applications frequently require two special power supplies, with large space requirements. To reduce the volume occu-

pied, P. H. Odessey of Polarad Electronics Co., 135 Liberty Street, N. Y., has developed the dual regulated d-c power supply illustrated.

This unit fits a standard relay rack space 17 inches by 19 inches. It contains two independent electronically regulated power supplies, each capable of delivering 400 m.a. at 800 volts. Voltage adjustment limits are from 275 to 325 volts.

Each power supply has an internal impedance of 1½ ohm, and a ripple below one thousandth of one percent.

Mechanical design features include the dishpan type of construction to facilitate servicing from front or rear without removal from the rack. Each power supply has a separate on-off switch, fuse, and pilot light. No electrolytic capacitors are used.

This dual power supply has been developed particularly for television and other applications where an extremely low internal impedance and ripple are mandatory.

NEW TEST EQUIPMENT

Release of their "B" Sweep Calibrator Model No. 8127 for commercial use in radar and television test work is announced by United Cinephone Corporation, Torrington Connecticut.

This instrument provides calibration marks for use in calibrating the sweep speed of a synchroscope or triggered sweep oscilloscope. The markers consist of short video pulses, of less than ½ microsecond duration, spaced apart by a known number of microseconds.

Range switch permits choice of four different time intervals between calibration markers:

- 2.5 microseconds
- 10 microseconds
- 50 microseconds
- 100 microseconds

Markers have an amliptude of 40 volts, with choice of polarity.

Trigger pulse (Internally generated): Choice of polarity. The positive trigger has an amplitude of 120 volts; negative 65 volts. The repetition rate is continuously variable by means of a calibrated control from 2000 to 3000 c.p.s.

Operation from an external trigger pulse, positive or negative, of 66 volts.

Continuously variable duration of 20 to 3000 microseconds. (gate length is length of time during which markers are generated following each tripper pulse. All markers that would appear subsequent to this interval are suppressed.)

Operating voltage: 110 to 120 volts, 60 cycles.

Power Consumption: 85 Watts.

Weight: 23 pounds. Height: 8". Length: 16". Depth: 7⅞".

NEW PICKUP

Shure Brothers announces the development of the Glider, their new post-war crystal phonograph pickup. It features two advanced engineering achievements: the Lever-Type Cartridge and the low-mass tone arm.

The cartridge houses the lever-driven

[*continued on page* 54]

THIS MONTH

[from page 40]

to monitors. It may be used for isolating distributed pulses or as a mixer to combine synchronizing signals with picture signals to form the complete video signal.

Also included in the set is the synchronizing generator (RCA Type TG-1A), a unit used for design and production testing of television receivers and for application work in experimental laboratories, and a regulated power supply (RCA Type 580-C) which supplies the required plate power for the monoscope camera and the distribution amplifier. This unit may also be used for general-purpose work in the laboratory.

Other laboratory and testing instruments included in the RCA display include a video sweep generator (Type 711-A), a high-frequency wide-band sweep generator (Type 709-B), an ultra-high-frequency signal generator (Type 710-A), and a laboratory type oscilloscope (Type 715-B).

NEW TUBE FOR TELEVISION AND FM

A new transmitting tube, Type GL-9C24, a triode, was exhibited by General Electric Company Electronics Department.

Designed particularly for application in a grounded-grid circuit as a class B radio-frequency amplifier and a class C radio-frequency amplifier and oscillator, the tube will be used in television and FM operation at the higher frequencies.

Full ratings on the new GL-9C24 apply up to 220 megacycles. The tube has been tested under class B r-f power amplifier conditions with a band width of 5 megacycles. The anode is water-cooled and capable of dissipating 5 kilowatts.

As a class B r-f amplifier in a grounded-grid circuit the new tube has a maximum d-c plate voltage rating of 5000 volts. Actual 220 megacycle tests under broadband and synchronizing peak conditions show a useful power output of 3.4 kilowatts per tube at a d-c plate voltage of 4000 volts. The use of a grounded-grid circuit in this application minimizes the necessity for neutralization.

At the top FM operating frequency of 110 megacycles, tests of the GL-9C24 under class C r-f power amplifier conditions in a grounded-grid circuit at a d-c plate voltage of 6000 volts have shown a useful power output per tube of 6.4 kilowatts. Here the maximum plate dissipation rating is 5 kilowatts and the maximum d-c plate voltage rating is 6500 volts.

AN/ARC-1

Airborne communications and navigation equipment exhibited by the Western Electric Company at the I. R. E. convention included the AN/ARC-1 radio telephone equipment adopted as standard for HF by the U. S. Navy air arm in World War II. Also included in the Airborne C & N display are the insert type receiver and hand-held differential microphone.

The AN/ARC-1 equipment consists of four major items; a transmitter-receiver, and dynamotor in a single case; a remote

We recommend these *Gammatrons* for the new amateur bands

In answer to many requests for our recommendations as to the Gammatrons which will give peak performance on the bands released to amateurs on November 15, we have been commenting as follows:

HK-24 and HK-24G "These triodes fill the bill for operation up to and including the 205 megacycle band. Your mechanical arrangement will largely determine your choice. We give the nod to the 24-G for top performance at 205."

HK-54 "Excellent up to 148 megacycles. Just the thing for the chap who wants 300 to 350 watts output from a pair on 28 megs—plate modulated."

HK-254 "If you want to put out a half kilowatt on 54 megacycles, use this big brother of the HK-54 in pushpull. Ratings decrease above this frequency to approximately 280 watts input to one tube at 200 mc."

HK-257B "Don't overlook this beam pentode for your bandswitching job. It requires practically no driving power. A couple of receiving tubes, such as 6V6's, will take you in a hurry from a 3.5 mc. crystal to 28 megs where pushpull 257-Bs will give you up to 400 watts out."

HK-454 "This is the tube for the man who wants a full kilowatt output on 28 megacycles. It's also excellent on 54 megs."

Additional data on Gammatron tubes appears in "The Radio Amateur's Handbook" and in "The Radio Handbook." Data sheets on individual types will be sent on request, and our engineering department will gladly provide special information or advice on your particular applications. You can now obtain Gammatrons at stores handling amateur components.

HEINTZ AND KAUFMAN LTD.
SOUTH SAN FRANCISCO · CALIFORNIA
Export Agents: M. Simon & Son
25 Warren Street, New York City, U. S. A.

control unit featuring automatic frequency selection, and a mounting base on which it is statically and dynamically balanced. The ARC-1 contains ten pre-set channels and requires only simple resetting when changing to a new set of channel frequencies. It uses approximately half the number of crystals ordinarily employed in conventionally designed equipment. The use of the same crystal for transmitting and receiving is hailed as an outstanding development.

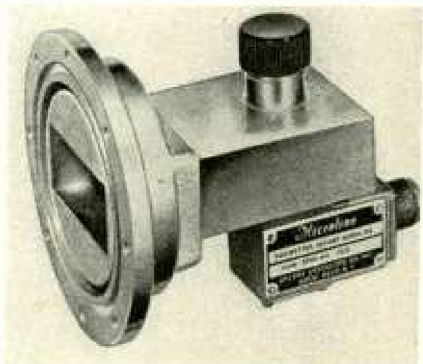
The AN/ARC-1 is being considered for adoption by commercial airlines for transport use because of its ease of maintenance and proven dependable operation. This equipment operates from a nominal 24 volt battery supply and provides radio telephone communication in the frequency range of 100-156 megacycles between aircraft or between aircraft and ground stations.

MICROWAVE INSTRUMENTS

A complete line of klystrons and precision microwave measuring instruments was exhibited publicly for the first time by the Sperry Gyroscope Company. These instruments represented some of the results of Sperry's basic research in microwaves.

The exhibit included groups of measuring instruments for all microwave frequency bands together with color photographs and scale models of Sperry radars, communications, and aircraft instrument landing systems which show applications of measuring equipment.

Also displayed were two series of Microline instruments in operation as a microwave test bench to illustrate microwave techniques. Energy for the test was supplied by a versatile microwave signal source which employs a reflex klystron

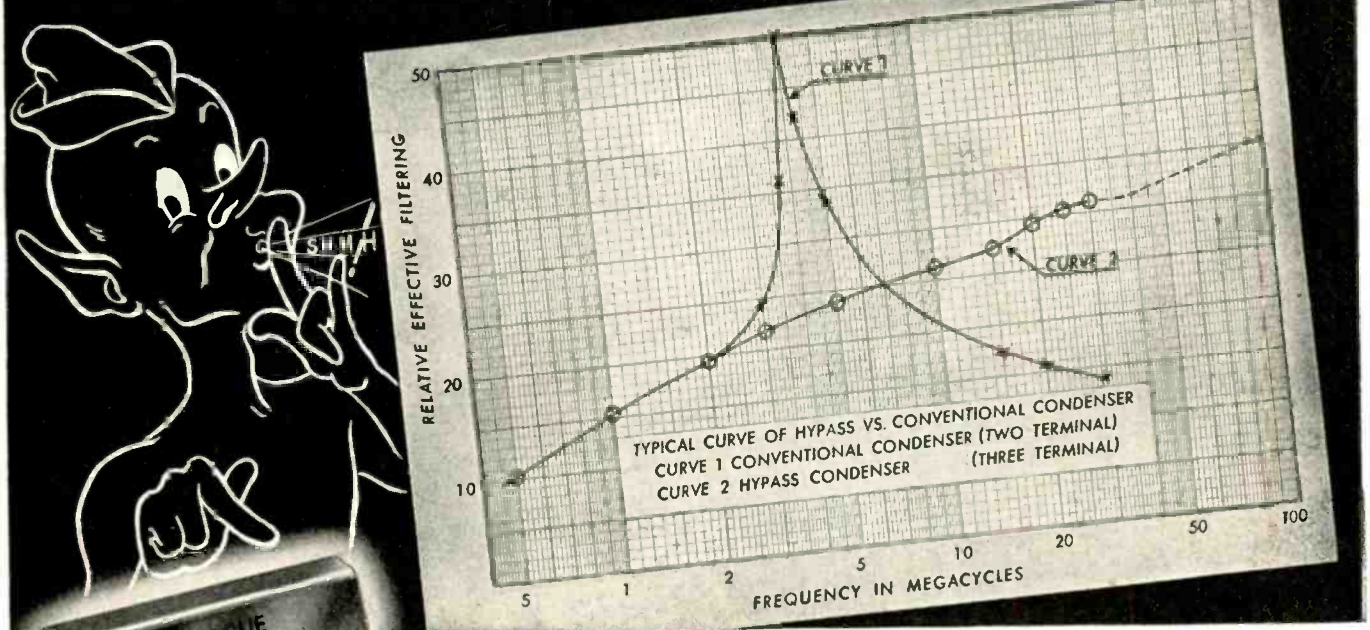


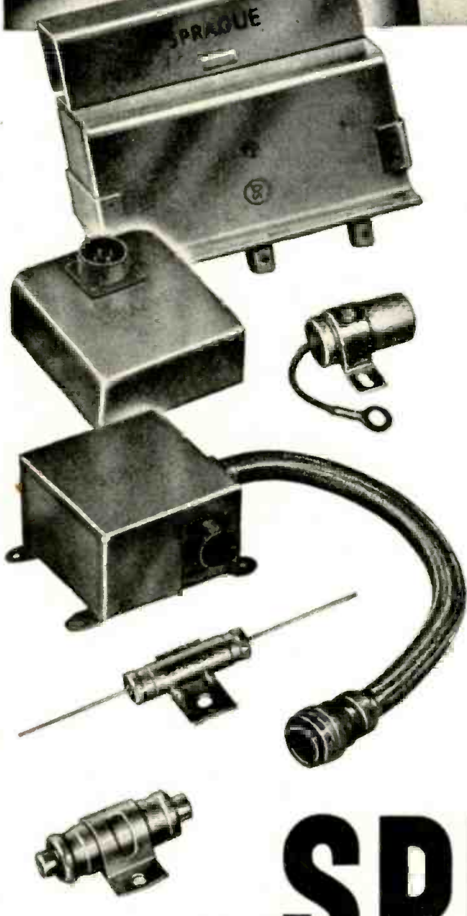
oscillator together with a square wave modulator, variable output impedance transformer, and an exceptionally well-regulated high voltage power supply to provide any type of signal output desired. The two benches provide convenient methods for making power, frequency, and impedance measurements on coaxial and waveguide components and transmission lines.

HEAT DISSIPATING UNIT

The Eastern Heat Dissipating Unit is used in connection with television, radar, short wave radio communications, high pressure mercury lamps, X-Ray tubes, induction heating units, and many other applications. It was developed for military requirements in conjunction with radar and electronic tube cooling problems. Units

RADIO INTERFERENCE ?





SPRAGUE HAS *the Answers!*

From inexpensive noise suppression capacitors for automotive use, to heavy-duty designs for service on power equipment, and for current ratings from 5 to 200 amperes capacity, Sprague produces modern filter units for practically any need. An unsurpassed background of engineering experience in dealing with all types of radio noise interference problems, is here at your disposal. Write for Sprague Capacitor Catalog 20.

ANTI-RESONANT FREQUENCY PROBLEMS SOLVED

Have you a vibrator "hash" problem that a conventional by-pass capacitor shunted by a mica capacitor only partially solves? If so, write for details on Sprague HYPASS Capacitors, the 3-terminal networks that do the job at 100 megacycles or more!

SPRAGUE ELECTRIC COMPANY
North Adams, Mass.

SPRAGUE

ARMY E NAVY

5-Times Cited for Distinguished Wartime Service

PIONEERS OF ELECTRIC-ELECTRONIC PROGRESS

were designed in various sizes and capacities, some with the close-heat control range of 2 degrees.

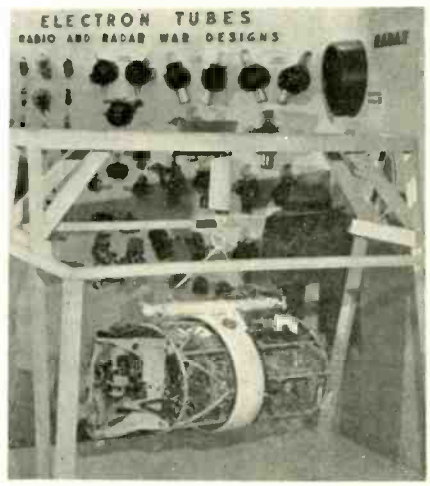
The model illustrated will dissipate up to 1200 watts with a constant controlled temperature, irrespective of surrounding temperatures, within 2 degrees C. It is complete with thermostat control, thermostatic valves and flow switch. Eastern has built airborne units of much smaller sizes and industrial units of much larger sizes and capacities. The specifications for the unit shown are: size: 16" x 7½"; metals: Steel, Bronze, or Aluminum. Other models can be designed to dissipate up to 5000 watts.

CARDIOID CRYSTAL MICROPHONE

A new cardioid unidirectional crystal microphone, with high output, dual frequency response selection, and other features was exhibited by Electro-Voice, Inc., South Bend, Indiana.

By means of a new, exclusive principle of unidirectivity developed by Electro-Voice engineers, this new Model 950 Cardax gives wide angle front pick-up, but is dead at rear.

In addition, the new Cardax has a dual Frequency Response selector on back of microphone which affords wide range flat response for high fidelity sound pick-up or wide range with rising characteristic for extra crispness of speech.



View of Western Electric AN/APS-4 "Ash" radar exhibit. This is the lightest airborne radar yet developed

FOREIGN PUBLICATIONS

Reports on scientific projects in Germany and German-occupied countries are obtainable from the Department of Commerce in photostat form at the noted prices:

Siemens - Hell - Teleprinter (represents a cross between facsimile and telegraph and usual printer-telegraph), $2; Manufacture of Selenium Rectifiers by Sueddeutsche Apparat Fabrik, Weissenberg, $1; Japanese Radio Set, Mobile Wireless Set C, Mark 1, Mark 305 Type Transmitter (high frequency mobile transmitter and receiving unit for vehicles and small naval craft), $4; Japanese Radio Set Model 95, Mark 4, Short Wave Transmitter Improvement 1 (for continuous wave, fixed station operation), $4.

Cyclotron Investigation, Heidelberg, $2;

For your resistors for experimental work, pre-production models, pilot runs, and small production runs call upon your local IRC Distributor for prompt, intelligent service!

Announcing the

IRC INDUSTRIAL SERVICE PLAN

now offered by over 300 IRC Distributors!

IRC Distributors from coast to coast are now able to give industrial users of resistors a new, extra service on all standard IRC products.

Under the new IRC Industrial Service Plan, your local IRC Distributor is building and maintaining adequate stocks of standard IRC units for many industrial requirements . . . and he can now fill your moderate-quantity orders, from stock, *at direct-factory prices!*

Take advantage of this new IRC plan, speed your reconversion and development by getting acquainted with your local IRC Distributor. If you do not have his name, your IRC Representative will be glad to recommend one or several in your vicinity, or write direct.

IRC Catalog No. 50 lists standard products stocked by IRC Distributors. *Send for your copy.*

DEPT. 7-B, 401 NORTH BROAD STREET, PHILADELPHIA 8, PA.

Luftwaffe Research Institute, Bad Blankenberg, $1; Quadded Toll Cables, $1; Carrier Telephone Systems (Germany), $3; Wire Program Services of the Reichspost, 41; Radio Operator's Information File (U. S. Army Air Force), $16; Investigation of Electronic Targets in the Prague Area (photocell developments), $2; Broad-band Rehbock U5 (artificial echo producing device used to adjust radar sets), $1.

NEW FCC APPOINTMENTS

The Federal Communications Commission recently announced as a further step in its reorganization of the Engineering Department, the following changes, which will be placed in effect at an early date:

The Field and Research Branch will be headed by Assistant Chief Engineer George E. Sterling and will consists of four divisions:

Field and Monitoring Division, headed by *George S. Turner.*

Technical Information Division, headed by *Dr. Lynde P. Wheeler.*

Laboratory Division headed by *Chas. A. Ellert.*

Allocation Division headed by *Paul D. Miles.*

The Safety and Special Services Branch will be headed by William N. Krebs and will consist of three divisions:

Marine and General Mobile with *Howard C. Looney* as Acting Chief.

Emergency and Miscellaneous Division headed by *Glen E. Nielsen.*

Aviation Division with *George K. Rollins* as Acting Chief pending the return of *Edwin L. White* who will head this division.

As indicated in its release of November 28, 1945, the Broadcast Branch, consisting of three divisions, namely, Standard, FM and Television, has already been organized and the Common Carrier Branch consisting of four Divisions, Domestic, International, Rate and Field is in the process of reorganization.

PERSONAL MENTION

James M. Blacklidge

The Standard Transformer Corporation announces the promotion of James M. Blacklidge as General Sales Manager.

Mr. Blacklidge brings to his new position a particularly able and varied background. For the past nine years he has been associated with Stancor in a number of capacities, each of which grew in resposibility as the company developed. His operations as Sales Manager of the Industrial Division contributed greatly to Stancor's distinguished war production record.

J. Kelly Johnson

J. Kelly Johnson, E. E., has opened his office as Radio and Electronic Consultant at 55 West 42nd Street, New York 18, N. Y., after being associated for many years with radio and electronic manufacturers, among them Hammarlund Manu-

J. Kelly Johnson

facturing Co. of New York; Wells-Gardner and Silver Marshall Company of Chicago and Hazeltine Electronics Corporation of New York and Chicago. During the war he was attached to the Office of Procurement and Materiel, U. S. Navy, as Electronic Adviser.

Captain David Saltman

★ Captain David Saltman, after four-and-one-half years service in the army, has returned to his former post as advertising production manager of Radio Magazines.

Dave was with the Ninth U.S. Army when it pushed out of Holland into Germany and with the First U. S. Army during the Battle of the Bulge. While with the Ninth he was liaison officer between a tank destroyer battalion and supported infantry units during the Siegfried Line Battle.

At the conclusion of the Bulge Battle Dave went back to Ninth Army and participated in the dash from the Rhine to the

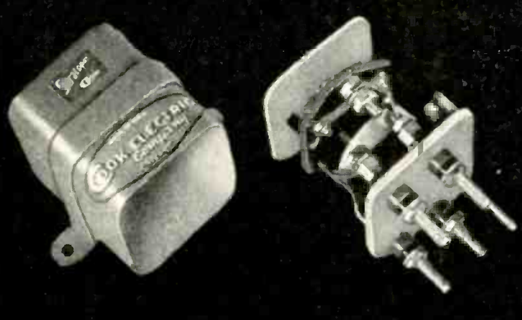
Here are the advantages when you Stratopax your electrical devices and components -

The science of Stratopax is the sealing of electrical devices in metal enclosures in an inert pressurized gas atmosphere. Stratopax, a service of Cook Electric Company available to all manufacturers of electrical devices and components, is the modern concept of the hermetic seal, with new and greatly improved techniques in sealing, inert gas filling and tightness testing.

Illustration of Stratopax relay used with a machine control unit ready for plug-in connection (left) and with cover removed before gas filling and sealing (right).

Here are the five basic features of Stratopax

1. PREVENTS CORROSION resulting from atmospheric changes, chemical conditions and fungus, by the use of specially compounded inert Nithelon gas.
2. PREVENTS EXPLOSION where gas and dust atmospheres are present.
3. PREVENTS ARCING AND BREAKDOWN in high altitudes for aircraft applications.
4. ADDS TO LIFE OF INSTRUMENT by permitting maximum service from contact points and through improved heat dissipation.
5. PREVENTS TAMPERING with factory adjusted equipment, and provides easy replacement if necessary.
6. RELAXATION OF SPECIFICATIONS and consideration of discontinuance of plating metal parts, insulation of coil windings, complete removal of coil winding wrappings, moisture and fungus proofing, design features for appearance only, and numerous other factors that become superfluous when Stratopax is used.



Contactor ready for Stratopaxing before covering. Wrap around mounting bracket, blister on cover for adequate terminal clearance, and binding post terminals meet specifications for unit.

While the packing and sealing of instruments may at first seem relatively simple, the steps involved in Stratopaxing already existing equipment are, however, more complex. How Cook engineers adapt existent equipment to Stratopax with consideration of present mounting and space limitations, and the steps taken in preparation of Stratopax are completely described in the Cook Stratopax Engineering Report. Fully illustrated, it explains thoroughly the need for, and features of, Stratopax techniques used in filling, sealing, testing and selection of gases. A request on your letterhead will bring you a copy immediately.

Two typical Stratopax enclosures showing fill tube protectors, glass seal terminals and variations of design and mounting to meet requirements.

A service of the Stratopax Division of

COOK ELECTRIC Company

CHICAGO 14, ILLINOIS

Elbe Rivers. During this latter campaign he was assigned by an Army Corps to an armored spearhead for the purpose of keeping the Corps headquarters informed as to the progress of the advancing armor. For this purpose he used an AM radio set mounted in a half-track vehicle. Because of the distances involved, even communication by CW was practically ineffective. As a result of his training experience, Dave says, he succeeded in getting back mesages by CW over distances sometimes greater than 60 miles by accelerating the vehicle engine motor for about five minutes prior to transmitting. This added transmitting power, in some cases, meant the difference between success or failure in his mission.

Communication was also an important factor in the Battle of the Bulge. In one instance he was equipped with an FM radio mounted in a jeep and his radio was the only means of contact with a roving task force whose mission was to feel out the enemy's position at the time our forces had been overrun.

Capt. David Saltman

After V-E Day, Dave joined Patton's Third Army headquarters where he worked with the prisoner-of-war section of the provost marshall's office until his return to the U. S.

We are proud to welcome Dave back to the staff of Radio.

George Balsam

★ The appointment of George Balsam as its Advertising Manager and Director of Sales Promotion is announced by Aerovox Corporation of New Bedford, Mass.

George Balsam

Mr. Balsam comes to his new post with an extensive advertising and sales promotion background gained mainly as account executive with Rickard and Company and O. S. Tyson & Company, the New York advertising agencies, where he specialized in technical accounts. For many years prior to his agency connections, he specialized in direct-mail service to industrial accounts. He succeeds Paul L. Kuch who resigned in order to enter his own advertising service business.

Julian Loebenstein

Radio Receptor Co., Inc., of 251 West 19th Street, New York City, manufacturers of radio and electronic industrial equipment and airport communications systems, have appointed Julian Loebenstein as

Julian Loebenstein

RACON's . . . *the leading speaker line . . . for all types of sound installation!*

Most of the best industrial p. a. installations in use are RACON speaker equipped. They are the finest speakers made and there is a type for every conceivable application.

For Marine p. a. installations, too, RACON leads. Approved by the U. S. Coast Guard, RACON speakers are used aboard Army and Navy vessels. Only RACON can supply, when needed, patented Weatherproof, Stormproof Acoustic Material which is impervious to any weather condition and prevents resonant effects.

Most manufacturing plants will soon order sound installations. Specify RACON Speakers! All types now available in unlimited quantities.

Left: MARINE HORN Speaker, approved by the U. S. Coast Guard. Several sizes available. Re-entrant type, suitable for indoor or outdoor use — may be used as both speaker and microphone. 2½', 3½', 4½' and 6' sizes available.
Right: RE-ENTRANT TRUMPET; available in 3½', 4½' and 6' sizes. Compact. Delivers highly concentrated sound with great efficiency over long distances.

RACON ELECTRIC CO., INC. 52 EAST 19th ST. NEW YORK, N. Y.

Sales Manager in their new Selenium Rectifier Division.

Mr. Loebenstein has been associated with Radio Receptor Company for the past four years in the capacity of Production Manager. Prior to his association with this company, he was for many years Sales Manager of the Appliance Division of the Consolidated Gas Company of New York.

Further new appointments made by Radio Receptor Company, Inc., for their Selenium Rectifier Division are the following Sales Agents:

E. T. Turney, Jr., of Turney & Beale, 215-05 27th Avenue, Bayside, N. Y., covering the New York metropolitan area, New Jersey, and parts of Connecticut and Pennsylvania.

J. E. Oliphant & Company, 505 Uhler Bldg., Marion. Ohio; covering the Western half of Pennsylvania, the Western half of New York, Ohio, Indiana, Michigan, Kentucky, West Virginia, Tennessee and Virginia.

Edward J. Cohen

★ Edward J. Cohen, for the past twenty-one years one of the better known sales executives of the radio industry, has just announced his resignation as vice-president and general manager of the Insuline Corporation of America in order to become an associate and co-partner of J. J. Perlmuth & Associates of Los Angeles, manufacturers' sales representatives.

"Eddie," as Mr. Cohen is known to all radio jobbers and manufacturers throughout the States, was associated with I.C.A. for twelve years, during which period the company developed to the position it now occupies as one of the foremost manufacturers of components and accessories supplying radio and automotive distributors in all sections of the country. Mr. Cohen's merchandising knowledge and sales ability were responsible in great measure for the success of Insuline Corporation of America.

Prior to joining I.C.A., Mr. Cohen was eastern sales manager for the Franco Battery Company, and before that was vice-president of the Baltimore Radio Corporation, one of the first radio-parts mail-order houses in the country.

Edward J. Cohen

Ray T. Schottenberg and C. M. Chorpening

★ Ray T. Schottenberg, Sales Manager. Jobber Division, The Astatic Corporation, Conneaut, Ohio, has returned from a tour of Eastern New York State. While in the East, Mr. Schottenberg and Leonard Allen, Astatic's representative, called on jobbers.

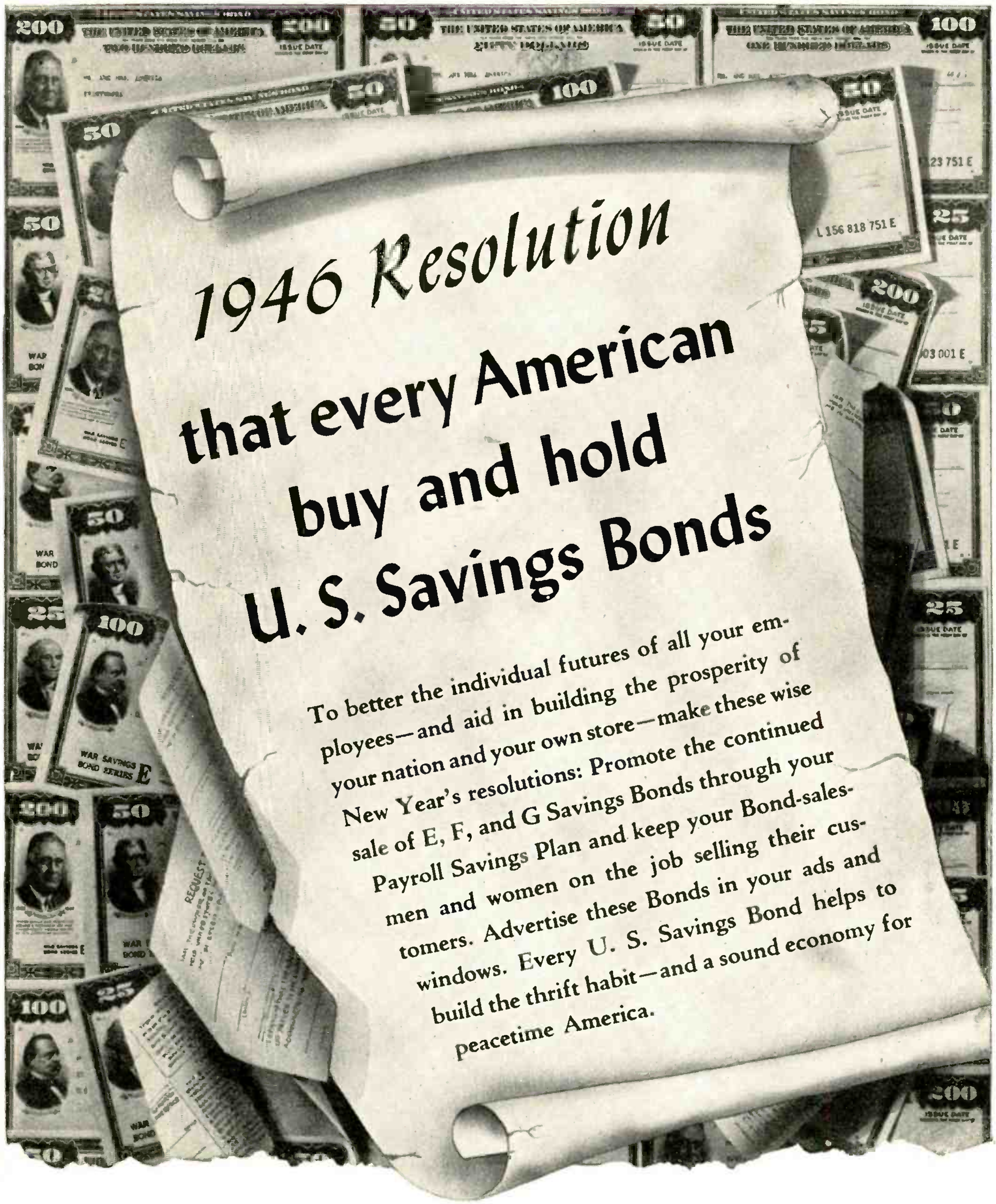
C. M. Chorpening, Vice-President and Director of Research, G. A. Morrell, Chief Engineer, and W. J. Doyle, Sales Manager Manufacturers Division, of The Astatic Corporation, Conneaut, Ohio, attended the Mid-winter I.R.E. Meeting in New York.

Lt. Colonel Nathan Boruszak

★ Lt. Colonel Nathan Boruszak, Director, Purchase Division, Signal Corps Procurement District here, has been promoted to the rank of Colonel.

In January 1941, the Colonel was called to active duty and placed in command of a Signal Corps Company at Fort Lewis, Washington. Being an expert in Signal Corps procurement activities, Colonel Boruszak has accomplished successful tours of duty in the Signal Corps Procurement Districts at San Francisco, Chicago, Dayton and Philadelphia.

A graduate electrical engineer from the University of Wisconsin, and also having completed the university's ROTC course, the Colonel was commissioned a Second Lieutenant in the Officers' Reserve Corps in 1924.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NEW PRODUCTS

[*from page* 41]

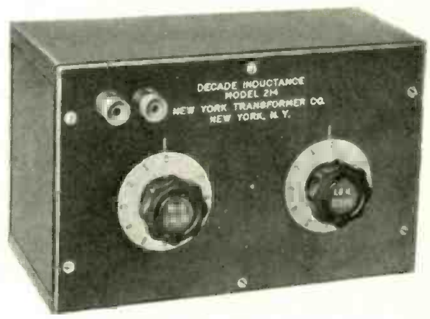
crystal, which results in lower needle impedance and higher needle compliance. The lever is so designed that it gives greater shock immunity to the crystal. The light aluminum tone arm is curved and is free from resonance. It has an adjustable swivel screw that prevents the needle from striking the turn-table if the arm is dropped.

The Glider uses no springs or counterweights. It has a scientifically determined frequency response. The standard output voltage is 1.6 volts.

INDUCTANCE DECADES

New York Transformer Company, 62 William Street, New York 5, N. Y., presents a new series of Inductance Decades principally for use in bridge and low level filter cricuits.

The inductance ranges are from .001 henry steps to 100 henries total. These units are triple shielded against external



fields. They are available in enclosed cases with two decades per case. On special order, these can be made with three or five decades in a single case.

These decades are adjusted to within 2% at 1000 cycles, except for the 100 henry decade which is adjusted at 200 cycles. The inductances will not change appreciably with quite a variation of AC currents or voltages. The useful frequency range of these units is from 30 to 20,00 cycles.

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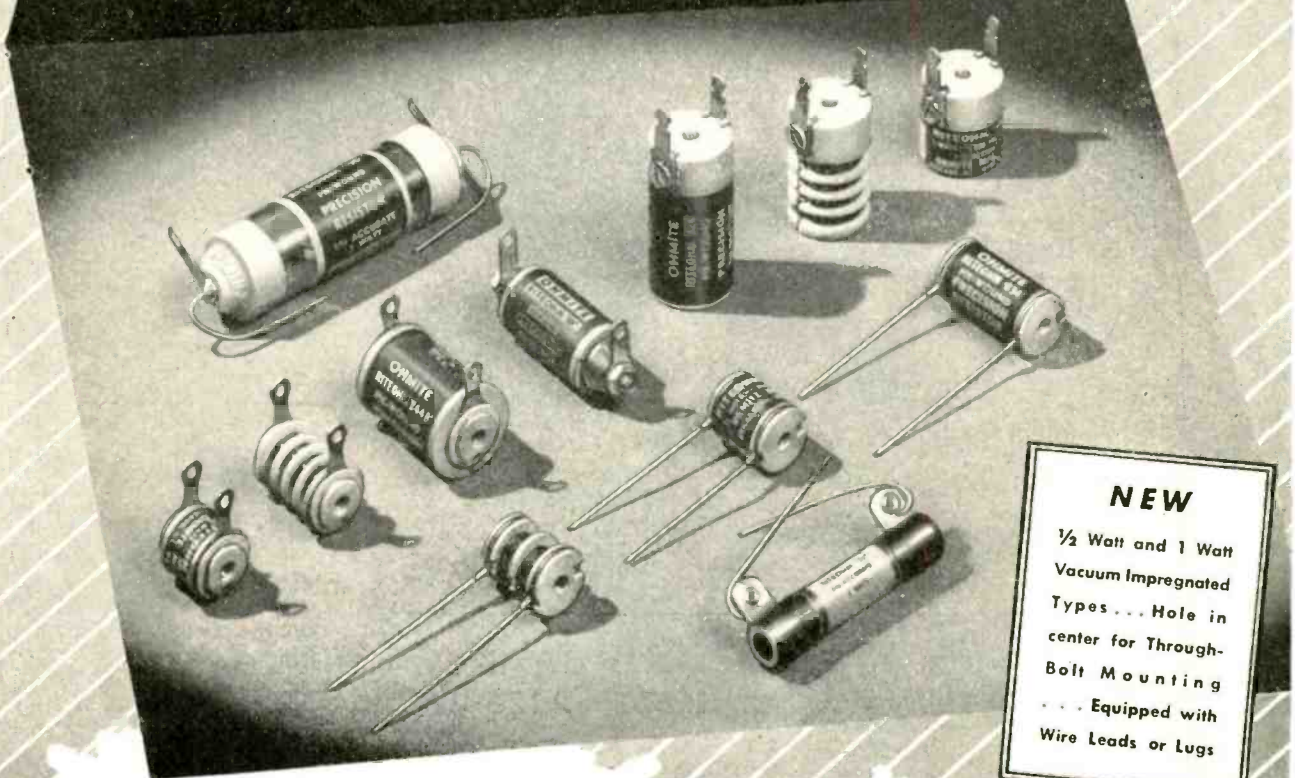

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OHMITE presents a *new* line . . . a *full* line . . . of finer precision resistors! Every type . . . every size . . . ready for every need! Each Riteohm is designed and built with all the specialized skill and experience that have made OHMITE units the standard in this field. However critical the application . . . consistent accuracy and reliability are assured. In these Riteohms you get *time-proved protection against humidity, temperature and corrosion.*

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modern railroads for improved communication systems, has been announced by Operadio Manufacturing Co., St. Charles, Illinois.

The new railroad-type loudspeaker is engineered to produce a maximum of voice identification, intelligibility and volume. In addition, it is specially designed to withstand dirt, wind and water. For railroad traffic control or intercommunication, the loudspeaker is completely adaptable for mounting on locomotive exteriors, within locomotive cabs, in a caboose or in switch-yards.

Outstanding feature is the entirely new pressure neutralizing grill and filter, which completely eliminates air pressure on diaphragm when loudspeaker is used on the exterior of an engine or caboose. Slip stream filtration avoids accumulation of soot or dirt and speaker housing is completely sealed and weatherproofed. Waterproof terminal cover permits external connection without opening unit, and fittings are designed for standard railroad conduit and unions. For further information, contact Operadio Manufacturing Co., St. Charles, Illinois.

CBS COLOR TV

[*from page* 32]

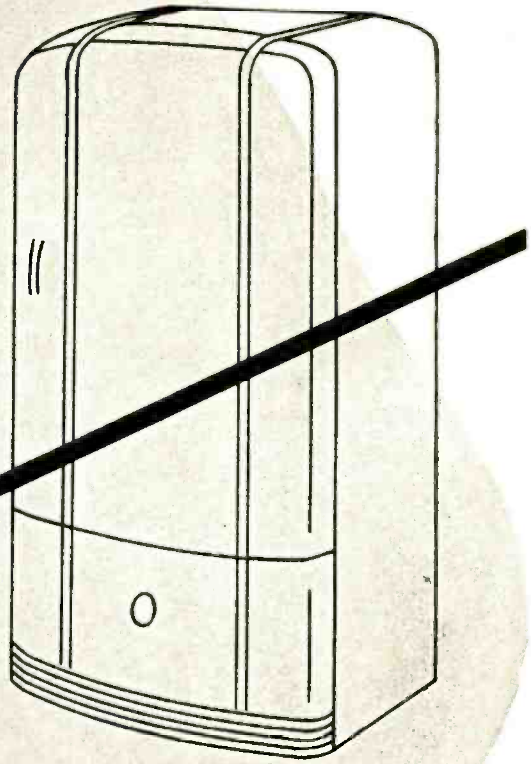
ligible. In the region they are operated in this service the mutual conductance of each tube is approximately 10,000 micromhos, so that the source impedance of this stage may be considered as 50 ohms. In addition, the high current capabilities of the stage and the negative feedback present in the cathode follower connection enable the preserving of a flat frequency response in spite of the shunt capacitance of the radio-frequency amplifier load. The stage gain is 0.8 and the output voltage 550 volts.

Power Supplies and Control Equipment

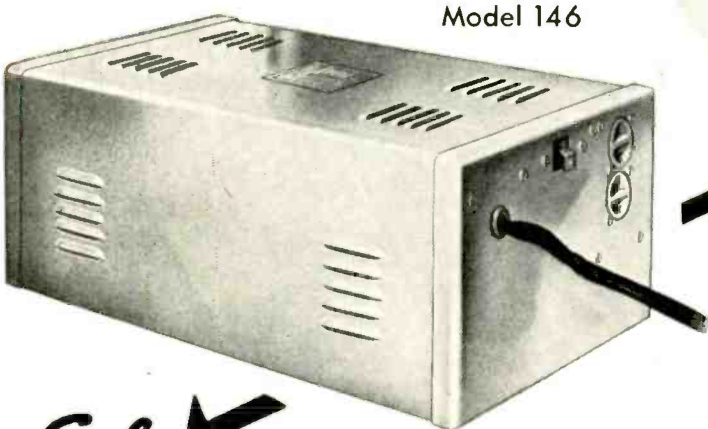
The video-frequency amplifier and modulator uses a relatively large number of power units, since a separate coupling pack is required for each stage, and in addition, separate regulated supplies are used for the 6AG7 and the two 807 stages. The two stages using 6C22 tubes are fed from a common anode supply. This produces a desirable effect, since the current drawn by the cathode follower stage is increasing when that drawn by the amplifier stage is decreasing, and vice versa. This effect reduces the magnitude of current change in the pack load, and improves the low-frequency response.

The radio-frequency system also uses a number of supplies, not only because a variety of voltages are required, but also to permit easy control and tune-up, and to prevent interaction between the modulated amplifier and the stages feeding it. Separate supplies are pro-

TO OPERATE AN AC REFRIGERATOR ON DC



Model 146



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Mod. No.	Input Volts DC	Output Volts AC	Output Watts	Load P.F. (%)	Dimensions (in.)	Wt. (lbs.)	Principal Applications
302	6	115	75	80-100	9⅜x6⅜	15½	Radio Receivers, Appliances
507	12	115	150	80-100	10¾x7½x8¼	25	Radio Receivers, Transmitters, Appliances
146	32	115	350	80-100	16x10x8⅜	48	Receivers, Transmitters, Coin Phonographs
268	115	115	750	80-100	20⅛x11¾x7½	66	Motors, Communications, Equipment

Electronic LABORATORIES, INC.
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DC-AC INVERTERS

VIBRATORS AND VIBRATOR POWER EQUIPMENT FOR LIGHTING, COMMUNICATIONS, ELECTRIC AND ELECTRONIC APPLICATIONS vided for the low-voltage stages of the exciter, for the two doublers, for the driver stage, and for the final amplifier.

Control of all power units, the water circulating pump, the main power circuit breaker, and all other necessary functions of the transmitter control are centralized in a console. From this point the transmitter may be completely started and stopped, or any portion of the unit turned on, as desired. Whenever it is desired to isolate any portion of the equipment, or whenever the opening of a door interlock switch or other protective device necessitates the interruption of any circuit, all other circuits dependent on that for proper functioning are automatically cut off. That is, complete interlocking for protection of personnel and equipment is included in the design of the control circuit. Pilot lights check the operation of each power circuit to speed the location of trouble in the system.

The console also contains cathode ray monitors for picture signals. Two image tubes are provided, one of which is continually on the radio picture actually radiated, while the other may be connected either to the incoming signal for comparison, or to any one of a number of monitoring points throughout the video and radio system for trouble shooting and service. An oscilloscope is normall associated with each of these image monitors, to check the synchronizing waveform at the monitored points.

COUNTER CIRCUITS

[*from page 26*]

The output voltage, E_o, is the average value of E_1 and E_2. Since the value of k in actual practice is of the order of .001, the ripple amplitude (a and b) will be exceedingly small with respect to the output voltage. As a result the ripple may be considered as being symmetrical with the introduction of a negligible error. The output voltage is then

$$E_o = \frac{E_1+E_2}{2} = \frac{kE}{2}\left(\frac{e^{t/RC}+1}{e^{t/RC}-1+k}\right) \qquad (5)$$

An examination of equation (5) reveals that as t becomes smaller and approaches zero, the value within the parenthesis approaches $2/k$ (where k is greater than zero and less than one). As t becomes larger without bound, the value within the parenthesis approaches one. This being the case, the output voltage will vary between the limits of E and $kE/2$ as the frequency varies from infinity to zero.

A further inspection of equation (5) will show that as k is increased or decreased the output voltage will vary directly. Increasing or decreasing the capacitance of C_1 causes a change in k.

hence, for any given frequency the output voltage may be controlled within limits.

The output voltage, E_0, as expressed in equation (5) is not a linear function of the frequency but rather an exponential one. However, by proper design of the circuit, a fair degree of linearity may be obtained up to a frequency of about 10,000 cycles. This can be accomplished by the proper selection of k and RC and also by returning the plate of D_1 to a positive bias which will keep increasing as the frequency increases. The effect of returning this diode plate to a positive source will charge C_1, after it reaches zero, to some value with polarity reversed. The voltage across C_1 will then be in series aiding that of the generator's voltage, and, for a given frequency, the steady-state condition will be reached at a higher value of voltage E_0.

A bleeder arrangement of the current from the circuit which the output voltage operates will serve as an excellent source for this positive bias. (See *Fig. 6.*)

Practical Applications

This particular type of a counter circuit has many practical applications. It has been very successfully used in aircraft absolute altimeters of certain types. By a frequency modulated reflected wave device in the altimeter, it is possible to obtain a beat frequency which is proportional to the aircraft's altitude above the reflecting surface, namely the terrain. The counter circuit then translates this beat frequency into a proportional voltage, which in turn operates a direct current meter in the output circuit. In this device the meter is calibrated directly in hundreds—or thousands of feet.

This circuit may also be used as a control device and as a speed indicating device. As a control device, this counter circuit can be made to operate a relay, in the plate circuit of the output tube, above or below any predetermined operating frequency.

This circuit, furthermore, lends itself nicely to preadjustment. By a series rheostat R_4 in the meter circuit, the quiescent residual relay current can be adjusted. Then, by means of capacitor C_1, the output voltage of the counter circuit (that is, the signal voltage on the grid of the control tube) can be adjusted to any value, within certain limits, for any given input frequency.

As a speed indicating device, any rotating mechanical equipment can be geared to generate a voltage of frequency proportional to its speed. The indicating device, a meter in the plate circuit of the output tube, can then be designed and calibrated in rpm.

PULSING CIRCUITS

[*from page* 30]

closely spaced positive-going pulses, and the cathode input is a sequence of widely spaced negative signals. Either of the input signals by themselves are incapable of causing the triode to conduct, however, when the pulses arrive in time phase, i.e., every tenth grid pulse arrives at the same instant a cathode pulse appears, the tube conducts heavily, lighting the neon lamp connected across the triode's plate load resistance. When the neon lights, the two inputs can be assumed to be in coincidence or in phase.

Summarizing, the circuits described are capable of either generating various types of pulses or utilizing pulses in controlling or measuring small increments of time. The uses to which they are put are innumerable, and their future usage in electronics is assured.

ACOUSTICAL TREATMENT

[*from page* 19]

or from an audio oscillator and commutator. The signal is stopped abruptly by operation of a key switch and the delay time computed from known factors such as recorder tape speed, delay time curve and marginal error. Several decay readings should be taken at each frequency with the microphone and speaker placed at various distances and the average reading taken to obtain more accurate results.

In most measurements it is desirable to face the loudspeaker away from the microphone so that direct sound energy is kept from interfering with the random energy under measurement. In special applications as many as five to ten microphones are often used with a commutator and recorder.

Absorptive-Reflective vs. Dispersive Treatment

Acoustic treatment usually follows one of two general principles: the familiar method of sound reflection and absorption, and the more recently developed means of sound wave dispersion. In the first, the optimum reverberation time is determined mainly by the amount of acoustic absorbent material used in the walls and ceiling; in the second, by the diffraction characteristics of a number of convex surfaces.

A typical example of a studio designed on the principles of reflection-absorption is one so constructed that one end of the room contains most of the sound-absorbing material and the opposite end.

being composed of seasoned wood paneling, acts as a resonant reflecting surface. The resonant period of these panels lies within the musical range between A below middle C to the octave above middle C, or between 200 and 500 cycles per second. This resonant condition, along with the natural tendency of wood to act as a tonal amplifier, results in increased richness and timbre of the fundamental sound waves. The panels are rigidly attached only at their edges in order to avoid damping their natural vibration period.

The lateral walls are composed of panels arranged in low-angle horizontal-V positions in order to eliminate the possibility of parallel-wave reflection from opposite wall surfaces and thereby preventing the occurrence of "flutter". Sound-absorbent material for ceiling and walls consists of a two- to four-inch thickness of rock-wool covered with perforated metal or hard-finished fiber of a pre-determined thickness which aids in attaining practically uniform characteristics over the entire sound frequency range.

In operation, the microphone is placed as near the dead end of the studio as possible, with the talent or various instruments facing the reflecting wall. Thus the single echo effect obtained by the direct reflection of sound back into the absorbing wall results in an appreciable degree of sound reinforcement and emphasizes brilliance and timbre. This method of studio design is referred to as "live end-dead end".

In the dispersive method of studio treatment, acoustic control is accomplished through the use of convex wood panels applied to the ceiling, side walls and to the two ends of the studio, with the axes of these panels or splays being mutually perpendicular to each other. (See *Fig. 1*).

These convex panels, more technically known as polycylindrical sound diffusing columns, are usually constructed by nailing a first sheet of one-quarter-inch or three-eighths-inch plywood to correctly shaped rib forms one inch in thickness and unevenly spaced to prevent intersection resonance, and then glueing a second sheet of plywood around the first. This method provides greater strength, neater appearance, and ease of assembly. Between the first plywood sheet and the ribs are placed one-half-inch by two-inch celotex or soft fiberboard strips to prevent vibration and rattle between panel and ribs, and the entire panel is strengthened by wood strips placed along the edges of the panel and across the back of the ribs. The chords of the various columns are themselves different in proportion, being so constructed in order to prevent unwanted vibration between two or more columns having the same resonance period.

Because of the absence of parallel surfaces in convex diffusing columns the possibility of echos is eliminated and a longer reverberation time is made possible. The net result is an improvement in the relative optimum conditions for music and speech which are so necessary in high-quality reproduction.

Other advantages over studios of conventional or previous design are:

(1) Ultra-modern appearance. Panels may be painted or sprayed as desired without affecting their acoustic characteristics at frequencies up to 10,000 cycles. From this point up to 15,000 cycles hard painted surfaces assume rising response characteristics, a factor often desirable in studio design in that it provides compensation for the loss in high frequency response usually present in audio equipment and thus contributes to a more uniform overall response curve.

(2) Improved frequency response is obtained for the same surface area.

(3) A more even distribution and decay of sound allows a much greater amount of sound re-enforcement to be used. A greater number of loudspeakers may be placed at various points in the audience for increasing "depth" of sound with less danger of feedback.

(4) Diffusing action does not reduce the total sound intensity within a room, as may sometimes be apparent, but rather increases the total number of reflections per second through re-radiation, and thus decreases the intensity of individual sound reflections. The amount of interference between primary and secondary or reflected sound waves is thereby decreased, and by this action the problem of microphone placement is greatly simplified.

From our foregoing discussion can be seen the enormous amount of development that has taken place in the field of acoustics engineering during the past decade. It will be interesting to note the improvements in design and methods of acoustical treatment which will certainly be forthcoming in the near future.

FM AFC SYSTEM

[*from page* 22]

When frequencies very much lower are used, special bandpass filters must be employed to provide the bandwidth and selectivity at the same time.

There are a number of advantages offered by this circuit. Perhaps the most important of which is the lack of tuned circuits and critical components. The

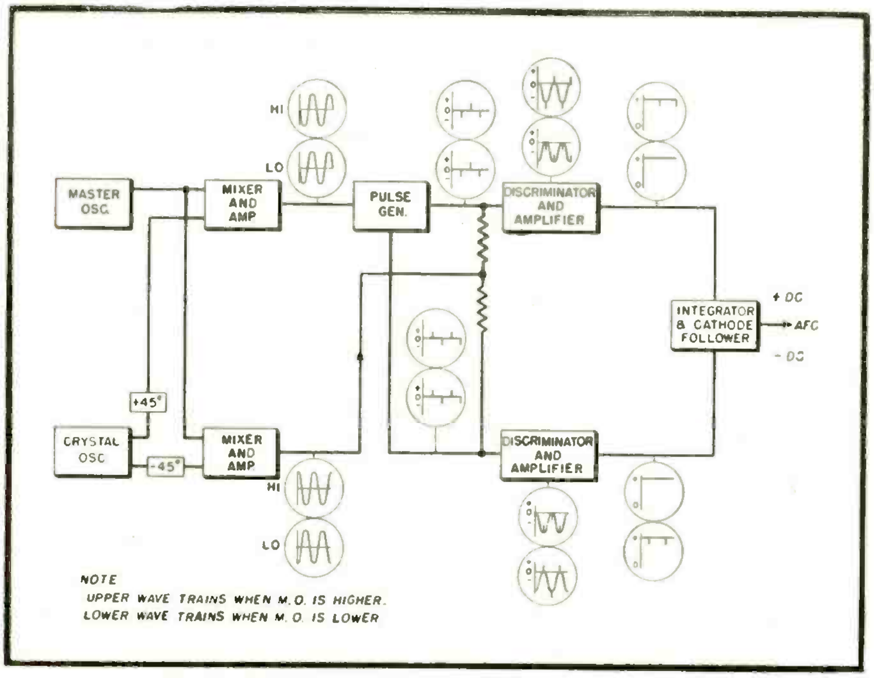

Fig. 6. Block diagram of center-frequency control network

frequency control unit proper contains no tuned circuits, dividers, or locked oscillators. No test instruments are needed to place this equipment in operation. Another important advantage is that tube characteristics are not important. Since each tube in the circuit is driven from grid current to cutoff, merely acting as electronic switches, the actual condition of the tubes becomes relatively unimportant. Long before any tube would become inoperative in the circuit, it would be discarded because of routine tube checks.

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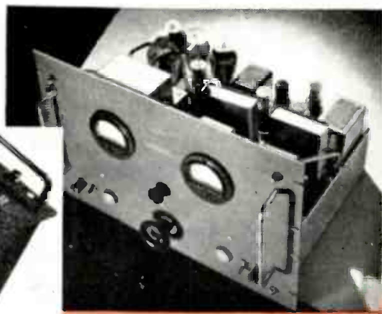

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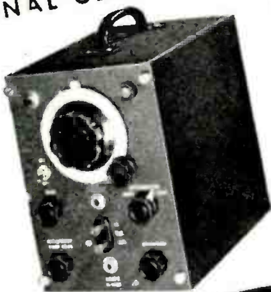

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SYLVANIA NEWS
CIRCUIT ENGINEERING EDITION

FEB. *Published by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. 1946

TINY T-3 TUBE ASSURED A BIG SUCCESS IN RADIO

New Wonder Tube Developed by Sylvania for Midget Portables

The development by Sylvania Electric of the tiny T-3 radio tube is an important factor in making possible light weight, "vest pocket" radio sets.

Ever since the announcement of Sylvania's development of a peanut-sized electronic tube for the famous "war secret" proximity fuze, manufacturers and circuit engineers have been busy making plans for producing super-small radio sets and walkie-talkies that would capture the public's imagination. Now that the Sylvania T-3 (commercial version of the proximity fuze tube) has been perfected, these revolutionary radio ideas are becoming more and more practical.

Future designs of this versatile tube will permit a wide variety of applications, ranging from sets no larger than a package of cigarettes up to deluxe farm receivers. The tiny tube features extremely small size with feather-weight. It has a life of hundreds of hours, is rugged and exceptionally adaptable to operation at high frequencies.

For further, interesting information, or for the answers to any of your questions concerning this remarkable tube, write to SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pennsylvania.

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