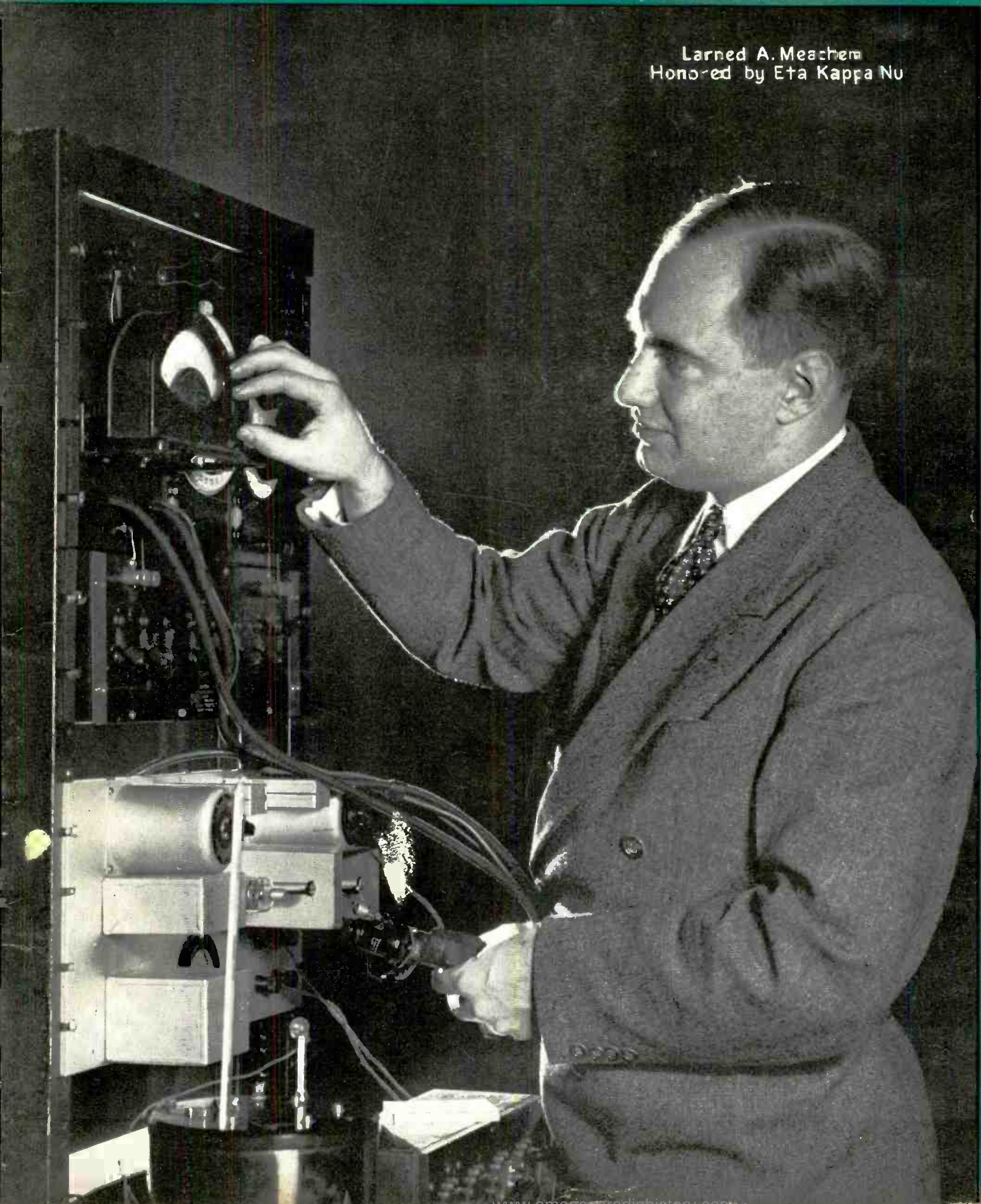
electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture



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Radio . . . Communication and Industrial Applications of Electron Tubes . . . Design . . . Engineering . . . Manufacture

McGRAW-HILL PUBLISHING COMPANY, INC.

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Publication Office
99-129 North Broadway, Albany, N. Y.
U. S. A.

Editorial and Executive Offices
330 West 42nd St., New York, N. Y., U. S. A.

James H. McGraw, Jr., President
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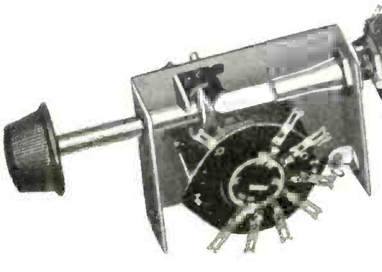
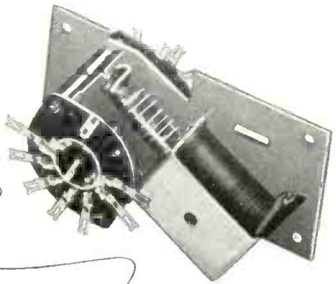
CONTENTS—FEBRUARY, 1940

DEPARTMENTS

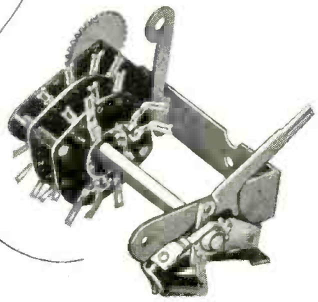
ELECTRONICS, February, 1940, Vol. 13, No. 2. Published monthly, price 50c a copy. Subscription rates—United States and possessions, Canada, Mexico and Central American countries, $5.00 a year. All other countries, $6.00 a year or 36 shillings. Entered as Second Class matter, August 29, 1936, at Post Office, Albany, N. Y., under the Act of March 3, 1879.
Branch Offices: 520 North Michigan Ave., Chicago; 68 Post Street, San Francisco; Aldwych House, Aldwych, London, W. C. 2; Washington; Philadelphia; Cleveland; Detroit; St. Louis; Boston; Atlanta, Ga.





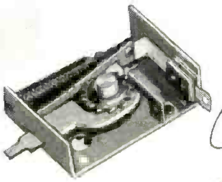
Single push button operated selector switch for Automobile or home radio. Station selection or wave band switching.

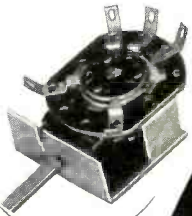
Coincidental single shaft operated selection switch, and volume or tone control. Station selection in automobile or home radio or wave band selection.



Solenoid operation selector switch, Single push button, automobile, or home radio controlled remotely.

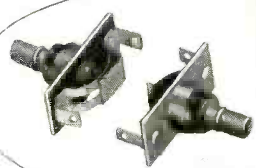
Special single contact switch to operate remote solenoid and index dial at same time.





Single-Push operated tone switch. Selections of various tone positions.

Key operated line or tone switch, where unauthorized adjustment is imperative such as coin phonographs. Can be applied to any type of shaft operated switch.



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Versatility . . . beside the orthodox type, we are equipped to design and create switches and controls for various special applications, including complicated switching mechanisms.

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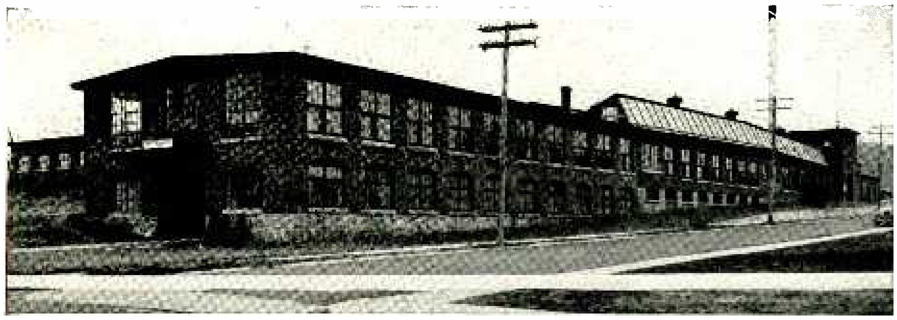

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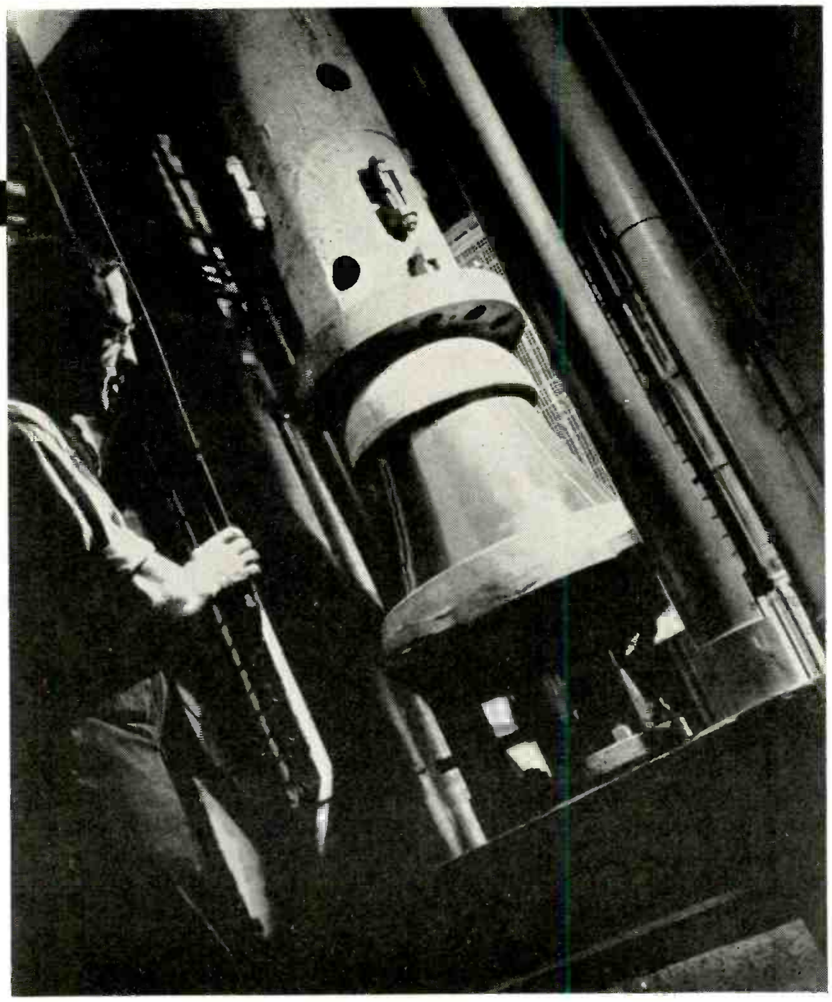
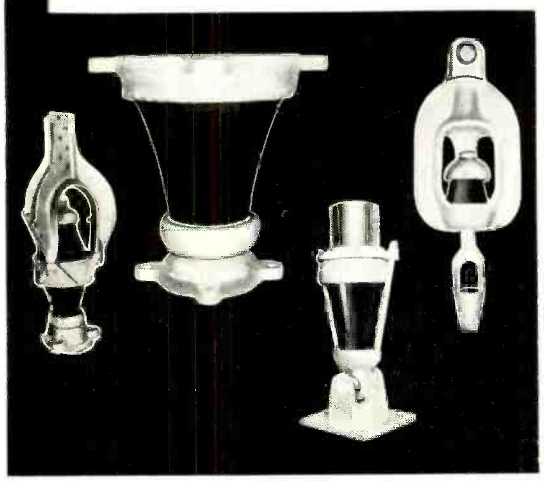


. . . ALL LAPP TOWER INSULATORS INCORPORATE THE SAME ENGINEERING DESIGNS Visitors at the Lapp plant are often most amazed at this demonstration—the proof test of a porcelain base insulator with 1,500,000-lb. loading. On design test, this same unit withstood 3,000,000 lbs.

We *are* proud of a porcelain cone of two-and-a-half-inch wall thickness that will stand up under 3,000,000 lbs. of compression loading. But we don't claim any magic for it. It's merely the application of sound engineering principles in mechanical design and in porcelain production.

Back of every Lapp development is the same kind of thinking. Products for radio transmission include tower footing and guy insulators, porcelain water cooling systems and pressure gas-filled condensers. Every engineer contemplating installation of a new transmitter, or modernization of present equipment, should hear the Lapp story.



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- AIRCRAFT INSTRUMENT WIRING
- HIGH VOLTAGE PLATE LEADS
- WHEREVER A HIGH-TEMPERATURE-RESISTING AND HIGH-DIELECTRIC WIRE IS REQUIRED.

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and in Auto Receivers built by:

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Crosley	RCA-Victor, Ltd. (Canada)
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Mission Bell	Stromberg-Carlson (U.S. and Canada)
Noblitt Sparks (Arvin)	Zenith
Northern Electric (Canada)	Western Electric
Packard Bell	

CROSS TALK

► **FLOP** . . . Through the courtesy of Radio Engineering Laboratories we have been playing with a frequency modulation receiver for a week or more. We are disappointed. Let us hasten to say that our disappointment is not with the receiver or with frequency modulation. The trouble is in another direction; and we think it is serious.

This receiver, and the Alpine transmitter are good; the band is wide, the distortion is low, the entire system is exceedingly quiet. But the programs, although taken from one of the large chains, are simply fierce. We listen from after-dinner to time to take the dog out for a walk (9 PM) and except for theme music a $10 radio would do us just as much good as the R.E.L. job. In other words we have ears but nothing to listen to.

On Sunday the Philharmonic comes in so well that we lock the front door, pull down the blinds, take the car down the block and park it so the whole place looks as though we have gone to the country for the day, or to Florida for the winter—just to be immune from interruption. But this is just about all the good we get from the f-m system.

It seems that the serials now on the air are so plentiful and so firmly intrenched and so interspersed with other palaver that it is not until 9 PM or later that the musicians have a share of the ether. Our demands are not much; we don't want a full symphony every night. A bang-up jazz band is always tolerable, and would be mighty pleasurable with this R.E.L. receiver—but serials, like love, seem to be easy to start and difficult to stop. While love often comes to a logical and foreordained end, there is never any termination to a serial.

In New York City, several other frequency modulation stations are under construction. Maybe the program they radiate will be better.

► **A.W.O.L.** . . . Now it seems that the town of Millburn, New Jersey, has a police radio system, two-way. During the holidays a little situation arose which is now in the process of a natural although somewhat anguishing solution. Let the Millburn & Short Hills ITEM tell it, "an officer whose name is as yet undisclosed was on duty in one of the police cars and the night being cold and blustery, the lone vigil was anything but conducive to the spirit of the season.

"Bethinking himself of a girl friend who might shorten the hours from dusk to dawn, she was taken along on the nightly round." As they went toward one of the "township's back areas" the officer reported his pseudo position regularly until he finally forgot to turn the send-receive switch. He left it in "transmit."

Thus it was that a startled sergeant at Headquarters heard a remarkable communication, "Aw sister, have a heart, give a guy a kiss." The ITEM does not state how many other police cars Millburn has but it implies that all of them went hunting dark lanes pronto and "the broadcast finally came to a natural end as all such inspired moments, and now a police trial is in the making."

Note to police radio men—when in doubt leave the switch in "receive" position.

► **CONFERENCE** . . . As this issue is mailed, a group of students and broadcast engineers will be headed for Columbus, to attend the 1940 Broadcast Engineering Conference at Ohio State University. As in past years, the program is up to the minute, and the speakers are authorities in their fields. For example, the symposium on frequency modulation will be conducted by Major Armstrong, Paul de Mars of the Yankee network and Engineers Weir and Shea of G. E., all men who eminently qualified for the job. Similarly worthwhile sessions will be held on station measurements, u-h-f propagation, noise, receivers, transcriptions, transoceanic relays, television, and even the relationship between Law and Engineering. For those who can afford the time, the Conference is highly worthy of attendance.

► **AUDIENCE** . . . As we go to press, a report by Alfred H. Morton, Vice President of NBC in charge of television activities, reveals that the mailing list of their program schedule, mailed to owners of television receivers, has increased in three months from 249 names to 1005 names, and that the list is growing at the rate of 10 per cent per week. Estimates based on these figures show that there were, in the first week of January, approximately 2000 receivers, with an average audience of perhaps 8,000 people, with a potential audience of 10,000. While the number itself may not be impressive, the rate of growth, we think, will come as a shock to those who have been claiming that television is a dismal failure. The report also shows that the audience enthusiasm, as indicated by return cards on which the viewers check their reaction to the programs, is steadily climbing.

PATENTS . . . How to Write

In the rapidly moving field of electronics, patents form an important part of the literature. But patents must be written according to rules, so that reading them is not always an easy task. Mr. Goldsborough's article gives a quick insight into the writing of patents, useful not only to those who cannot afford the services of an attorney, but also to the larger group of engineers who must read patents for information.

TO SUPPORT a valid and enforceable patent, an invention must be "new" and "useful." That is to say, the invention must be original, not known nor used before, and must be operative. Furthermore, gambling devices are not patentable; neither is any invention that is contrary to law or subversive of public morals.

From the inventor's standpoint, the usefulness of a patent depends on commercial value. A patent on a non-commercial article or method would be worthless to the inventor, even though it cost him nothing to obtain. The inventor, therefore, should ascertain first if a market exists for his invention and, thereafter, the records in the Patent Office should be searched to determine whether or not it is "new." The charge for a preliminary search is never excessive and there are many patent attorneys in Washington, D. C., who will be glad to handle the details. It is advisable to have such a search made, even though the inventor, because of lack of funds, must be his own attorney in preparing and filing the application.

A patent application must comply in form with certain definite requirements set forth in the Rules of Practice, a copy of which may be obtained by writing to the Patent Office. Strict compliance with the Rules will forestall innumerable vexatious delays and misunderstandings; they should be carefully studied before the writing of an application is undertaken.

Writing the Application

If the invention is capable of illustration, it is advisable to have the drawing made by a patent draftsman; his fee will not be high unless the invention is complicated and requires more than one sheet of drawings.

Before starting the specification, the inventor had best determine to what statutory class his invention pertains, i.e., is it an "art", a "machine", a "manufacture" or a "composition of matter?" The following definitions are offered as a guide:

An Art is a method or process whereby ingredients or instrumentalities are manipulated, combined or rearranged in order to produce a new or improved result or an old result more effectively or expeditiously. A patentable method or process may be manual, mechanical, electrical, chemical or metallurgical and may, and generally does, involve the utilization of apparatus or machinery to some extent, but it must be something more than the mere operation of a specific machine or piece of apparatus.

A Machine is an instrumentality, composed of one or a plurality of elements, which is utilized to perform some useful function in the mechanical arts, such function being the uniting, segregating or transforming of materials or energy of some sort. In other words, a machine is an instrumentality which, either alone or as utilized by the energy of human beings or animals, does work of some sort. For example, a printing press and a lathe are machines and, likewise, a crowbar and a screw driver are machines.

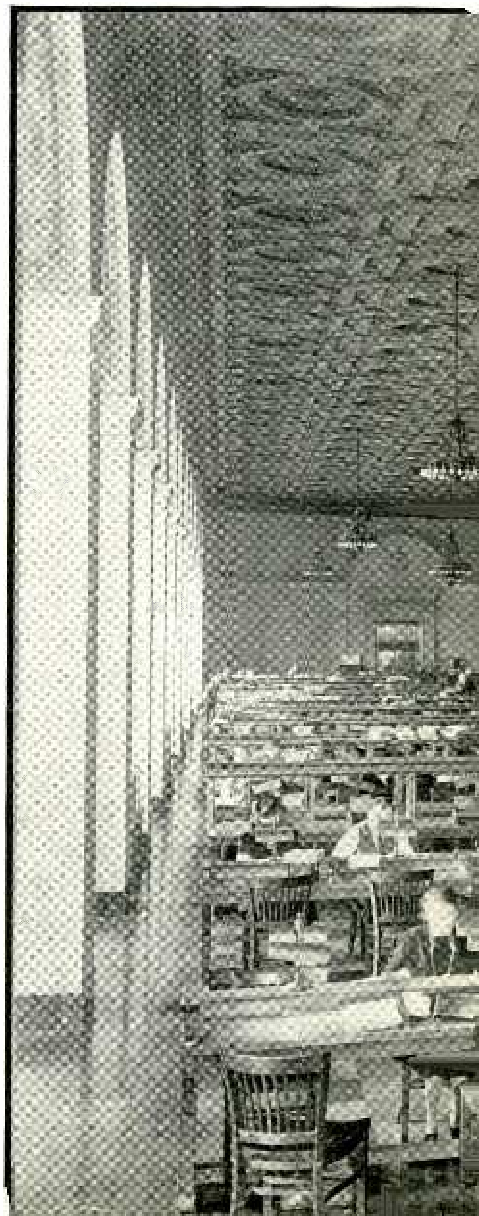
A Manufacture, according to the writer's understanding, is an instrumentality having passive properties.—That is to say, one which is not utilized for uniting, segregating or transforming materials or energy, but is used by itself as an adjunct to the convenience or comfort of the user, such, for example, as a wall or floor covering, a pavement or a box.

A Composition of Matter is what the name indicates, and in order to be patentable, must have such useful characteristics as are due to the combination of the various ingredients and, therefore, something more than a mere assembly in which each ingredient performs its own function without modification because of its association with the other ingredients.

In the following pages, U.S. Patent No. 2,010,133, relating to resistors, and No. 2,073,060, disclosing a novel capacitor, will be referred to as examples.

Preamble

For the convenience of the Patent Office in classifying the patent and to facilitate searches, every patent application should start with a brief preamble explaining, generically, to what Art the invention pertains and



and Understand Them

By
THAD R. GOLDSBOROUGH

giving the specific niche in the Art wherein the invention is further to be classified. For example, the application that resulted in patent No. 2,010,133 began as follows:

> "My invention relates to resistors and more particularly to resistors of types suitable for use in radio receivers, wherein noise occasioned by variation in resistance during the passage of current therethrough must be minimum."

It is to be noted, at this point, that the Preamble almost invariably contains the title of the application and of the subsequent patent. In the formal papers accompanying the application referred to, the title was "Resistor."

Following the preamble, the writer has always found it helpful to give a brief resumé of the prior art, pointing out, if possible, the defects of prior art devices and thus laying a foundation for the invention. It must be kept in mind, however, that the application should not contain any remarks in derogation of an issued patent although the shortcomings of the patented device may be referred to.

Objects of the Invention

Having laid the foundation for the invention, the next part of the application should deal more specifically with the problems confronting the inventor. Such problems, in the application, are conventionally referred to as "objects."

A few of the objects enumerated in the mentioned patents are quoted below:

> #2,010,133. "It is, accordingly, an object of my invention to provide a new and improved resistor that shall be substantially free from noise when used in an amplifier."
>
> #2,073,060. "It is, accordingly, an object of our invention to provide a new and improved method for forming a stable anodic film on an aluminum electrode."
>
> "A still further object of our invention is to provide a capacitor manufacturing method such that the shelf life of the finished product shall be greatly enhanced."

The "objects" should not include the actual invention itself. For example, in the resistor patent application it would be incorrect to say: "It is an object of my invention to provide a resistor composed of asbestos, ground glass, bakelite and colloidal carbon." Such an object is totally out of place, because it is the solution of the problem, i.e., the invention per se.

After enumerating the objects, a brief description of the invention should be given. The following description appears in patent No. 2,010,133:

> "The foregoing objects and other objects ancillary thereto I prefer to accomplish, in short, by first coating particles of filler material, such as asbestos, powdered glass, sand, or the like, or a mixture of filler materials, with a polymerizable resin in solution and thereafter causing conducting material, preferably graphite and/or carbon black, to be precipitated upon the coated particles from a colloidal solution thereof."

The next section of the specification called for by the Rules of Practice is a brief description of the drawings. To go from the synopsis of the invention to the description of the drawings, however, introduces a rather abrupt change into the continuity of the specification. It has been found helpful, at this point,

THE SEARCH ROOM OF THE UNITED STATES PATENT OFFICE. It is the privilege of anyone to examine a copy of any patent ever issued and, upon the presentation of the proper credentials, to examine the complete original file of any patent. It is here that all searches are made before making an application.

therefore, to use what is sometimes termed a "Liaison Paragraph."

Brief Description of Drawings

According to the Rules of Practice, each figure of the drawing should next be briefly described, and a few observations on the verbiage of conventional descriptions are not amiss.

The figures of the drawing should never be referred to as actual objects. If the invention is mechanical in nature, the figures may be described as "views." In Patent No. 2,073,060 there is but a single figure; it is referred to as follows:

> "The single figure of the drawing is a conventionalized sectional view of a wet electrolytic condenser of the general type exemplified by the patents hereinbefore referred to."

> In patent No. 1,977,997, disclosing an electronic control system for causing color changes in accordance with musical tones, the two figures of the drawing are described as follows:

> "Figure 1 is a simplified schematic view of a complete control system comprising a preferred embodiment of my invention, and

> "Figures 2 and 3 are diagrammatic detail views of portions of the system shown in Fig. 1."

The figures should be numbered and described in proper consecutive order. That is to say, a sectional view, if based upon a view in vertical elevation, should bear a higher number, and views of details should be described subsequent to the description of the principal figure.

Detailed Description

Contrary to the belief of many inventors, a patent is strengthened by minute and detailed disclosure, rather than weakened.

In dictating the detailed description of the invention as exemplified by the drawing, the writer has found it somewhat helpful to imagine that he is verbally explaining it to a blind man. He first describes the invention without including the numerals referring to the parts of the drawing, which numerals he later applies to the drawing and inserts into the rough draft of the specification after it has been typewritten. The numerals, of course, should run in consecutive order and, if the odd numbers only, 1, 3, 5, 7, etc., are initially used throughout the specification, the even numbers may be interpolated into the draft without disturbing the sequence, should omissions be found. When two or more figures of the drawing disclose equivalent parts, such parts should always bear the same reference numerals in each of the views. The use of letters of the alphabet should be avoided, as well as numerals bearing subscripts or exponents such as 6_n, 9^s, and the like.

Those who take up the art of specification writing for the first time are very prone to supply only a catalog of component parts at this point. To merely enumerate the various parts of the device or the various elements entering into a new composition of matter, etc., is not at all helpful.

It is not feasible, of course, to quote the detailed descriptions appearing in either one of the patents being utilized as examples; the reader is strongly urged to obtain one copy of each patent for future reference.

If the invention is in the chemical field, or relates to a composition of matter, the inventor should be sure to include reference to a number of equivalents of the various elements involved. Only by including a plurality of species of the same genus can a foundation for valid broad claims be established.

A patent may be obtained by any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvement thereof, or who has invented or discovered and asexually reproduced any distinct and new variety of plant, other than a tuber-propagated plant, not known or used by others in this country before his invention or discovery thereof, and not patented or described in any printed publication in this or any foreign country before his invention or discovery thereof, or more than two years prior to his application, and not patented in a country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months before his application, and not in public use or on sale in the United States for more than two years prior to his application, unless the same is proved to have been abandoned, upon payment of the fees required by law and other due proceedings had.—*Rules of Practice, U. S. Patent Office.*

Mode of Operation

Obviously, if the invention pertains to an article of manufacture, there is no "mode of operation" to describe. If the invention pertains to an "art" or a "process," the necessary sequence of steps has been recited in the detailed description. On the other hand, if the invention relates to a machine, a circuit, or a system, it is often advisable to recapitulate the manner in which it functions, even at the risk of verbosity and repetition.

In order that the operation may be clearly understood, a certain condition of the device or system should be assumed. Usually this is the normal condition of the device or that obtaining when the device is at rest. The operation should be followed in detail throughout a complete cycle. That is the device, or system, should be started from a condition of rest, followed through a period of normal operation and brought to rest. The description should follow the logical sequence of events as they would occur in practice. Give reasons for the various events in case they are not entirely obvious.

Advantages of Invention

There is no obligation imposed upon the inventor to include in the specification the advantages accruing from his invention, but the custom has grown up to do so in order that the value of the invention may more clearly be apparent. In other words, the paragraph or paragraphs relating to the advantages of the invention constitute what might be termed a "selling talk" which serves the purpose of impressing the Examiner and also is of value in the event that patentee desires later to sell his patent. For these reasons, it is always well to include, at this point, a summary of all of the advantages attained by the invention.

Claims

The claims, of course, define the boundaries of the invention, and constitute the actual subject-matter of the patent grant. Even though such is the case, it is considered best to interpose a paragraph somewhat like the following between the body of the specification and the claims:

> "Although I have shown and described certain specific embodi-

ments of my invention, I am fully aware that many modifications thereof are possible. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims."

The paragraph so inserted does not really enlarge the monopoly granted by the patent, but its use has become so universal that it is regarded, by many attorneys, almost as a fetish.

Claim writing is an art in itself. If possible, the inventor should order a copy of a very excellent book on the subject, "Patent Claim Drafting," from the author, Emerson Stringham, Box 288, Pennsylvania Avenue Station, Washington, D.C. It is well worth the price, $5.00. Before beginning the writing of the claims, it is advisable to review the specification in detail and to make note of any new or unusual terms found therein. This for the reason that the specification constitutes the dictionary by which the claims are later construed in the event of litigation.

At the present time, the Patent Office permits only 20 claims to be filed with an original application, unless a fee of $1.00 per claim, for each claim over 20, is paid. Such being the case, it behooves the inventor to make sure that the invention is adequately covered by 20 claims and, if not, to add as many more as may be necessary.

Each claim is supposed to define an invention separate and distinct from the other claims and, for that reason, the inventor should make certain that the differences between the claims are real and are not merely immaterial limitations.

The scope of the claims should vary from that of the broadest which the known art will permit to that of the most specific. In case the prior art is uncertain or is unknown, care should be taken to embody sufficiently broad claims to avoid dedicating any portion of the invention to the public by reason of failure to claim it. On the other hand, ridiculously broad claims covering features notoriously old in the art should be avoided.

Contrary to the "matter of fact" character of the specification, the claims afford opportunities for considerable imagination and ingenuity, and full advantage should be taken of this fact.

The term "means for," accompanied by an appropriate statement of function, should be employed to designate broadly portions of structures or groups of elements which may be patentable without reference to the specific details constituting such structures or groups of elements.

Care should be taken not to embody the entire structure in every claim, if the arrangement embodies sub-combinations that may be of value apart from the general combination. If the invention embodies several features, certain claims should be limited to those features.

The terminology of the claims should conform, insofar as is practicable, to that of the specification. It is confusing to employ one term in a claim and another in the specification to define the same element. This is not to be construed, however, as prohibiting the use of a generic term to define an element that may have a specific designation in the specification. Claims to an article of manufacture, a composition of matter and the method of making may appear in the same patent if each is "new and useful." A few claims from patent No. 2,010,133 will illustrate this.

Claim 1. "As element of a resistor device, a particle of inert, substantially non-conducting filler material, a coating of insulating material thereon, and a film of conducting material upon the outer surface of the insulating material."

Claim 5. "The process of manufacturing a material from which resistors may be formed which comprises coating a plurality of particles of inert material with an insulating layer and thereafter depositing a conducting surface film upon substantially all of said particles."

Claim 15. "A resistor element in the form of a rod constituted by a plurality of particles of insert material, substantially all of said particles having a first coating of an insulating material and an outer coating of graphite and carbon black, the said particles being in such intimate contact with each other that a substantially uninterrupted electrically conductive path is established between the ends of the rod."

If the invention is sufficiently important to warrant filing abroad, it is well to include, as the final claim, one worded as follows:

20. "The invention substantially as described in connection with the accompanying drawing."

In the United States, the foregoing claim is unstatutory; the Examiner in the Patent Office will require its cancellation. It has definite value, nevertheless, if foreign patent applications are to be filed. Such applications, by the way, should never be handled by the inventor himself, but should be entrusted to patent attorneys specializing in the foreign field.

Claims should never be of the so-called "functional" type. That is to say, the usual mode of operation of a machine cannot be claimed because it is not permissible to claim a result apart from the actual means employed to obtain the result, nor can a claim to but a single "means" be patented. The following few examples illustrate the difference between a functional claim and a claim in proper form covering the same general subject-matter:

Bad: An electrolytic capacitor having a longer shelf-life than capacitors heretofore known. In a capacitor of the wet electrolytic type, an electrolyte that promotes freedom from failure and unusually long shelf-life.

Good: In a capacitor of the wet electrolytic type, a film-retaining electrolyte having a higher pH value than that of a film-forming electrolyte in which one of the electrodes of the capacitor was first formed, and having a pH value at least as high as that of a film-forming electrolyte in which said electrode was subsequently formed. (Claim 6, patent No. 2,073,060.)

As exemplified by the claim immediately above, it is sometimes permissible to define an article by the method of manufacture. Such procedure should be avoided, nevertheless, if the invention can otherwise be defined, as was the case in the

(*Continued on page* 46)

Applications for letters patent of the United States must be made to the Commissioner of Patents, and must be signed by the inventor . . . A complete application comprises the first fee of $30, and $1 for each claim in excess of 20, a petition, specification, and oath; and drawings, when required. The petition, specification, and oath must be in the English language. All papers which are to become a part of the permanent records of the office must be legibly written or printed in permanent ink.—*Rules of Practice, U. S. Patent Office.*

A Cathode-Ray Frequency Modulation Generator . . .

By ROBERT E. SHELBY
Video Operations Engineer
National Broadcasting Company

THE device herein described is a means of frequency- or phase-modulating a carrier signal obtained from an oscillator of constant frequency and phase, such as a crystal-controlled oscillator. The majority of the known methods for generating frequency or phase modulation involve variation of the frequency or phase of the master oscillator. There is one well-known method of producing phase modulation of a carrier obtained from a constant source which involves the addition of two voltages of the same constant frequency having a constant phase difference of 90°, one voltage having constant amplitude and the other varying in amplitude with the modulation signal.

This method is limited to maximum phase shifts of the order of 30°, which means that in order to obtain a large shift at the final carrier frequency, it is necessary to employ frequency multiplication of large ratio. The method proposed here does not have this limitation. Theoretically it should give distortionless phase shift of many times 360°.

Structurally the device consists of an electron gun, two sets of electrostatic deflection plates (or magnetic deflection coils), and a target anode of special design, enclosed in an evacuated container of suitable size and shape. A typical arrangement is shown schematically in Fig. 1. It will be seen that the device illustrated is similar to a conventional cathode ray oscillograph tube. The only fundamental difference is the novel design of the target anode. Figure 2 illustrates one form which the target anode may have. It consists of two (or more) metallic plates with curved edges, upon which the electrons from the electron gun impinge. In order to obtain phase modulation in which the angular shift is a linear function of the modulation amplitude the edges of the plates have a curvature given by the polar equation

$$r = a\,\theta \qquad (1)$$

which defines an Archimedian spiral.

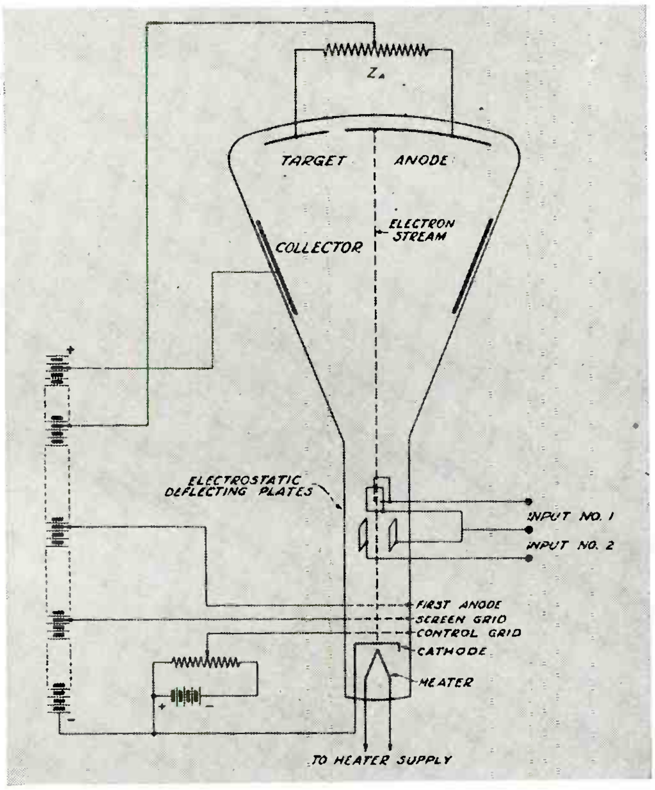
In operation, the electron stream is deflected in such a way that it traces out a circle on the target anode, the diameter of the circle being a variable which is directly proportional to the instantaneous value of the modulation signal. This involves no new concepts other than those associated with the familiar cathode-ray oscillograph. When controlled in this way the electron stream produces a phase (or frequency) modulated wave upon striking an anode having the special design just described.

Details of Operation

The electron gun is controlled and focused by adjusting the d-c potentials applied to the cathode, control grid, screen grid, and first anode, just as in the case of oscillograph tubes and picture tubes. The electron stream is sharply focused on the target anode and when there is no voltage applied to the electrostatic deflecting plates it is adjusted to strike the exact geometrical center of the target anode. The inputs, which consist of two carrier waves of equal frequency and almost equal amplitude but differing in phase by 90° and having the same amplitude modulation, are applied to the two sets of electrostatic deflecting plates. Figure 2 illustrates one means of supplying the inputs. The output appears in the target anode circuit, across the impedance Z_A. If Z_A is a pure resistance the output voltage appearing across it will be a flat-topped wave. By using a target anode composed of a larger number of curved sections the fundamental frequency of the flat-topped output wave may be made any desired multiple of the input frequency. Thus it is seen that, if desired, frequency multiplication may be obtained during the process of converting amplitude modulation into frequency or phase modulation.

For a more detailed explanation of the way in which amplitude modulation is translated into phase modulation, we refer now to Fig. 3. First, with no modulation, the phase shifting network and amplitude controls are adjusted so that the electron beam describes a circle on the target anode. If the master amplitude control is adjusted so that this circle is of the size designated by c_1 (Fig. 2) then the voltage appearing across Z_A will be as shown in Fig. 4A. Note that the electron stream passes from one segment of the target to the other at points p_1 and p'_1. If now the two deflecting voltages are decreased 50 per cent by changing the master amplitude control, all other controls being left the same, the locus of the end of the electron stream will be c_2 and the voltage across Z_A will be as shown in Fig. 4B. The electron stream now passes from one segment of the target to the other at points p_2 and p_2'. Likewise if the master amplitude control is adjusted to give voltages 50 per cent greater than those which gave the locus c_1, then c_3 will be the new locus, the electron stream will pass from one target segment to the other at points p_3 and p_3' and the voltage appearing across Z_A will be as shown in Fig. 4C. Now, if the master amplitude control is reset so that the electron circle falls on c_1 and a fifty per cent modulation is then applied to the carrier in the manner indicated by Fig. 3

Fig. 1—Arrangement of generator. The structure is very similar to that of an electrically-deflected cathode-ray oscilloscope tube, except that a target anode is used in place of the fluorescent screen



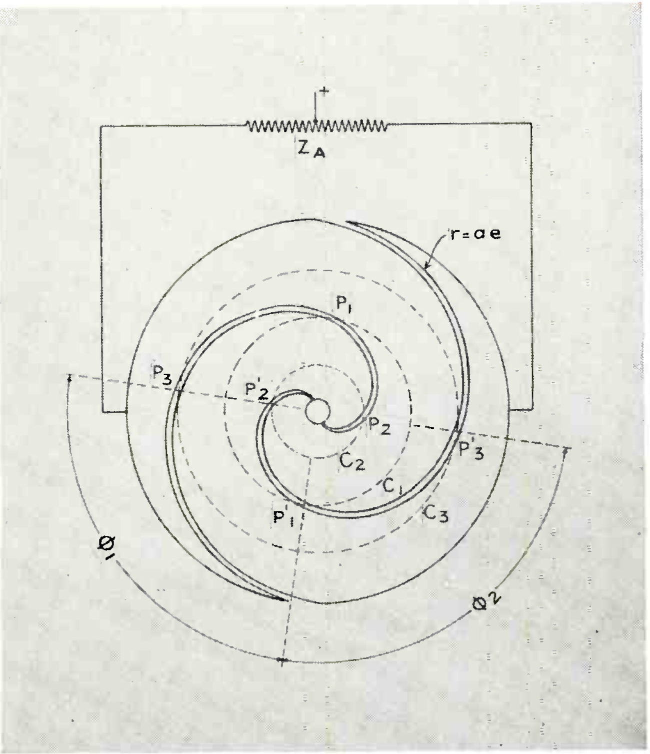
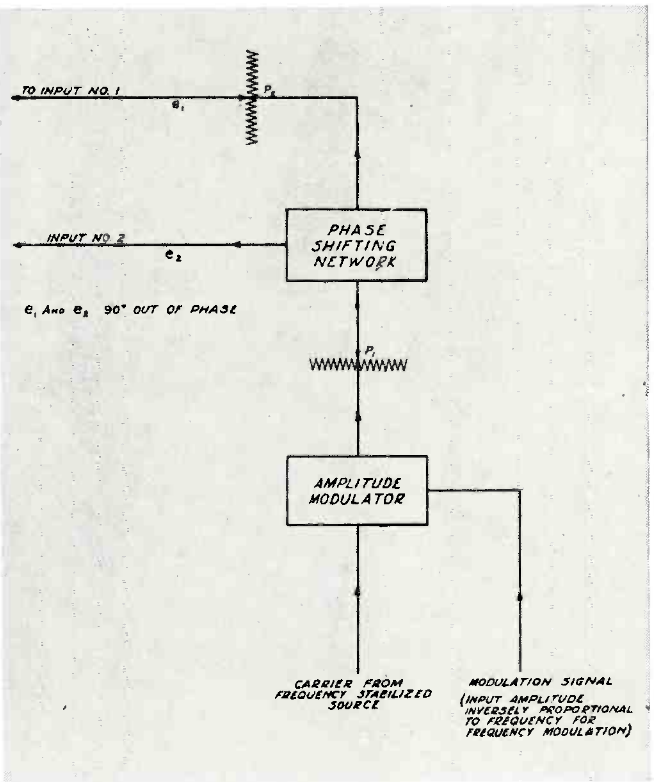


Fig. 2—Typical target anode, consisting of two metal plates divided by a pair of Archimedian spirals. The cathode ray beam scans the target in a circle of variable radius, producing square waves in the output

Fig. 3—Circuits for supplying the inputs to the generator. The carrier and modulation signal are combined in an amplitude modulator whose output is divided into two phases and applied to the deflecting plates



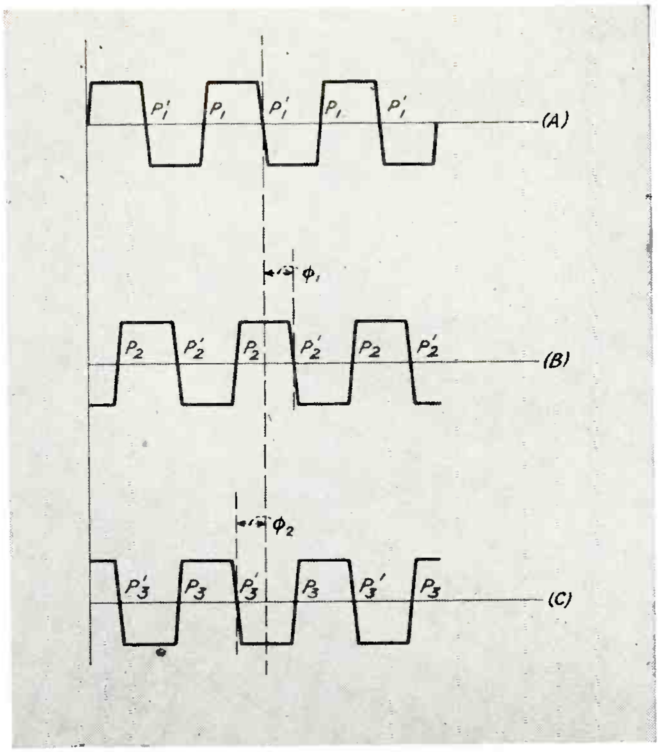


Fig. 4—Square wave outputs of the generator, lettered to correspond with the scanning circles shown in Fig. 2, opposite. The phase shift results in frequency modulated waves when the signal is passed through a frequency multiplier

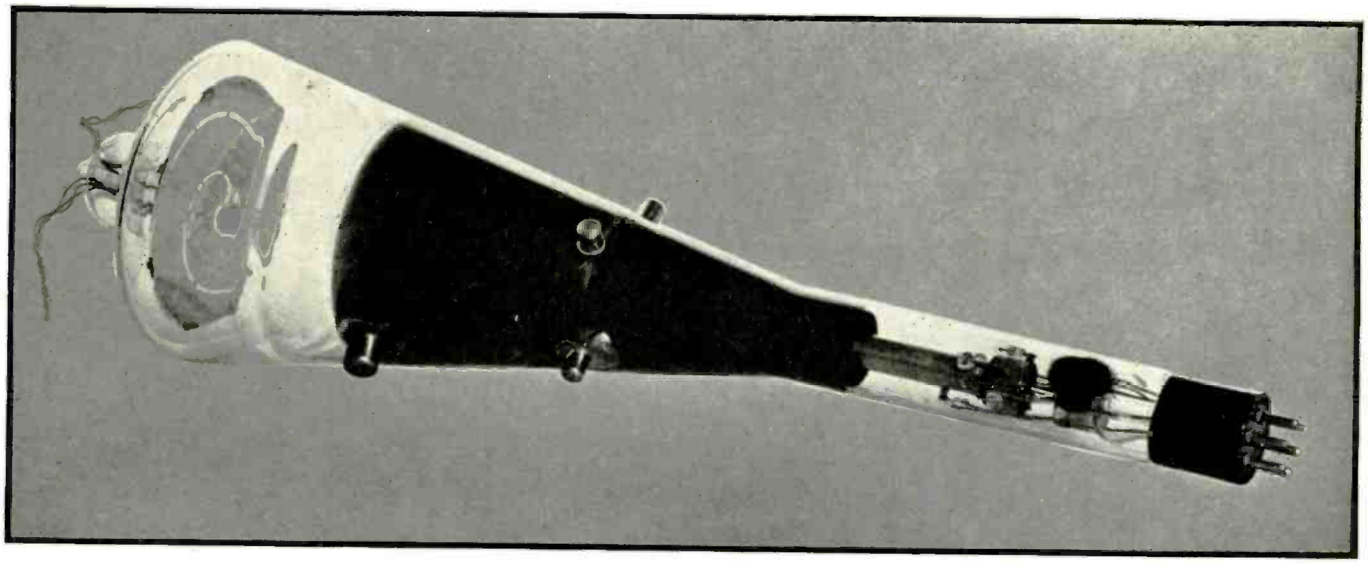
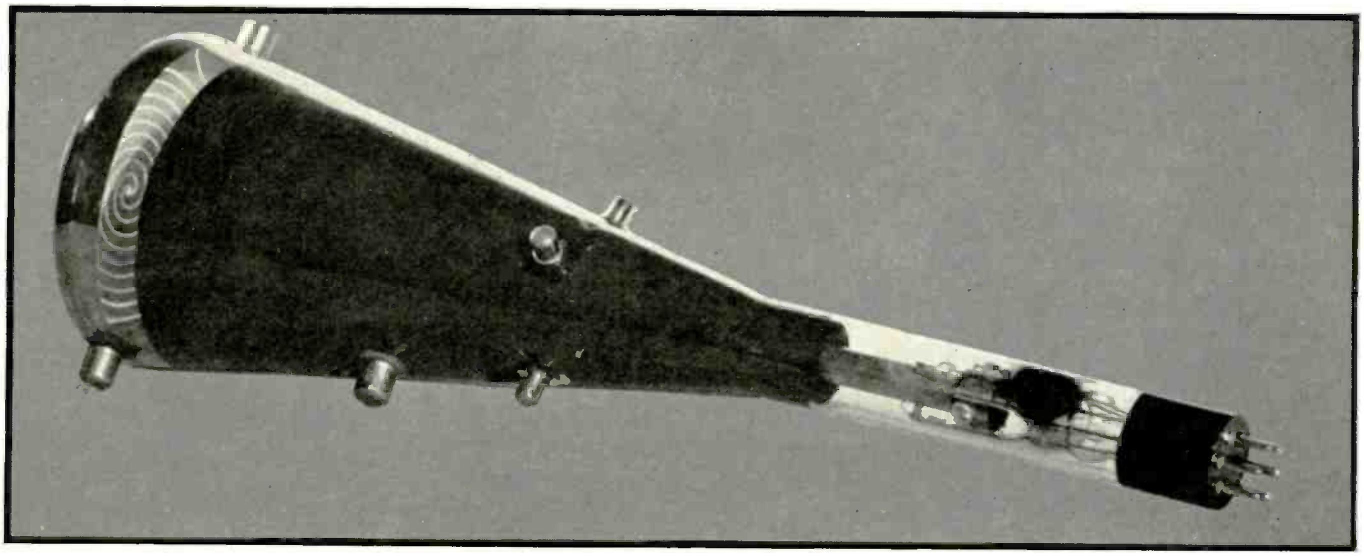


Fig. 5—Early form of the cathode-ray frequency modulation generator, mounted in a standard oscilloscope tube envelope. The target anode is composed of spirals which make one complete turn

Fig. 6—Later form of the generator. The spiral anode makes five complete turns, and hence the degree of phase shift, for a given change in scanning radius, is proportionately increased



the locus of the end-point of the electron stream will expand and contract between the limits c_2 and c_3 and the output wave will shift in phase between the limits indicated by Fig. 4B and 4C.

The amount of maximum phase shift in the device described above will be determined by the curvature of the target anode boundary—that is, it will depend upon the value of a in the equation $ra\ \theta$. For the target illustrated in Fig. 2 the phase shift is plus and minus approximately 90° when the input is amplitude modulated 50 per cent. Amplitude modulation of 75 per cent on the input will give shift of plus and minus 135°, etc.

It should be noted that this device is fundamentally a generator of phase modulation—not frequency modulation. However, any phase modulator may be made to produce the equivalent of frequency modulation by means of a network in the audio input having a characteristic that is inversely proportional to frequency. It will be understood that whenever the cathode ray modulator is referred to as a generator of frequency modulation, the use of such a network is implied.

Variation of the anode voltages will cause the sensitivity of the electron stream to vary so that for constant voltages on the deflecting plates the size of the circle described on the final anode by the electron stream will vary as the anode voltages vary, thereby producing a form of phase modulation. This means that the d-c voltages supplied to the electron gun must be well-filtered and free from fluctuations.

Auxiliary electrodes may be added to the modulator tube for control or monitoring purposes. For example a fluorescent screen may be provided beyond the target anode, so that the electron stream will produce a pattern upon it when it passes between segments of the anode or beyond the outer edges of the anode plates. Additional electrodes, located in the same plane as the final anode, but electrically separate from it, may be used for adjusting the modulator and also for indicating overmodulation. Such an electrode, of small area, located at the geometrical center of the anode (where the anode plates are cut away) is useful in centering the electron stream. A narrow annular ring around the outside of the main target facilitates adjustment of the phase shifting network to obtain circular deflection of the electron stream. Many other auxiliaries are possible.

The description so far has related to the production of modulation in which the phase shift is directly proportional to the modulating voltage, but the system is quite flexible in this respect. By use of a properly shaped target, the phase shift may be made any reasonable function of the modulating voltage, this being determined by the curvature of the edges of the target plates and the nature of the path traced on the target by the electron stream.

The amplitude of the flat-topped output voltage wave may be varied independently of the frequency (or phase) modulation by varying the d-c potential applied to the control grid. If it is desired to amplitude modulate the output wave in addition to or instead of phase modulating it in the manner described, this may be done readily by applying the amplitude modulation signal to the control grid, provided the electron gun is so operated that the rate of electron emission from the gun is a linear function of control grid voltage over the operating range.

The photograph of Fig. 5 shows the general appearance of an early model of this device constructed by the Radiotron Division of the RCA Manufacturing Co. It consists of a standard type cathode ray oscilloscope tube with a spiral target of the type specified above sealed into the large end in place of the usual fluorescent screen. The target was constructed by applying a coating of platinum to a sheet of mica of the kind used for Iconoscope mosaics and scribing the separating line in the platinum surface to give the proper shape to the two electrodes. The target is mounted by wire supports which are sealed into the large

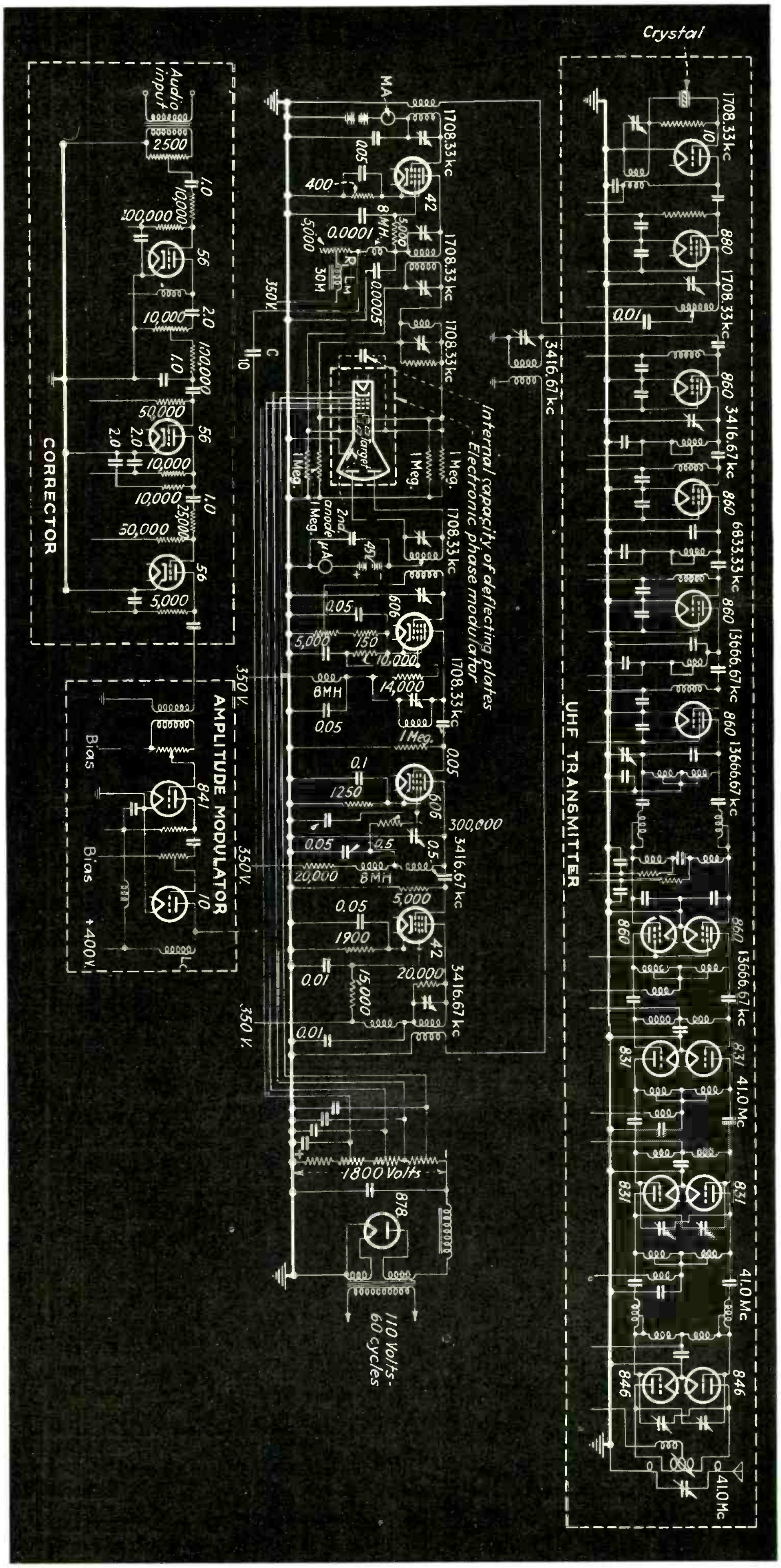


Fig. 7—Complete circuit diagram of transmitter used to test practical operation of the f-m generator

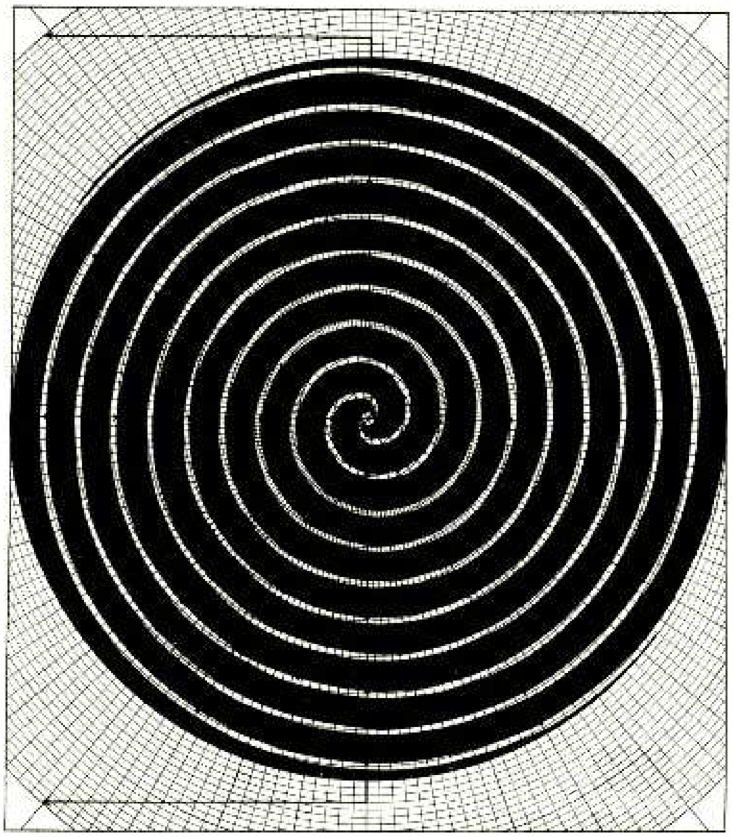


Fig. 8—Spiral anode of five turns, similar to that shown in the tube in Fig. 6. The spirals were formed by scribing through a platinum film on a mica support, thus separating the surface into two insulated segments

end of the tube. Electrical connections to the two electrodes of the target are brought out through this same seal.

The spiral of this target was designed to give a maximum over-all phase shift of 360°—that is to say, for this particular target the value of a in the equation $r = a\ \theta$ is $\frac{1}{\pi}$ inches per radian (the diameter of the target is approximately four inches). In order to facilitate adjustment and to judge operating performance four concentric circles and sixteen radial lines were marked on the surface of the target with willemite. The entire surface of the target was also covered with a very thin coating of willemite. This results in the electron beam tracing out a visible path on the target, which is helpful in testing the tube.

In constructing this tube the Radiotron engineers made provision for utilizing secondary emission from the target anode to provide additional output. This was done by providing a separate collector for secondary electrons in the form of a coating on the inner wall of the tube.

Figure 6 shows a photograph of a later model. The general design is the same except that the target anode consists of a conducting coating deposited directly upon the inner surface of the large end of the tube and the spiral in this case contains five complete cycles. The configuration of this target is hown by Fig. 8.

Figure 7 shows a schematic of the transmitter set-up employed to test the frequency modulator tube. That portion of the circuit enclosed by the upper dotted rectangle represents a conventional r-f transmitter. It was of the crystal-controlled type with buffer amplifiers and frequency multiplier stages driving a final amplifier delivering a carrier output of approximately two kilowatts.

The crystal-controlled oscillator in the transmitter was used as the primary source of stabilized r-f voltage, the amplifier chain in the transmitter being broken between the buffer amplifier and the first doubler stages for insertion of the cathode ray phase modulator and associated apparatus, as shown.

To obtain the 90° phase relationship between the voltages on the two sets of deflecting plates of the cathode ray tube, a phase-splitting network consisting of a capacitive reactance in series with a pure resistance was employed, one set of deflective plates being connected across the capacitive reactance and the other set across the resistance. In this set-up the internal capacity between one pair of the deflecting plates was utilized as the capacitive reactance. A parallel tuned circuit was bridged across the other set of deflecting plates to permit tuning out the reactance of the variable resistor and also that due to the capacity between these deflecting plates, thus obtaining a purely resistive impedance. The variable resistor in this circuit was used to adjust the relative amplitudes of the voltages on the two sets of deflecting plates, and the amplitudes of the two deflecting voltages were adjusted simultaneously by means of the variable resistor R_1 in series with the d-c plate supply to the modulated amplifier.

The output circuit connected to the two halves of the target anode was tuned to the fundamental crystal frequency and coupled inductively to the grid of an amplifier which in turn fed a frequency doubler. The succeeding stage fed a shielded r-f transmission line, the other end of which was coupled to the 860 stage in the transmitter which ordinarily operated as a doubler but which was used as a straight amplifier in this case. From that point on the various stages of the transmitter were operated in their usual manner.

The transmitter was located in the Empire State Building and reception tests were made with a frequency modulation receiver located in the Development Laboratory in Radio City. These tests showed that the cathode ray frequency modulator performed as predicted. When properly shielded against stray magnetic fields and provided with well-filtered d-c potentials, it introduced no measurable distortion and was perfectly stable in its operation.

In conclusion, acknowledgment is made of the cooperation of the RCA Radiotron Laboratories in constructing and supplying the tubes used in these tests and of the helpful suggestions offered by Radiotron and NBC engineers. The author also wishes to acknowledge with deep appreciation the encouragement and cooperation extended by Profesor E. H. Armstrong of Columbia University during the early tests on this device.

Compression with Feedback

A practical volume-limiting feedback amplifier for broadcasters, which makes use of a tube in the feedback path whose plate resistance is varied as the volume changes. Low distortion and constant frequency response result

By H. H. STEWART and H. S. POLLOCK

Queens University, Kingston, Ontario

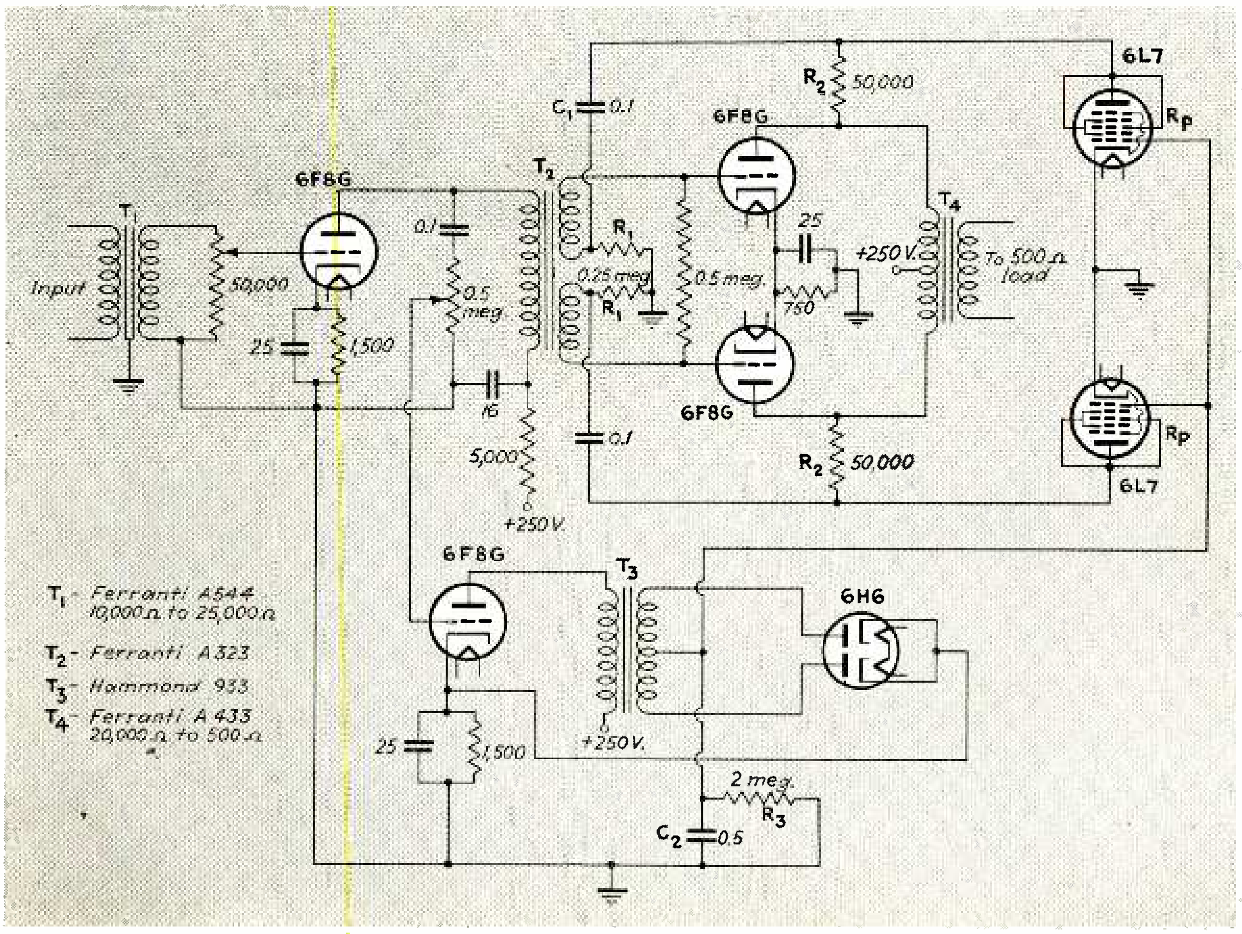
THE use of volume-limiting amplifiers or compressors in connection with radio transmitters is now fairly common and several excellent designs have been developed. It is felt, however, that an amplifier in which distortion is reduced by compression, should be of interest.

Unlike other electronic limiters where the gain is controlled by a variable-μ tube or a variable attenuator network, the gain is here reduced, when compression begins, by employing a negative-feedback circuit in which the percentage of output signal fed back to the input, increases with increasing input. This is accomplished by developing a bias in the output circuit of an auxiliary amplifier fed from the input side of the compressor, which is used to control the plate resistance of a tube acting as one of the elements of the feedback circuit. Since the distortion in a negative feedback amplifier is reduced when feedback increases, it will be held down to a low value under compression.

Referring to Fig. 1, the input stage of the main amplifier is a triode using one section of a 6F8G, the other section acting as the auxiliary amplifier for the 6H6 control rectifier. The input stage is transformer coupled to a pushpull output stage using another 6F8G. Negative feedback is used on this stage. The feedback factor is determined by R_1, R_2, and the plate resistance of a 6L7. When R_1 and R_2 are fixed at suitable values this feedback factor can be controlled within limits by varying the plate resistance of the 6L7's, since they are effectively in parallel with resistors R_1. If the bias on the 6L7's is increased negatively, plate resistances increase and the feedback factor increases. Since gain decreases as the feedback factor increases, an increasing input signal, increasing the bias on the 6L7's will decrease the gain and thus produce compression.

With an initial positive bias on

Fig. 1—The feedback amplifier developed by Messrs. Stewart and Pollock. The 6L7's, controlled by the lower 6F8 and the 6H6, act as variable elements in the feedback path



the 6H6, the control of the auxiliary amplifier gain will delay compression till any desired output, within the limitations of the amplifier, is reached. In this particular case, since a separate power supply is used, the bias is conveniently obtained from the cathode of the auxiliary amplifier.

The rectifier circuit is of the usual type. Fast action is obtained through the use of a step-down rectifier transformer with the moderate value of 0.5 μf for C_2. The releasing time may be controlled by R_3. With an amplifier plate resistance of 7700 ohms, a transformer ratio from primary to one half secondary of 2:1, and a resistance of 1000 ohms for the 6H6, the acting time is 1.5 milliseconds. The releasing time, with $R_3 = 2$ megohms, is 1 second.

Plate currents are metered by one meter with a switch and suitable shunts in the cathode circuits, not shown in the diagram. Change in current in the 6L7's gives an indication of the amount of compression. It is interesting to note that the d-c current in this circuit, between the start of compression and the cutoff point, varies inversely with the input signal level in db and the total current range corresponds to a input range of 20 db.

The input-output characteristics shown in Fig. 2 indicate the operation with and without compression. The compression curves bend slowly because of the fact that the increasing negative bias on the 6L7's decreases the plate current, thus reducing the voltage drop in R_2 and increasing the plate voltage on the 6L7's. This tends to decrease the plate resistances, thus reducing the rate of resistance increase at first. The use of a high inductance choke in parallel with R_2 would make the compression curve flatten rapidly but might introduce other difficulties.

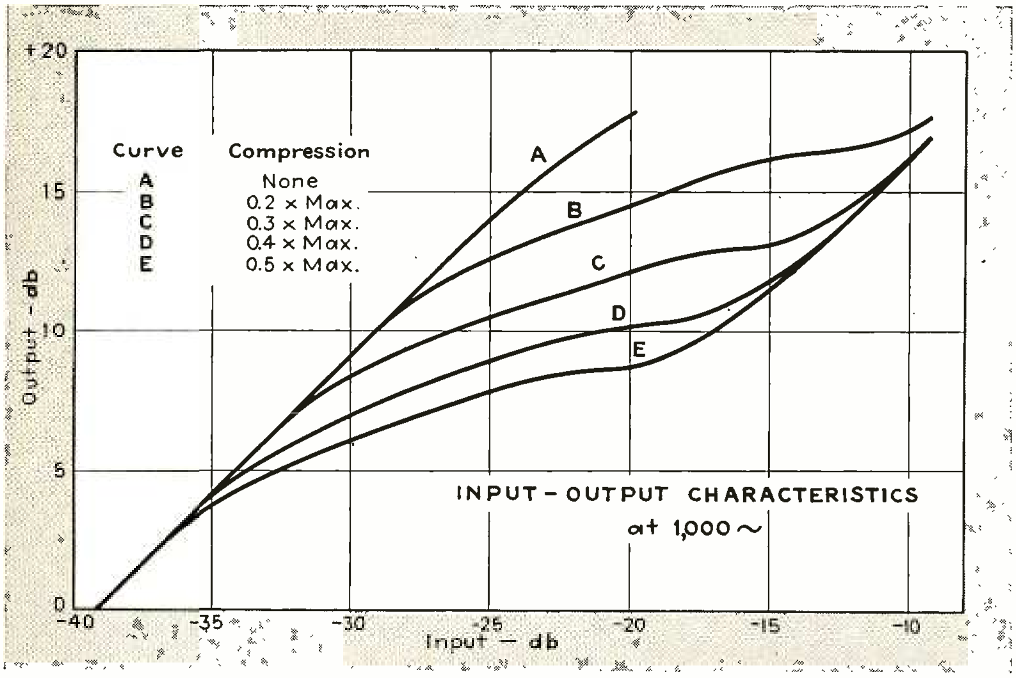


Fig. 2.—Input-output characteristics of the amplifier, taken at 1000 cps for five different degrees of compression. About 20 db compression in the output is available over the range from —40 to —20 db input

Compression is limited because of the limited variation in feedback-factor. The compression range may be derived by making a few simplifying assumptions. Consider the output stage and its feedback circuit made up of R_1, R_2 and R_p. Let $G =$ the gain of the output stage without feedback, then

$$G = \frac{\mu R_L}{R_L + r_p}$$

where $\mu =$ the amplification factor of an output tube,

$r_p =$ the plate resistance of an output tube,

and $R_L =$ the plate load on one tube.

Let $G_f =$ the gain of the output stage with the circuit as shown and with no compression (zero bias on the 6L7's),

$G_c =$ the gain of the output stage with full compression (6L7's biased to cut off),

$B_f =$ the feedback factor with no compression,

$B_c =$ the feedback factor with full compression, and

$R_p =$ the plate resistance of a triode-connected 6L7 at zero grid bias.

Then, neglecting the reactance of C_1 in comparison with R_1 and the effect of the feedback circuit on the load impedance of the output stage,

$$B_f = -\frac{\dfrac{R_1 R_p}{R_1 + R_p}}{\dfrac{R_1 R_p}{R_1 + R_p} + R_2}$$

$$= -\frac{R_1 R_p}{R_1 R_p + R_1 R_2 + R_2 R_p}$$

$$\text{and } B_c = \frac{-R_1}{R_1 + R_2}.$$

$$\text{Then } G_f = \frac{G}{1 - B_f G}$$

$$\text{and } G_c = \frac{G}{1 - B_c G}$$

The compression range in db then =

$$20 \log \frac{G_f}{G_c}$$

As an example, in the circuit shown, the values are as follows:—

μ = 20	R_1 = 0.25 megohms
r_p = 7700 ohms	R_2 = 50000 ohms
R_L = 10000 ohms	R_p = 5300 ohms

$$\text{Hence } G = \frac{20 \times 10000}{17700} = 11.3$$

$$B_f = \frac{250000 \times 5300}{250000 \times 5300 + 250000 \times 50000 + 50000 \times 5300} = 0.0938$$

$$B_c = \frac{250000}{300000} = 0.835$$

$$G_f = \frac{11.3}{1 + 0.0938 \times 11.3} = 5.5$$

$$G_p = \frac{11.3}{1 + 0.835 \times 11.3} = 1.09$$

and the compression range =

$$20 \log \frac{5.5}{1.09} = 14 \text{ db}$$

The maximum measured compression range as indicated on Fig. 2 by the horizontal or vertical intercept between the two constant gain lines or their projections is about 13 db. The useful compression range is somewhat less than this, being about 10 db. The discrepancy between the measured and the calculated compression range is due to the use of nominal values in the calculated example.

The curves in Fig. 3 show the effect of compression in reducing distortion. As shown, the distortion under compression actually goes down with increasing output, for a limited range. This may be due in part to the rate of gain reduction being greater than the rate of inherent distortion increase. Also, any distortion in the feedback circuit contributes to output distortion, and when the 6L7's are driven beyond cut off this factor will disappear at the compression limit. It will be noted from the curves that this is where the distortion under compression goes through minimum. A push-pull compressor stage with a balanced feedback network is necessary to eliminate transient distortion due to compressor action, as well as being desirable from the standpoint of low inherent distortion. Noise and hum level is low, being 75 db below 6 milliwatts output. This is due in part to the use of a separate power supply of the regulated type.

The frequency characteristics are shown in Fig. 4. The characteristic without compression was made flat within 0.5 db from 30 to 11000 cycles by adjustment of the loading on the input and interstage transformers. With compression the characteristic rises somewhat at high and low frequencies, due to a fall in side amplifier response. This characteristic is included as a possible matter of interest although it does not have much significance under actual operating conditions, since the energy producing compression is chiefly on the lower intermediate frequencies. Curve 3, Fig. 4, is a frequency characteristic with fixed 60 cycle voltage on the side amplifier circuit. This gives a better idea of the frequency response under compression.

The amplifier described has been placed in broadcast service (at CFRC). Experience shows that it is able to handle all ordinary peaks. There are no thumps when compression takes hold and the general operation, as indicated by listening tests, is quite smooth.

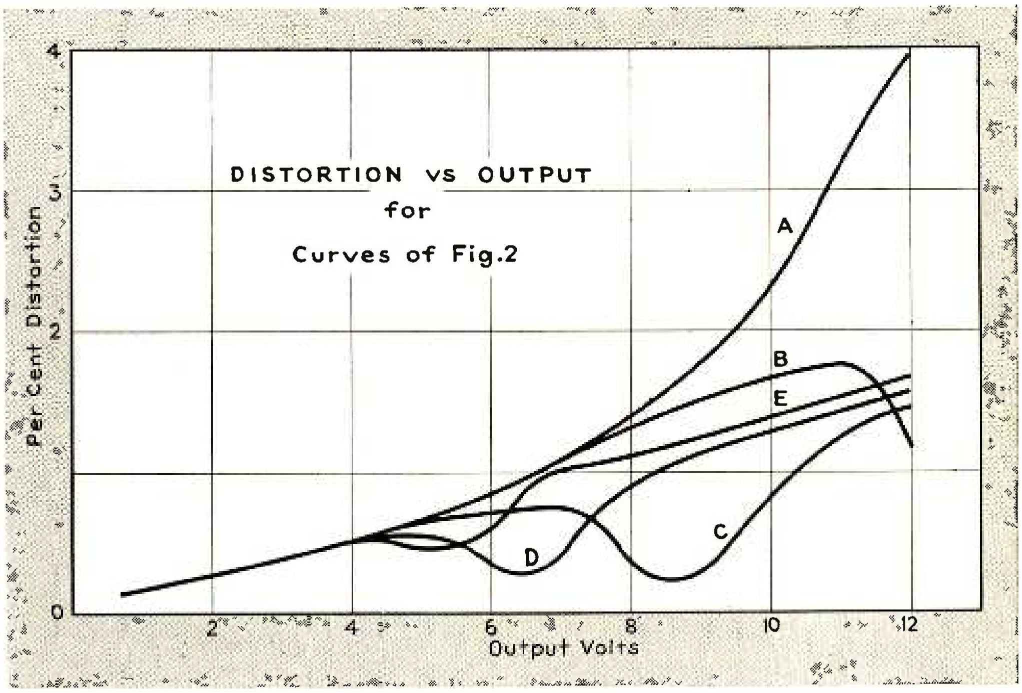


Fig. 3—Distortion curves of the amplifier as a function of output voltage, taken for the five degrees of compression shown in Fig. 2. The distortion is reduced more than two per cent in all cases, at maximum output

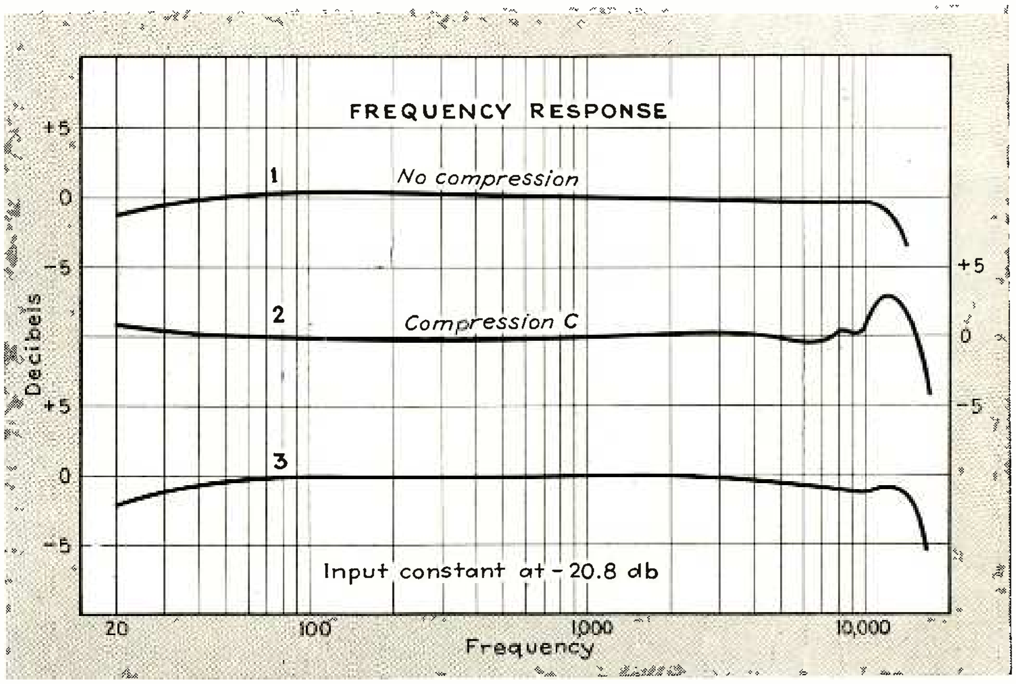


Fig. 4—Frequency response curves of the compression amplifier with constant input for two of the cases shown in Fig. 2. The lowest curve was taken with 60 cps applied to the side amplifier circuit to simulate compression conditions

The DuMont Proposals

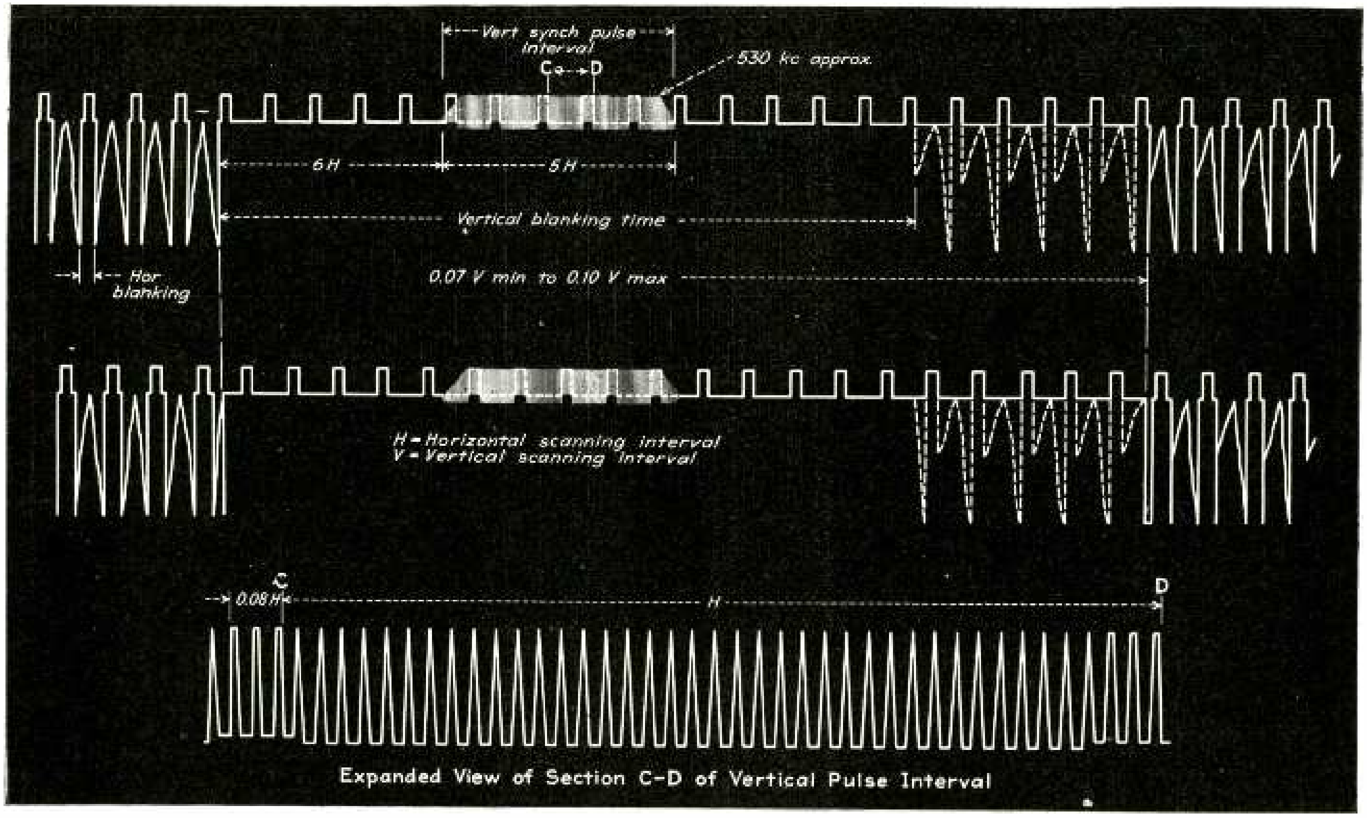
The DuMont Laboratories demonstrate 625-line television images at 15 pictures per second, using a "flickerless" screen material and a modified vertical synchronizing pulse. Change in transmission standard proposed for images throughout range from 441 to 800 lines

In December, the Federal Communications Commission requested the membership of the R.M.A. Committee on Television to witness a demonstration proposed by the Allen B. DuMont Laboratories in Passaic, New Jersey. The DuMont organization had undertaken a series of experiments to determine whether or not the present television transmission standards might be improved upon without upsetting the established 441-line system. The demonstration was to show what had been accomplished in this endeavor, and it was accompanied by three definite proposals for changes in the present R.M.A. standards. These changes, it was claimed, would permit pictures of higher definition to be sent within the present six megacycle station channel, and further would permit receivers to synchronize with images sent at 441-lines, 30 pictures per second (the present standard) or at a higher number of lines at a smaller number of pictures per second. The demonstration was held, and it was witnessed by a large number of engineers active in television development, both in the membership of the R.M.A. Committee and outside it. At the time of writing no published statement has been made by the Committee concerning its opinion of the proposals, and it is understood that they are being studied further before a report is made to the F.C.C.

More Detail Within Six Megacycles

The fundamental limitation to the detail of a television image is the space in the ether available to the transmitting station. The F.C.C. allocations are based on a total band of six megacycles for each station, this band including the sight as well as the sound transmissions for that

Detail of the video signal proposed by the Allen DuMont Laboratories. The signal is the same as the R.M.A. Standard video signal except in the vertical synchronization pulse interval (top, center). Here a 500 kc sine wave is introduced. This sine wave is readily separated from the rest of the wave by the use of a 500-kc tuned circuit



Expanded View of Section C–D of Vertical Pulse Interval station. No change in this total bandwidth is proposed. However, it is proposed to increase the number of lines in the image and at the same time to reduce the number of pictures sent per second. The R.M.A. standards set up 441 lines per picture and 30 frames per second.

The bandwidth occupied varies as the square of the number of lines and as the first power of the frame repetition rate. Thus if the number of lines is increased by a factor n, the number of frames per second must be decreased by n^2. Alternatively, if the number of frames is decreased by a factor m, the number of lines may be increased by a factor $\sqrt{m}$. The first proposal made by the DuMont organization is that the frame rate be given *either* of two values, 30 pictures per second interlaced at 60 fields per second (the R.M.A. standard), *or* 15 frames per second interlaced at 30 fields per second. It is proposed that transmitters and receivers be built capable of operating at either of these rates. When the 30 frame rate is in use, the number of lines is necessarily in the neighborhood of 400 or 500, to permit operation within the six-megacycle band, using single side-band transmission. With the 15 frame rate, (reduction by a factor of 2), the number of lines may be increased by 1.41 times, that is to some value between 575 to 700 lines. If the value of 441 is used in the first case, the value with the reduced frame rate becomes $1.41 \times 441 = 625$ lines. This latter value was used in the demonstration. The result is an increase of 41 per cent in the vertical resolution of the picture, and a 41 per cent increase in the horizontal resolution, which is equivalent to doubling the number of picture elements (corresponding to halving the number of frames per second).

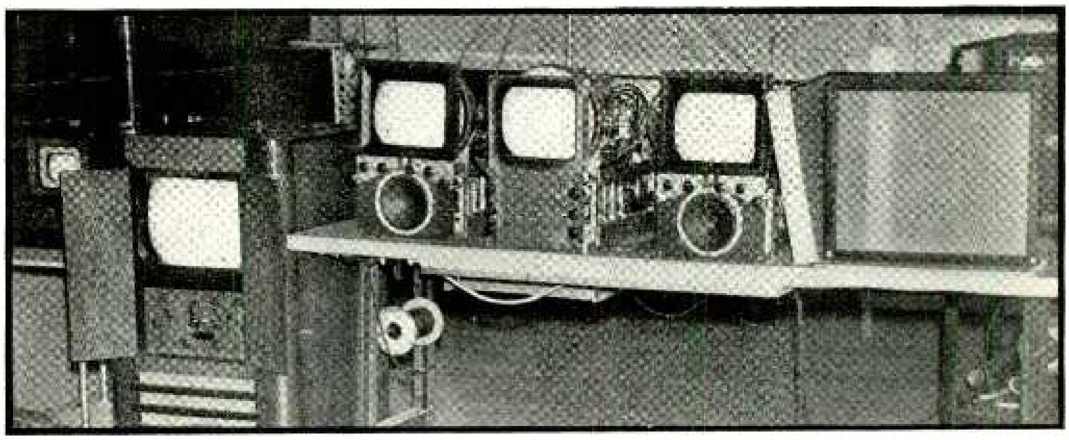
The question remains whether a frame repetition rate of 15 pictures per second is sufficiently high to avoid flicker and to permit the proper representation of motion in the image. The flicker problem is definitely increased with the slower frame rate, as the demonstration showed, when the usual fluorescent materials are used in the picture tube. In fact with such materials, the flicker is so noticeable that the entertainment value of the picture is very seriously impaired.

The DuMont engineers have found at least a partial answer to this problem by developing a new type of fluorescent phosphor which has a persistence characteristic suited to the 15-frame repetition rate. This phosphor, which glows with a vivid orange color, develops an illumination which persists for approximately 1/15th second and then rapidly dies away. By the use of such a phosphor, the screen may be illuminated substantially continuously at all points when a 15-frame per second rate is used. The flicker is thereby very much reduced (if the persistence were exactly 1/15th second and the decay instantaneous there could be no flicker at all). The phosphor demonstrated displayed a barely perceptible flicker when operated at 15 frames per second, but the amount of flicker was so small that it could be neglected. The desirability of developing a phosphor of this type which would display a white light was admitted by Mr. DuMont, and he displayed conviction that such a material would result from research.

The question of whether a frame repetition rate of 15 per second would suffice for the representation of rapid motion in the image depends principally on the subject matter. For many types of subject, in which the motion is not too rapid, 15 frames per second is completely satisfactory. In the demonstration a film was shown in which the representation of motion was entirely adequate at 15 frames per second. When the subject matter moves rapidly, however, the frame rate becomes a serious limiting factor. In fact, the standard rate of 30 frames per second imposes a limitation in this respect, for example during a fencing match or a juggling exhibition. The proposed 15-frame rate is correspondingly inadequate for such subjects. The question of the suitability of 15 frames per second, from this point of view, thus rests on the types of subject matter offered to the camera.

Making the Standards Flexible

The next proposal made by the DuMont organization is that the number of lines in the picture (441 in the R.M.A. standards) should be made indefinite, and that the transmitting and receiving equipment should be capable of operating at any number of lines per frame between 400 and 800 (possible values 441, 567, 625, or 735). The higher values could be used, within the six megacycle channel, only with the 15-frame-per-second rate. With the number of lines thus left open to change it would be possible to make improvements from time to time.



The receivers demonstrated: left to right, a five-inch Westinghouse receiver, the new 20-inch DuMont receiver, three DuMont receivers for comparing 441 and 625 images at 30 and 15 frames per second, and (extreme right) a translucent screen for viewing motion pictures in comparison with the television images

However, such changes in the number of lines could not be made readily with the synchronizing system standardized by the R.M.A. Accordingly, the DuMont engineers have developed a new type of vertical synchronizing pulse which is capable of controlling a receiver at any rate required, for any number of lines from 400 to 800 lines. The only change noticeable in a properly constructed receiver, when the

(Continued on page 63)

A LIGHT REGULATOR

By BRITTON CHANCE

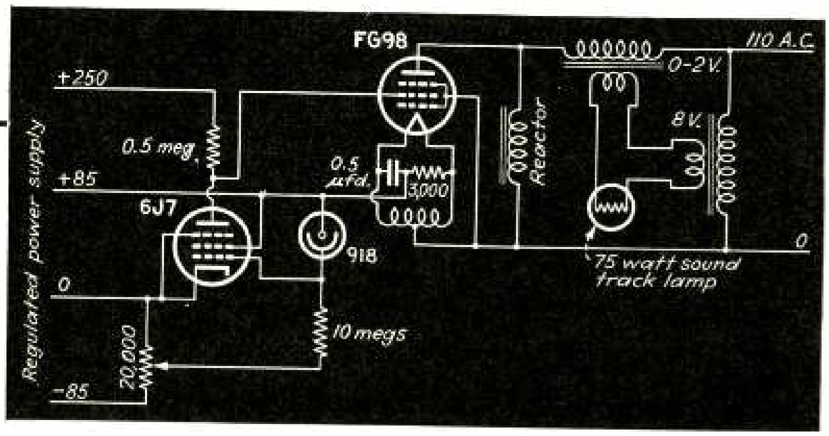


Fig. 1—Circuit diagram of a control unit which makes use of a reactor shunted by a thyratron. It has large current capacity, but is limited in its speed of action

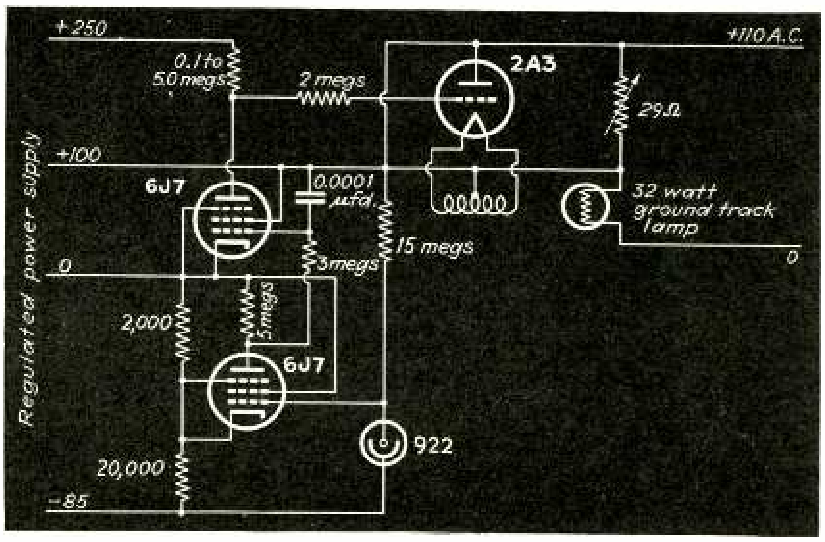


Fig. 2—A light control unit in which a triode shunts a resistance and which is characterized by rapidity of action. Rapid color changes may be measured accurately

THIS device resulted from a study of the accuracy of photometric measurement with a single photocell. The apparatus comprises two high gain photometers illuminated by the same light source, one for controlling the intensity and the other for observing changes in this controlled intensity due to light absorption. Changes in light absorption are measured with an error of one part in ten thousand.

There are three pertinent types of errors.

1. Tube characteristic variations. Modern vacuum phototubes have excellent stability and life. Amplifier tubes, carefully selected for low grid current, showed no significant variations.

2. Circuit parameter variations. These are avoided by using components of adequate size to avoid heating.

3. Voltage fluctuations. As far as the phototubes and amplifiers are concerned, adequate stability can be obtained by the use of regulators such as shown by Bousquet.[1] The ripple can be diminished by the substitution of a battery for the neon tube. The supply for the light becomes the most serious problem. A-c regulators will hold the voltage constant to ± 1 per cent. Batteries used on their optimum characteristic will do somewhat better than this. However, it has been pointed out by Müller[2] that the illumination from a lamp varies as the third or fourth power of the voltage, requiring a voltage stabilization of millivolts to obtain a 0.1 per cent accuracy in illumination.

For such an obvious reason as this photoelectric control of the illumination was developed.

Two types of regulators were used. The first type operated from ac and utilized a thyratron. It was characterized by a wide range of control and an incapability of operating faster than once every 1/50 of a second when using 50-cycle supply. In other words the large current handling capabilities of a thyratron enabled us to obtain a relatively large output. However, we can only control the point during the forward cycle at which the thyratron fires, so this point must be ascertained from an integrated output of the light intensity since the last time of firing. Obviously there are some inherent difficulties due to this, but very good stabilization can be obtained.

The mode of application of such a control may follow any conventional method (Fig. 1). In this case a reactor has been shunted by a thyratron. This gives a satisfactory control of the current. Also no attempt has been made to cause the thyratron to supply the total lamp power as this usually gave rise to undesirable results. In a typical case, the photocell was connected to a d-c amplifier which in turn controlled the thyratron by the amplitude method in conjunction with a 90 degree lagging grid voltage. In this circuit 1.43×10^{-4} lumens change on the photocell caused a correction of 0.125 lumens in the light intensity, a ratio of 1:875. Obviously the actual degree of stabilization of the light intensity depended entirely upon the percentage variation of the input voltage. This input voltage was obtained from a Delta regulator, so the variation of the input was probably less than 1 per cent, and consequently the variation of the light intensity 1/875 of this.

While the use of the thyratron gave a rather good ratio of output to input the control was affected to some extent by the "hum" of the lamp and tended to hunt if the gain of the photocell amplifier or range of control was too large. Also the control operated only once every positive half cycle and did not give a "dc" light.

The second type of regulator, shown in Fig. 2 was designed to give a "dc" light and to have the control responsive to very rapid changes of light, in order to safely measure rapid color changes. The principle is similar except that dc is used throughout and a triode shunts a resistor, instead of a thyratron shunting a reactor. As the d-c supply fluctuations were quite small, only a small range of control was necessary and was amply supplied by a 2A3. High gain was necessary in the photocell amplifier so a 6J7 buffer stage was inserted and the photocell was operated so as to give a very large output, the tube drop being 75 volts and the current 17 ma. A check of 6J7 grid currents showed that they could easily be avoided near the operating point not only by observing the usual precautions as to low heater, screen and plate voltages but also by using a large value of plate load resistor which shifted the operating grid voltage towards more negative values where the large grid currents were not observed. In this way low grid currents were drawn and a substantial gain was obtained from the buffer stage. The next 6J7 controlled the 2A3 directly. The input-output ratio is 1/618.

There are a few precautions to be observed. Especial care must be taken that no voltage divider supplying more than one circuit element can give rise to a regenerative effect and set the control oscillating. Hence separate dividers are supplied for all elements. The insertion of a simple a-c feedback circuit between the 2A3 and 6J7 amplifier is helpful to damp oscillations. The power supplies are regulated to prevent any slow drifts and also to ensure filtering as the control circuit could easily modulate the light at the ripple frequency which is undesirable in this application. The lamp must be soldered into its socket and all external sources of a-c light must be avoided.

This second circuit has enabled reproducible measurements of an intensity of 0.1 lumens with an error of 9×10^{-6} lumens. The expected error from observing the variations of the light control current led to the value of 9.26×10^{-8} lumens for the error, so presumably other factors contribute to the photometer errors.

As these improvements in light source stability permitted the use of far greater gain in the photometer, several significant modifications have been made. The photometer which is referred to was developed for measuring small, rapid light changes with variable sensitivity and a d-c calibration.

The final design employed feedback to improve the frequency characteristic and to obtain variable calibrated sensitivity over a wide range. The output was sufficient to operate the ordinary five inch cathode-ray tube.

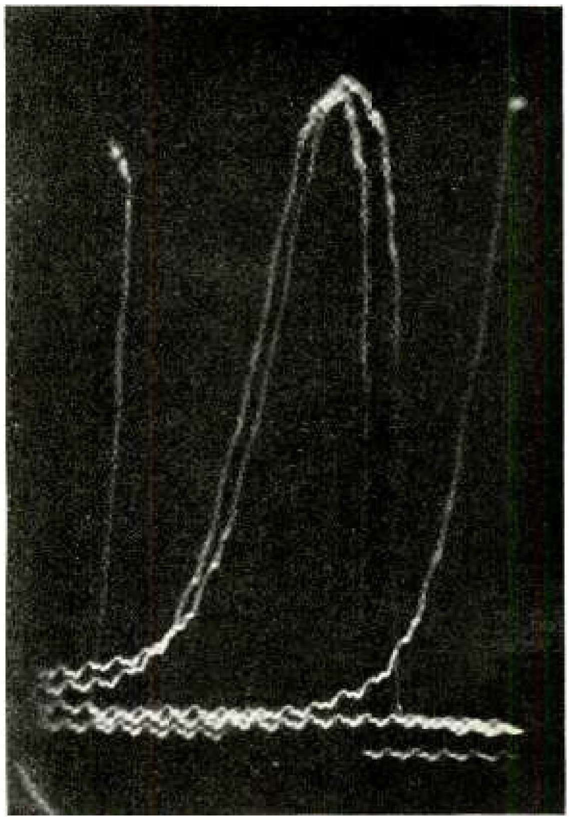


Fig. 4—Typical curves of color disappearance from a methylene blue solution in 0.02 second which were obtained with the apparatus described

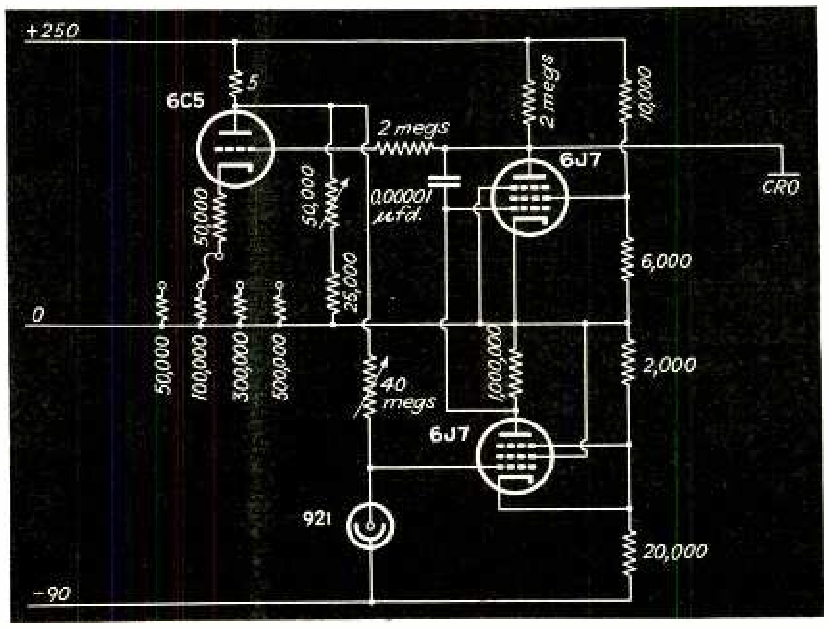


Fig. 3—In the final design shown here, the output of the phototube is amplified in two stages and the 6C5 is used for feed back directly to the phototube

The circuit, shown in Fig. 3, consisted of two voltage regulated power supplies, a 90 volt supply for the low gain stages and a 250 volt supply for the output. The phototube, a 921, worked into a 40 megohm load and gave an output of 220 volts. The small variations in this voltage were amplified by a directly coupled 6J7 giving a gain of about 25. The output controlled a 6J7 stage. A 6C5 was used for feedback directly to the photocell.

Figure 4 shows a curve obtained from such an apparatus. It shows in triplicate the disappearance of color from a 0.0005 per cent solution of methylene blue.

Submitted to the Faculty of the Graduate School of the University of Pennsylvania in partial fulfillment of the requirements for the degree of Ph.D.

This is a section of a thesis on the Accelerated Flow Method for Rapid Reactions to appear shortly in the Journal of the Franklin Institute.

[1] Bousquet—*Electronics*, July, 1938.

[2] Müller—I and E Chem. (Anal. ed.), January, 1939.

FREQUENCY MODULATION

I

F-M Applied to a Television System

By C. W. CARNAHAN, *Hygrade-Sylvania Corp.*

IT is the purpose of this paper to consider the possibilities of a frequency modulation system in the transmission of television signals. Some of the advantages of this form of modulation are pointed out, and the conditions necessary for the transmission and reception of signals acceptable according to present standards are given.

Current interest in frequency modulation is centered on the wide band, noise suppressing system developed by Major E. H. Armstrong. It is probably only a matter of time before a similar system will be used in the transmission of television.

In the meantime it is of interest to examine the case for narrow-band frequency modulation in the region from 40 to 110 Mc.

Band Width Considerations

In the wideband noise-suppressing frequency modulation systems now in use for sound transmission, the width of the radio frequency band is enough greater than the highest modulating frequencies to make it possible to assume that the overall response of the radio frequency amplifiers, including the converter, to a change in signal frequency, is practically instantaneous. If the radio frequency channel width is of the same order as the highest modulating frequency, this assumption can no longer be made. If a sudden, instantaneous, change is made in the signal frequency, the frequency of the amplifier output will not change instantaneously to the new value.

We will consider first the response of a typical converter circuit, shown in Fig. 2. This is shown as a series *R, L, C* circuit for convenience in deriving the response. Figure 1 shows the typical video signal and its frequency modulation equivalent. The frequency is $\omega_1/2\pi$ prior to $t = 0$, and $\omega_2/2\pi$ after that.

Figure 3 shows the envelopes of the responses of the tuned circuit in terms of $\frac{\omega_o t}{2\pi}$, where ω_o is the nominal band width, to the type of signal shown in Fig. 1, for various values of ω_1 and ω_2. Two responses are shown for each pair of frequencies, one corresponding to a transition from ω_1 to ω_2, and the other to a transition from ω_2 to ω_1.

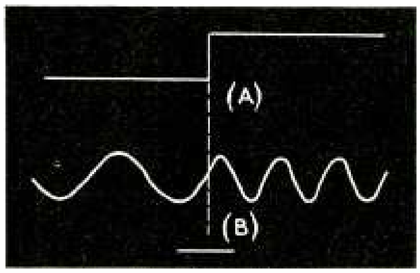
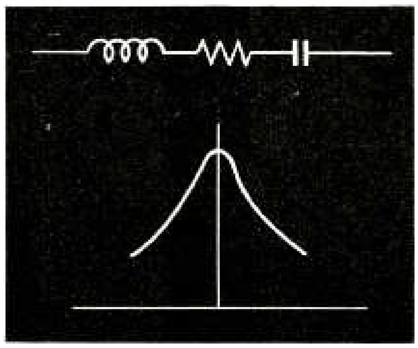


Fig. 1—General television signal and frequency modulation equivalent

Fig. 2—Typical f-m converter circuit and characteristic



The dotted line in the top figure represents the response of the tuned circuit to a suddenly applied voltage at the resonant frequency. This represents the response of the circuit to an amplitude modulated signal. It will be observed that, while the forms of the frequency modulation responses are different, the time constants of all the responses are sensibly equal to that of the amplitude modulation. We may conclude from this that, as far as time of response is concerned, frequency modulation requires the same band width as amplitude modulation.

It will be noticed that, considering any one pair of frequencies, the form of the response depends on the direction in which the transition is made. One clue to the reason for the difference between the responses is as follows: The removal of the first frequency sets up a transient response at the resonant frequency. This response then beats with the new frequency. The beat shows up as oscillations about a simple exponential curve. Due to the asymmetry of the two applied frequencies with respect to the resonant frequency, the frequency of the beat will depend on the magnitude of the departure from resonance, and, for any pair of frequencies, will depend on the direction of the transition.

The signal which we have applied to the converter is ideal in the sense that it contains all frequencies, with no attenuation. In practice, there is a radio frequency amplifier of limited band width ahead of the converter, so that the ideal signal that we have considered never occurs. To be specific, let us assume that the radio frequency amplifier has an ideal band pass characteristic, with linear phase characteristic and infinite attenuation beyond the band limits. An ideal signal consisting of a sudden change in frequency is applied to the input. Figure 4 shows the output of the filter for transi-

(Continued on page 30)

in TELEVISION . . . . .

II

Interspersed F-M and A-M in a Television Signal

By A. V. LOUGHREN, *Hazeltine Service Corp.*

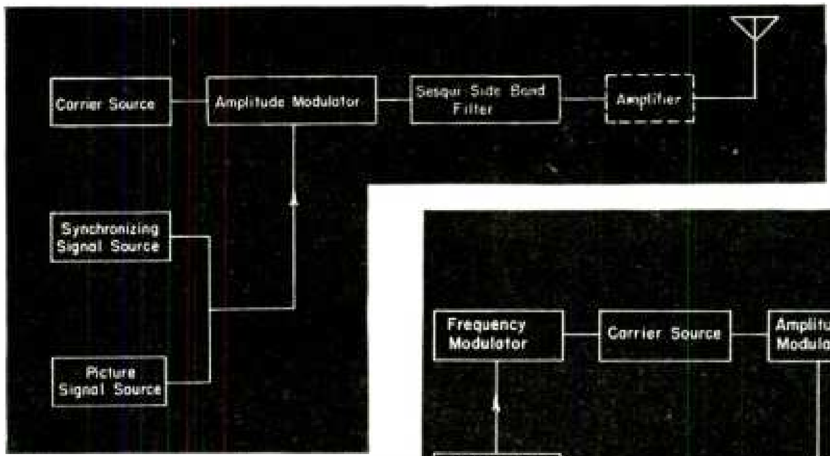


Fig. 1—Standard amplitude modulation television transmitter

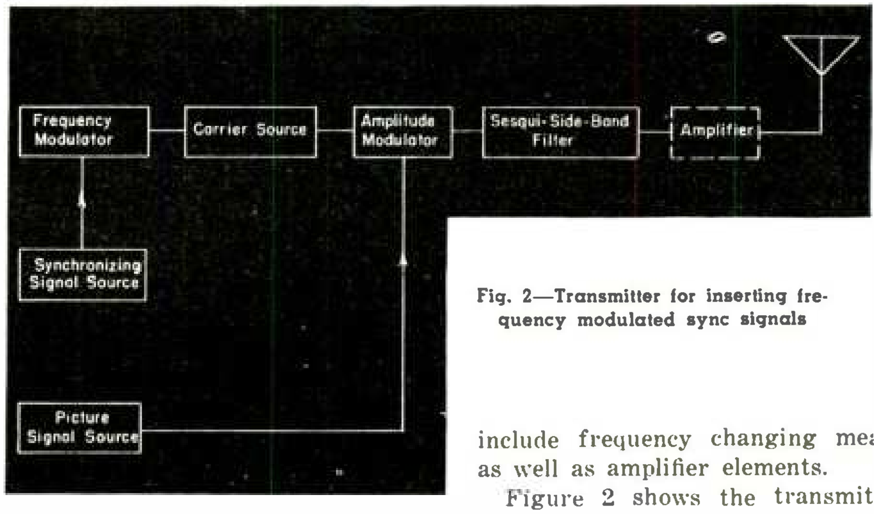


Fig. 2—Transmitter for inserting frequency modulated sync signals

IN the transmission of television synchronizing signals, there are advantages to be secured by utilizing the capabilities of frequency modulation, even though the picture signal is transmitted in the present manner by amplitude modulation. It is proposed that this improvement be considered for use in any television system for which the synchronizing signal has yet to be determined, for example, in systems operating in channels above 150 Mc. This proposal is applicable to any form of synchronizing pulses, but gives much more freedom in the choice of their pattern and in the choice of methods of separating the vertical and horizontal pulses.

It is a common practice in television signal design to combine all of the transmitted information into a single video-frequency signal which is then used to modulate the radiation from the transmitter. The usual practice modulates the amplitude of the radiation; it has been proposed, however, by several workers to modulate the radiation frequency instead. The step of combining the picture and the synchronizing signals before modulation requires that both signals be applied to the transmitter through a common modulator and that they be radiated as modulation components of the same kind.

The alternative signal design principle presented in this article involves modulating the radiation separately with picture and synchronizing signals, choosing for each a suitable type of modulation. In a preferred application of this principle, amplitude modulation is retained for the picture signal while the synchronizing signal is represented by frequency modulation.

Figure 1 shows the transmitter arrangement for the present R.M.A. signal, in which both picture and synchronizing signals are transmitted by amplitude modulation. The amplifier shown dotted at the right may be used or omitted, depending on the power level at which the modulator operates; if used, it may include frequency changing means as well as amplifier elements.

Figure 2 shows the transmitter arrangement for the new signal. Separation of the modulation processes for the two signal components and introduction of a frequency modulator are the only essential changes in the transmitter as compared with Fig. 1.

Requirements of the Television Channel

A brief study of the television signal channel requirements shows that for picture purposes the entire available sideband width of about 4 Mc may well be used. For accurate reproduction of the R.M.A. synchronizing signal,[1] including the

[1] See May and November 1939 R.M.A. Engineer or Fink—"Principles of Television Engineering," McGraw-Hill Book Co.

slopes of the pulses, a band whose effective transmission extends from zero to 1.3 Mc is required. As a minimum requirement about half this band width is needed; this restricted band preserves at least a vestige of the necessary black "step" in the signal preceding each synchronizing pulse.

Today television system design is based on electronic rather than mechanical scanning. Practical electronic systems all require finite retrace intervals, and during these the picture information cannot be used. These intervals or any desired portions of them may therefore be devoted to synchronizing signal transmission without degrading the picture. In the R.M.A. signal, synchronizing and picture information share the composite signal channel not only on this time basis but also on an amplitude basis. The signal design reserves an amplitude region exclusively for each component of the signal, 20 to 25 per cent of the total amplitude range being reserved for synchronizing. It may be shown that time sharing alone is not enough, and that the R.M.A. amplitude sharing *or some equivalent* is a necessary supplement thereto. For if there is no distinction other than timing between the two components of the signal, the receiver must be capable of responding to the absolute phase of the incoming signal if it is to perform the separation with certainty—and the design of a device sensitive to absolute phase is essentially the solution of the problem of operating without synchronizing signals.

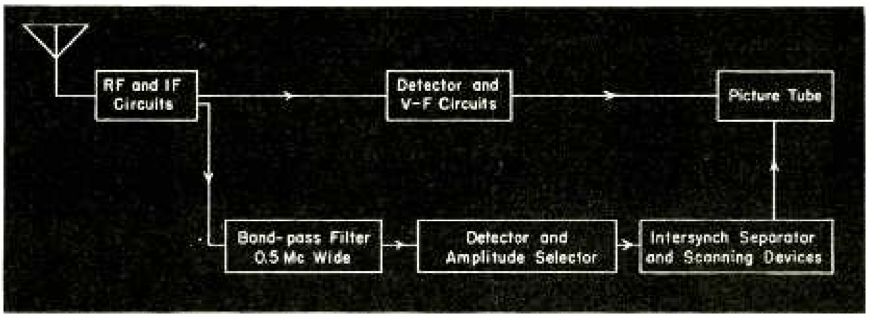


Fig. 3—While conventional receivers will react normally to the proposed signal, the above receiver has been designed especially for it

An example of the use of the new design principle will illustrate both the method of practicing it and some of its advantages. The radiated wave of this example will be formed by modulating the amplitude of the radiation in accordance with R.M.A. standards except that no synchronizing information is applied (the retrace intervals are just black) and also modulating the frequency of the radiation with the R.M.A. composite synchronizing signal, using the transmitter of Fig. 2. The frequency excursion should be preferably about 2 Mc in the direction of the major sideband. In other respects, such as sesquisideband operation, the radiated wave of this example agrees with R.M.A. standards except that the steepness of the slopes on the synchronizing pulses will be reduced by perhaps 25 or 50 per cent from their present magnitudes in order to retain all frequency-modulation sidebands within the uniform transmission band of the transmitter and thus avoid second-order amplitude-modulation terms associated with the synchronizing signals.

Effect on a Conventional Receiver

If the new signal is applied to a conventional television receiver, certain differences in operation result as compared with the R.M.A. signal. The conventional receiver is assumed to attenuate the signal carrier 6 db in its i-f circuits and to perform the synchronizing signal amplitude selection at a point in the receiver later than the introduction of this attenuation. In consequence, the synchronizing pulse amplitude will exceed the black level by two-to-one both at the picture-tube grid and at the point of amplitude selection as compared with the normal margin of four-to-three or five-to-four. As a consequence, amplitude selection is made very much easier. The d-c restoration level in the picture circuit is appreciably altered as compared with R.M.A. signal operation and a readjustment of the brightness control is necessary. In other respects, the operation of the receiver will be normal unless the i-f channel to the synchronizing circuits has an appreciable decrease in gain at the frequency of the synchronizing pulse, in which case realignment of that channel is required.

A receiver designed specifically for the new signal is shown in block form in Fig. 3. The picture channel along the upper line of the diagram may be entirely conventional. It appears preferable, however, to depart from the conventional practice to the extent of not attenuating the carrier 6 db prior to detection, but instead providing suitable attenuation in the low-frequency portion of the video amplifier characteristic. This practice permits taking advantage of having the d-c restoration at black rather than at some "infra-black" level.

Since the synchronizing signal includes no amplitude modulation components, as radiated, it is necessary that the receiver circuits provide frequency selection prior to detection. In the conventional receiver whose operation was described above, the 6 db carrier attenuation played this role. The new receiver will show much better signal-to-noise ratio and a further gain in margin of amplitude selection of synchronizing from picture, by using a band-pass filter tuned to the i-f synchronizing pulses for this frequency selection; the width of pass-band is a compromise between noise acceptance and signal delay, and is set at 0.5 Mc. This element is shown in the lower row of apparatus in Fig. 3. In the output from this filter synchronizing pulses are present with a margin of at least four-to-one as compared with picture components, and the subsequent amplitude selection offers no difficulty.[2] Further, the relatively narrow pass band and the wide amplitude margin produce a major im-

[2] The four-to-one ratio arises from the following:
1. Synchronizing is radiated 2 Mc off the carrier, but at peak radiation intensity.
2. Video sidebands in the synchronizing filter pass band may be represented, in the worst case, by a single sideband at synchronizing frequency.
3. The maximum intensity of a single sideband, in a modulated wave, can not exceed one-fourth of the maximum intensity of the complete signal. (The exceptions to this latter rule are not significant in this case.)

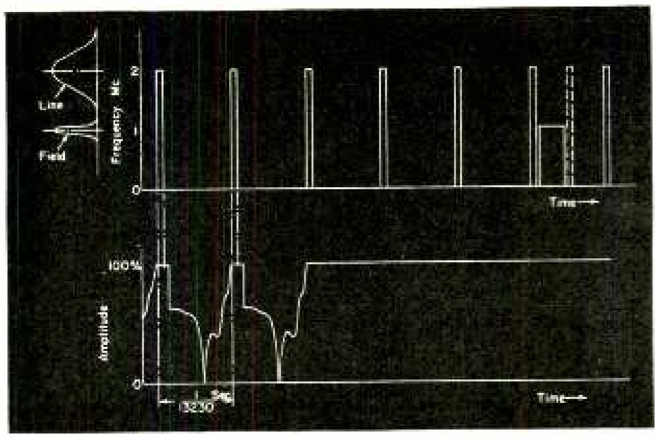


Fig. 4—Modulation content of a signal having different frequency excursions for horizontal and vertical sync pulses

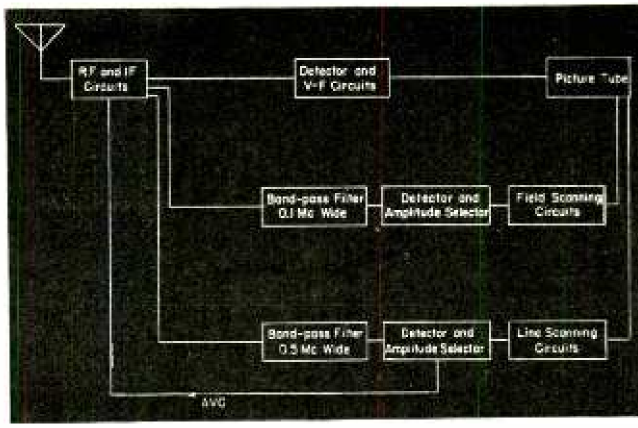


Fig. 5—Receiver designed for use with the modulation signal shown in Fig. 4, using separate scanning filters

provement in the synchronizing signal-to-noise ratio.

Advantages of the New System

Contrasting the system of the above example with the R.M.A. standard system, we find the following advantages for the new system:

(1) Without increasing the peak transmitter power an increase in picture signal is obtained which corresponds to a 60 or 70 per cent increase in peak transmitter power; the received picture signal-to-noise ratio is improved to the same extent.

(2) An entirely new method of synchronizing-signal selection is now available. Since the synchronizing information is now concentrated in a frequency band approximately 2 Mc above the carrier, frequency selection may be employed prior to detection to materially increase the margin of selection for synchronizing signals.

(3) The synchronizing signal may be selected in the receiver with an amplitude margin over picture components in its own frequency band of four-to-one in the new signal as against four-to-three (or five-to-four) in the standard signal.

(4) The received synchronizing signal-to-noise ratio shows an improvement corresponding roughly to the amplitude selection comparison of (3).

(5) The radiated wave now has no "infra-black" amplitude. Consequently d-c restoration arrangements at the receiver can be based on the black level rather than on some arbitrarily "infra-black" level. To make use of this possibility, it is necessary that the equalizing circuit provided in the receiver to correct for the missing sidebands be located in the video-frequency rather than i-f circuits.

It is interesting to note that the new signal requires no explicit sharing of the available amplitude range at the transmitter. Instead, advantage is taken of the fact that the maximum intensity of any one sideband cannot exceed one-fourth the maximum intensity of the complete signal. By use of frequency modulation, the radiation may be shifted in frequency during synchronizing intervals to a region where this margin becomes effective. The modulation capabilities of the signal are only partially utilized by amplitude modulation, so there is still room for the frequency modulation representing the synchronizing signals.

In the foregoing example, improvement in several aspects of performance is obtained with a relatively minor modification of the R.M.A. system. It is interesting to note that further material gains are possible if the entire signal is designed with the principle of interspersed modulation in mind. To illustrate this statement, a second example will be used. In this example, field and line-synchronizing signals will represent different frequency-modulation excursions of the carrier and may hence be separated by frequency selective means prior to their detection in the receiver. As a consequence of this separation, it will be possible to operate the receiver avc from the line-synchronizing signal rather than from the composite synchronizing signal as is the practice when the R.M.A. synchronizing wave is used, with the resulting advantage that the a-v-c time constant instead of being long compared to the picture period need only be long compared to the line period. The transmitter shown in the block diagram of Fig. 2 is suitable for radiating this signal.

Figure 4 shows the modulation content of the signal. The upper portion of the diagram represents the frequency-modulated synchronizing information while the lower portion shows amplitude-modulated picture signals. Standard R.M.A. practice has been followed in the construction of this signal where suitable. For example, the line-blanking interval is 15 per cent and the line-synchronizing signal duration 8 per cent, respectively, of the line period. The field-synchronizing signal consists of a single broad pulse; since it is completely distinguished from line pulses by its frequency of transmission, it is unnecessary to provide equalizing pulses and a long duration signal for use with slow integrating circuits. The field pulse has such duration that it does not interfere with transmission of line pulses in either field of the interlaced scan; a single line pulse of the alternate field is shown, dotted, immediately after the field pulse, to illustrate this relation.

Pass-band Characteristics

Suitable pass-band characteristics for synchronizing signal selection in the receiver are shown at the left of the diagram. A relatively narrow pass band for field-frequency pulses is centered 1 Mc from the carrier, and a relatively wide pass band for line-frequency pulses is centered 2 Mc from the carrier. The width of the line pass band represents a compromise between reduction of noise on the one hand and delay in synchronizing signal transmission on the other. For the line-synchronizing pulses relatively little delay is tolerable; a band width of 0.5 Mc is used. Relatively great delay may be permitted in the field-synchronizing signal channel; here the band width is reduced to the point where it is determined by system frequency tolerance requirements. The choice of frequency deviation for the line pulses is a compromise between best transmission conditions for synchronizing signals and the desirability of limited band width for inexpensive receivers. Here, a logical compromise seems to be 2 Mc. Frequency deviation for field pulses is chosen to produce minimum interference from both picture and line synchronizing signals; it is accordingly half of the line pulse deviation.

A receiver for use with the signal of Fig. 4 is shown in Fig. 5. The upper line of the diagram may be patterned after a conventional receiver or may preferably employ low-frequency attenuation in the video circuits rather than carrier attenuation in the i-f circuits. The two lower rows of apparatus are in general similar, each including its frequency selector, its detector and amplitude selector, and its corresponding scanning generator. The line-frequency circuit, however, includes the a-v-c connection back to the i-f circuits which is required if advantage is to be taken of the system's adaptability to fast avc.

The system of this second example includes all the advantages of the system discussed first. In addition it makes "inter-synch" separation prior to detection possible and advantageous; the a-v-c time constant may be decreased to one-hundredth of the value currently required, with a consequent decrease in the duration of disturbances caused by bursts of noise interference or by power-line transients.

The advantages of transmitting the synchronizing signals by interspersed frequency modulation are based on fundamental principles which lead to more effective utilization of the transmitter power. The added freedom of design in the synchronizing circuits of the receiver is attractive and its potentialities far exceed those realized in the examples described. Therefore this system is worthy of full consideration for those services in which this question remains to be standardized.

F-M Applied to Television

(Continued from page 26)

tions involving frequencies symmetrically placed with respect to the midband frequency. The envelope amplitude is shown, as well as the instantaneous frequency. Our interest in the amplitude function is confined to seeing that the amplitude modulation is small enough to be successfully removed by the limiter in the receiver.

In general, the response of the band pass filter to the sudden change in frequency is about the same as the response to a sudden change in amplitude at constant frequency. The same oscillations are observed, due to the ideal characteristics. The time constants are approximately the same, the response time being about one cycle at a frequency equal to the band width. Transitions occupying more than half the band width show fairly large oscillations in amplitude and frequency. Taking this fact into consideration, a peak to peak frequency deviation equal to one half the total band width, or a deviation ratio of one half, is probably the optimum.

Single Sideband Transmission

Turning now to single sideband transmission, Fig. 5 shows the overall radio frequency characteristic now used for selective sideband amplitude modulated transmission. The essential requirements for this type of transmission are that sufficient band width be provided to transmit one sideband of the highest modulating frequency, and that the carrier be located halfway down the sloping portion of the filter.

The same method may be used for frequency modulation, with some differences. In the first place, any converter circuit that is used for frequency modulation will have a radio frequency characteristic that has a linear slope over the frequency swing. Hence, it is relatively easy to arrange an overall frequency characteristic exactly similar to that used for amplitude modulation, with the frequency deviation region centered on the sloping portion of the characteristic.

As may be seen, this is exactly equivalent to the amplitude modulation scheme only for frequency changes in the vicinity of the carrier. For transitions closer to the edge of the band, the high frequencies will be overemphasized, while transitions on the other side of the carrier will be deficient in highs. Thus the picture detail will depend somewhat upon the brightness. If it is arranged so that picture white is produced by frequencies towards the edge of the band, where the high frequencies are emphasized, the unavoidable variation of spot size with brightness will tend to even out the non-uniformity in frequency response. The amount of non-uniformity may be reduced by decreasing the deviation ratio, at the expense of decreasing the converter sensitivity.

Unbalanced converter circuits seem to be necessary, to provide the additional amplification of the higher sideband frequencies. The balanced variety, where the carrier falls on the resonant frequency of the tuned circuit, will not provide the correct shape in the radio frequency characteristic.

The optimum shape of the radio frequency characteristic, and the optimum deviation ratio, are matters that should be left to experiment to decide. What we have attempted to show is that single sideband transmission of frequency modulation should be no more difficult than with amplitude modulation, and that, while the resulting signal will differ in some respects from the amplitude modulated signal, the overall effect should be the same as regards picture transmission.

Advantages of Frequency Modulation

Up to this point we have been concerned chiefly with the mechanics of a frequency modulation transmission over a comparatively narrow channel. Having found this to be feasible, let us now turn our attention to some of the advantages of frequency modulation.

Most of the classical advantages of frequency modulation should apply to the transmitter. The final stage could be operated class C at the maximum plate dissipation of the tubes. This should result in approximately

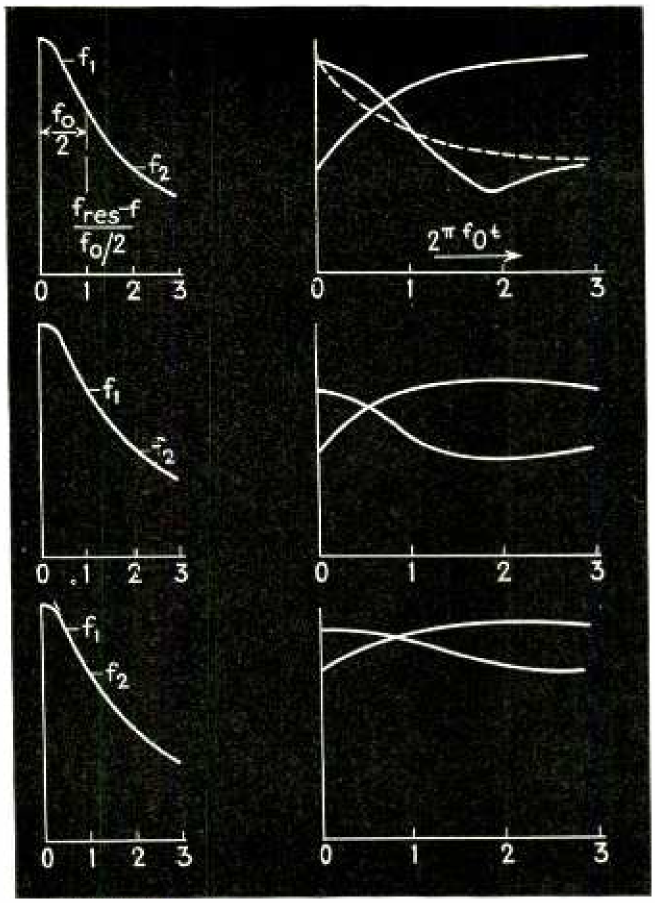


Fig. 3—Envelopes of responses of the circuit in Fig. 2 to the generalized signal shown in Fig. 1

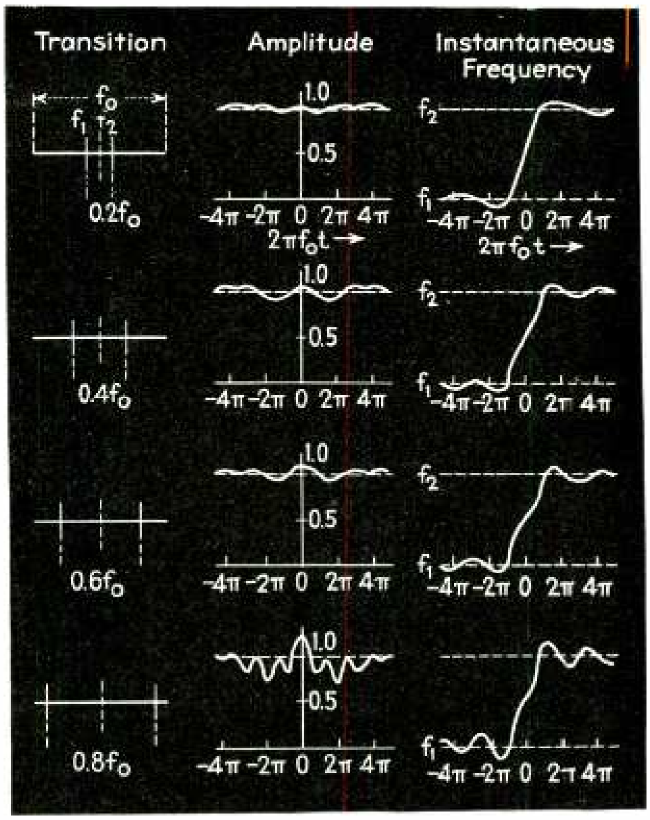


Fig. 4—Output responses of an ideal bandpass filter to symmetrical frequency transitions of the general signal

four times the average power output of a grid modulated amplitude modulation stage and considerably greater efficiency.

Low level modulation, followed by amplifiers having the desired radio frequency characteristics, would obviate the necessity of a high video level, and would accomplish most of the sideband attenuation before the final stage is reached. Compared with low level class B amplitude modulation, no attention need be paid to linearity in the frequency modulation amplifiers.

Predistortion of the high frequency components of the video signal could be accomplished, if desired, without increasing the peak power output in the final stage. If a frequency swing of one half of the converter slope is used, only 50 per cent of the converter slope is occupied by the normal peak to peak video signal. Predistortion of the high frequency components to compensate for aperture distortion, for example, increases the peak-to-peak video signal, and, on an amplitude modulation basis, this means a large increase in the peak power output of the final stage.

At the receiver, the most important question is the comparison between amplitude and frequency modulation in the matter of signal to noise ratio. No adequate treatment of the effect of noise on a television image and its proper evaluation has yet appeared. However, for purposes of comparison, we may consider three particular types of noise which are prevalent in television reception.

Crosby[2] has treated the first two types of noise, and from his results it appears that for equal average carrier amplitudes at the antenna, the signal to noise ratios for amplitude and frequency modulation receivers will be about the same if the total frequency deviation in the frequency modulation receiver is one half of the total radio frequency band width. However, with this deviation ratio at the receiver, it is still possible, with the same transmitter output stage as used in an amplitude modulated transmitter, to radiate four times the average power with frequency modulation. Thus, the average carrier amplitude at the f-m receiver is doubled, and so is the signal to noise ratio.

It is apparent, then, that to realize this gain in signal to noise ratio for the frequency modulation receiver, we must make the deviation ratio larger than that shown in Fig. 5B. To do this, we may extend the deviation width, leaving the carrier and converter slope unchanged, as in Fig. 6A, or we may decrease the converter slope, as in Fig. 6B, shift the carrier somewhat, and leave unoccupied sections of the converter on either side of the extended deviation band. Which of these two radio frequency characteristics gives the best results in terms of picture response, is best left for experiment to decide.

The effect of reflections in the frequency modulation system will be reduced fifty per cent, regardless of the deviation ratio. This is because the frequency of the reflected components will always lie within the deviation band, and since the interference produced by any reflected component is proportional to the difference in frequency between the direct signal and the reflection, and is equal to the interference produced in an amplitude modulation system only when this difference is equal to the deviation width, the average peak interference will be one-half that experienced by the a-m system. When the video signal remains at a constant level longer than the delay time of the reflection, there will be no interference, since the frequencies of the direct and reflected signals will be the same. Hence we may expect an effective reduction of reflection effects greater than the fifty per cent decrease in peak interference.

Synchronizing Functions

Two important functions in the receiver are the separation of the synchronizing impulses from the video, and a further separation of the vertical from the horizontal impulses. With present receivers employing amplitude modulation, the separation of the video from the synchronizing impulses is on an amplitude basis, while the two synchronizing signals are further separated on a basis of waveform difference.

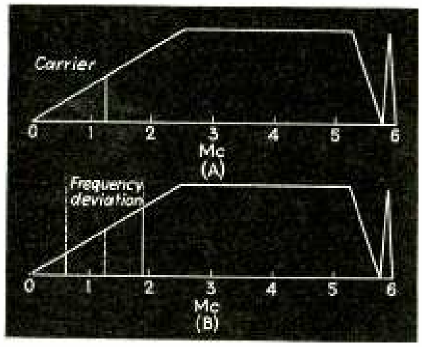


Fig. 5—Selective sideband characteristics for amplitude (A) and frequency (B) modulated signals

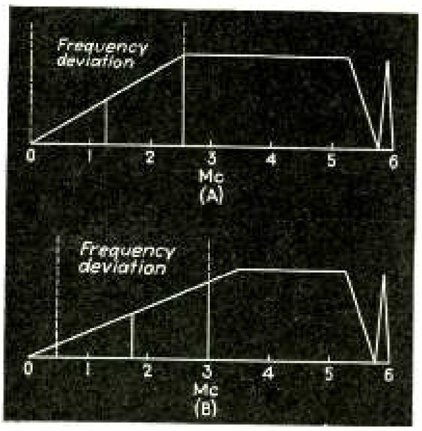


Fig. 6—Methods of extending deviation width of f-m system

Some novel synchronizing means become possible in a frequency modulated system. Figure 7 shows one of these. If we consider the frequency modulation equivalent of the present amplitude transmission scheme, we find that the synchronizing impulses are represented by a practically discrete frequency component some twenty per cent removed from the region occupied by the video components. Since the two components are already separated in frequency, it is possible to exaggerate this difference, and make the entire separation on a basis of frequency. Thus, in Fig. 6, the two synchronizing pulses are removed to the far end of the band, and the two pulses are assigned to frequencies differing by one half megacycle. The synchronizing signals are then selected by means of two sharply tuned circuits, and are separately rectified. In this manner, separation of the synchronizing pulses from the video, and the separation of the vertical from the horizontal is accomplished at the same time.

Let us examine further the separation of the vertical from the horizontal. In the receiver, the output of the limiter feeds two tuned circuits, which are resonant at the two synchronizing frequencies, respectively. Assuming that the frequency assigned to the vertical is at the edge of the intermediate frequency band, and that the tuned circuits have a *Q* of 100, the ratio of wanted to unwanted signal is about 4-to-1 for a frequency difference of one half of a megacycle. The damping constant of the tuned circuits, for a *Q* of 100, will be 3.75 x 10^{5}. Then, in the time interval represented by a half line duration, 3.75 x 10^{6} second, the transient response of the vertical impulse circuit due to a horizontal signal will be reduced to $e^{-14.0}$, or 0.001 per cent of its peak response. Thus, in the vertical impulse circuit, there will be no hangover of the horizontal response. Then, if a biased detector is used, so that the 25 per cent amplitude of the unwanted horizontal signal is not detected, a clean separation of the vertical impulse is effected without the necessity of equalizing impulses.

In summary, we have discussed the possibility of transmitting television in present channel widths by means of frequency modulation. Due to the channel restriction, it has been necessary to consider the frequency modulation equivalent of selective sideband amplitude modulation. Fortunately, the frequency to amplitude converter, if it is of the type where operation is confined to one side of a resonance curve, fits naturally into the selective sideband scheme. Using a system of this sort, it has been found that the detail at any point in the final picture will depend on the brightness at that point, so that the brighter portions of the picture will show greater detail than the darker portions. At this point, further theoretical analysis of the problem becomes uneconomical, and recourse should be made to experiment to determine the best overall frequency characteristic and deviation width.

Assuming a deviation width of one half of the radio frequency channel, the signal-to-noise ratio of the frequency modulation receiver may be doubled over existing amplitude modulation receivers by operating the present amplitude modulated transmitters at their peak power levels. Multiple image effects due to reflection will be reduced by at least fifty per cent or more.

At the transmitter, the production of a large amount of video modulating power, and the necessity of a sideband filter in the output stage, may be avoided by low level frequency modulation. Cleaner separation on a frequency basis of the synchronizing pulses at the receiver should make a simpler synchronizing signal possible, with consequent elimination at the transmitter of much of the present complex signal generating equipment.

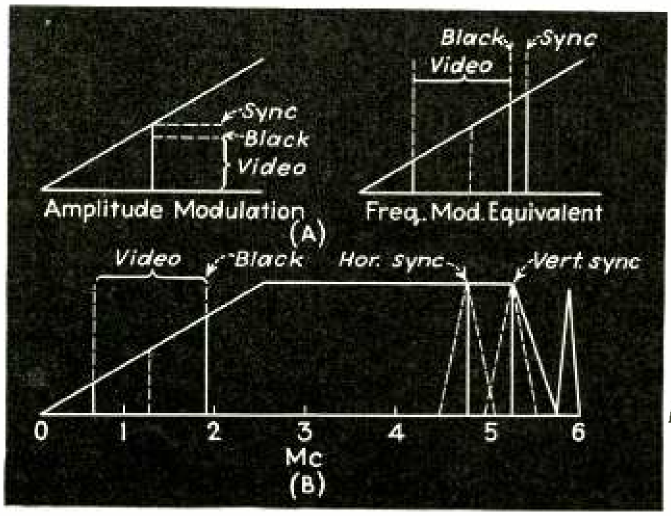


Fig. 7—A possible means of using frequency modulation in synchronizing functions

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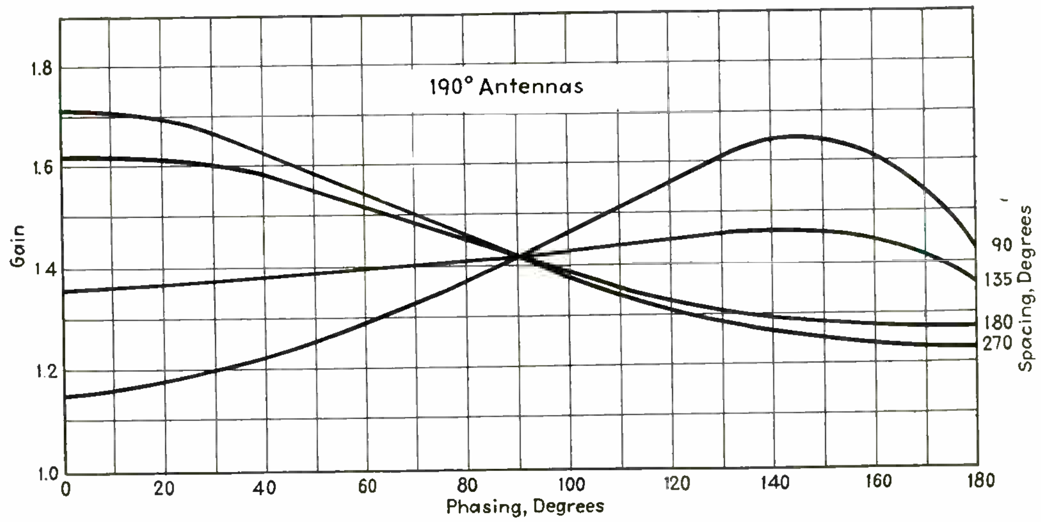
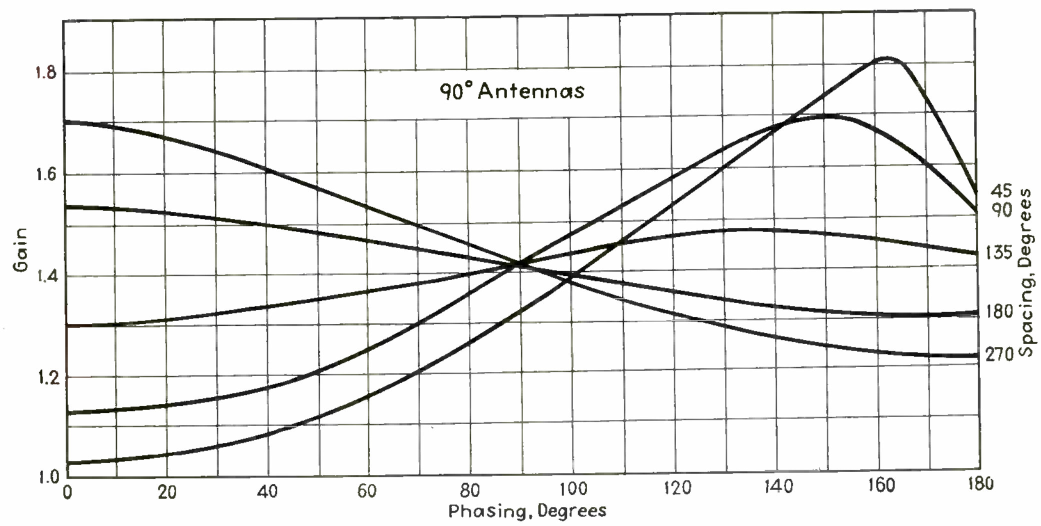
[2] Crosby, M. G., *Proc. I.R.E.*, 25, 472, April, 1937.

[3] Bingley, F. J., *Proc. I.R.E.*, 26, November, 1938.

DIRECTIONAL ANTENNA CHART

By WILLIAM S. DUTTERA
National Broadcasting Company





These charts show the voltage gain that may be derived from a two antenna array when the antennas carry equal currents and are both 90 degrees (one quarter wave length) or are both 190 degrees high. The voltage gain is the ratio of the maximum directional ground signal intensity to the non-directional ground signal intensity from a similar antenna. The voltage gain is shown as a function of the phasing for various spacings. The approximate gain for other spacings may be found by interpolation or may be computed. The actual gain obtained will of course depend upon the loss in the system and allowance must be made for this loss.

TUBES AT WORK

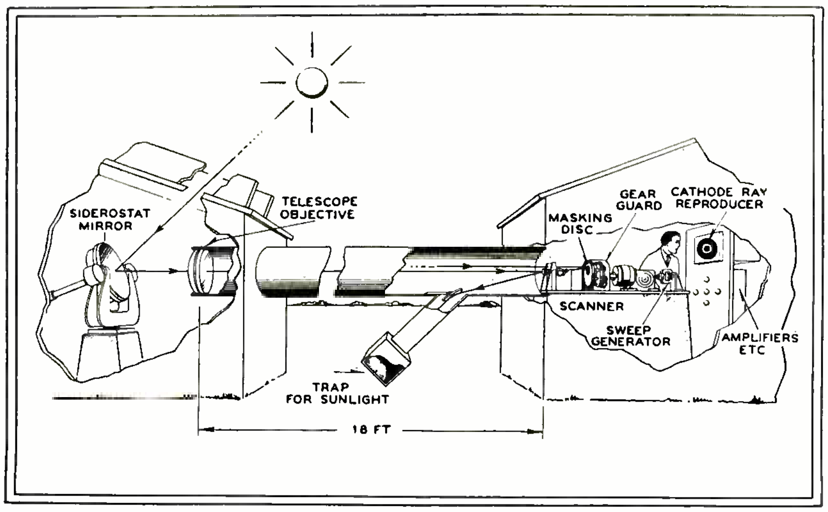
A new method of photographing the solar corona, using television circuits, a profile integrator using a phototube, a universal ultraviolet meter, and a thyratron "reactrol" control

Television Technique Adopted In Photographing Sun's Corona

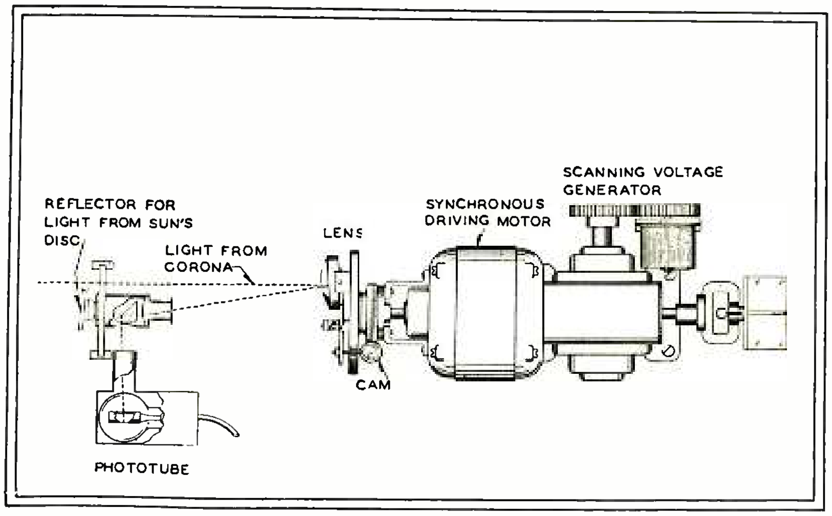
THE IMPORTANCE of the solar prominences (gas flames in the sun's corona) in correlating sunspot activity, and the dependent science of predicting radio propagation effects, are well appreciated. But the difficulty of photographing these prominences in the full light of the sun's disc has been so great that virtually the only time during which they can be photographed occurs during a total eclipse. Recently, however, a new technique for photographing solar prominences has been developed by Dr. A. M. Skellett of the Bell Telephone Laboratories, who reported it recently before the National Academy of Sciences. Briefly, the new technique consists in scanning an image of the sun, utilizing a spiral scanning path which explores the image just outside the disc of the sun. The method used is very similar to that used in the older systems of mechanical scanning in television. The scanner directs the light to a phototube where a corresponding current is produced. The d-c component of this current is produced by the light from the sky, and by general scattering of light from the sun's disc. The a-c component of the signal is derived from the light of the solar prominences. By passing the signal through a capacitively-coupled amplifier it is possible to eliminate the d-c component and to amplify the a-c component until it is of sufficient magnitude to control the grid of a cathode-ray picture tube, such as is used in television. The picture tube is scanned in a spiral pattern similar to, and in synchronism with, the scanning motion used to explore the sun's image. The image on the picture tube, thereby produced, is a reproduction of th solar prominences present on the sun. The image may be examined visually, and any changes in the prominences noted directly, or photographs may be made of the image for more extended study.

The details of the scanning setup are shown in the accompanying drawings. The image of the sun is formed, optically, by a concave mirror which directs it toward a horizontal telescope. The image of the sun's disc is intercepted by a small mirror at the other end of the horizontal telescope, and this mirror reflects this undesired light to a side arm of the telescope which traps the light by absorption. The light which comes from the region around the sun's disc passes the mirror to a masking disc and thence to the scanning mechanism. The scanning system consists of a lens and mirror rotated by a synchronous motor. The mirror is rotated, and at the same time displaced along a radius of its circular motion, by means of a cam and lever arrangement. The combination of ro-

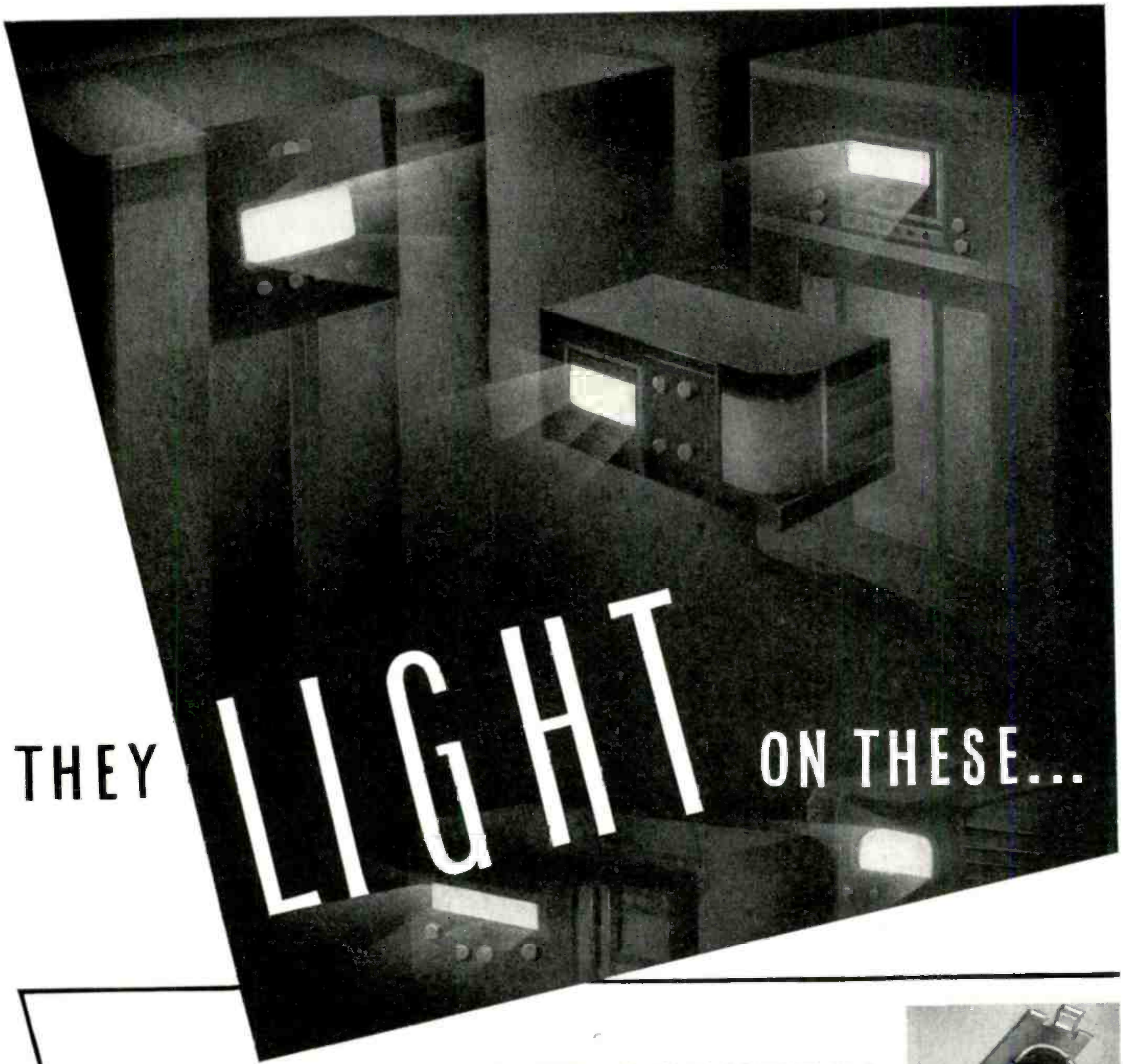
Solar prominences photographed with the "coronaviser" developed by A. M. Skellett. Note the scanning lines surrounding central black disc which represents the sun



The complete set-up of the coronaviser. The sun's image is reflected to a horizontal telescope, and the light due to the solor disc is intercepted. The light from the corona is passed to a spiral scanner and phototube which develops a video signal whose d-c component is then removed



The optical and scanning system of the coronaviser. The synchronous motor drives a mirror-lens which reflects the light from the corona into the phototube. Geared to the motor shaft is a potentiometer which develops scanning voltages. These voltages drive the scanning spot of a cathode ray tube on which the corona image is viewed



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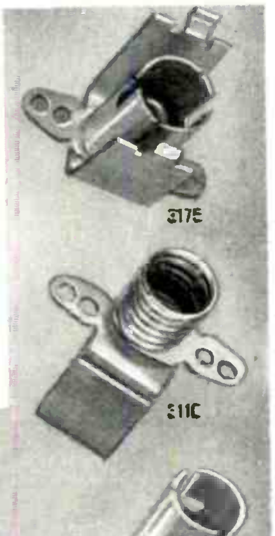

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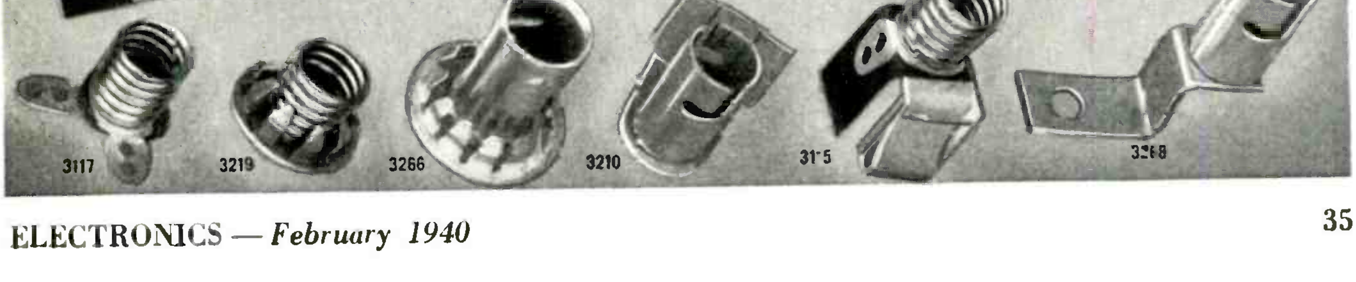


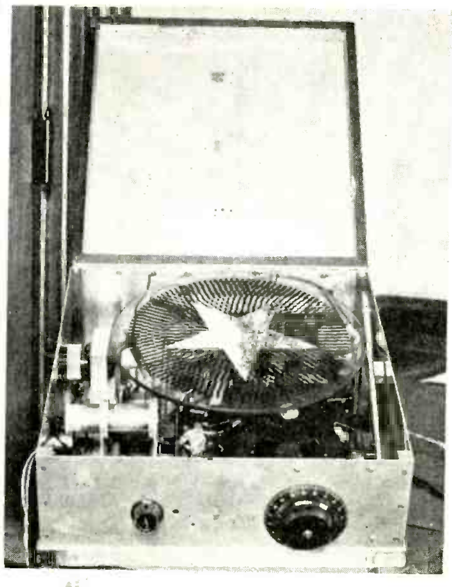
tational and radial motion produces spiral scanning. Light from the mirror-lens is reflected to a small telescope which directs the light to a conventional phototube.

The signal produced in the phototube circuit is passed through the capacitive connection to remove the d-c component, and amplified before being applied to the picture tube. The synchronous motor of the mechanical scanner is coupled to a generating system which develops a scanning voltage used to scan the picture tube in synchronism with the mechanical scanner. Tests with the equipment (known as a "coronaviser") have proved that the corona prominences may be photographed readily, but it is apparent that for the best results the equipment should be placed at a high altitude where freedom from dust and other sources of scattered light may be obtained, and further, the optical system of the telescope must be built to minimise scattered light and diffraction patterns. When these improvements have been made, it seems likely that the coronaviser will become a new astronomical tool of considerable importance.

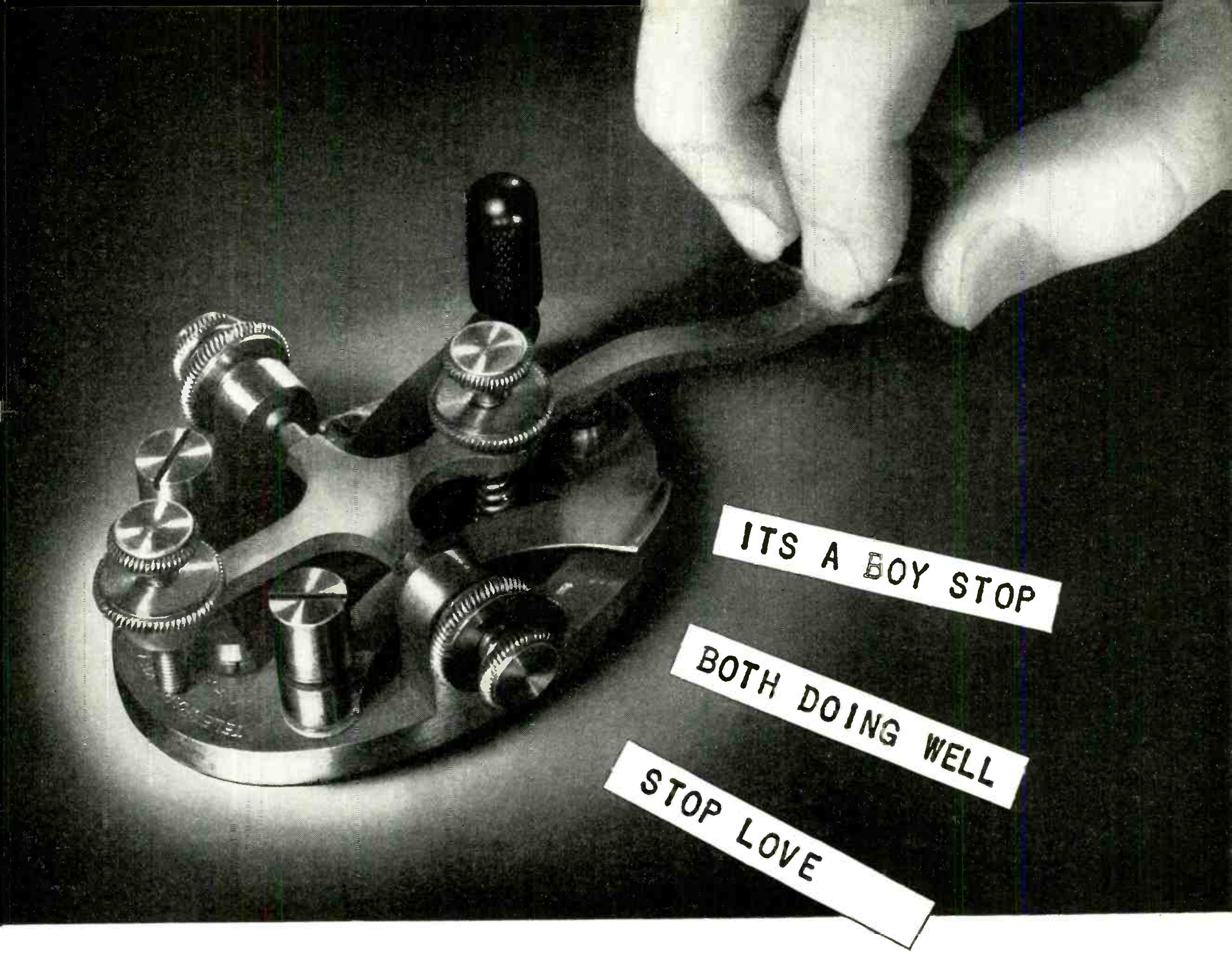
• • •

Integrator for Irregular Plane Surfaces

To INCREASE the accuracy and convenience of measuring the areas of irregular plane surfaces, the Stockton Profile Gauge Corporation, Lowell, Mass., has recently developed a polar integrator based on the use of a light source, reflector and photocell in a compact cabinet. Above the light source and at right angles to the light beam is a rotating disc of transparent material, preferably glass. On this disc and in concentric circles are



Photoelectric profile gauge



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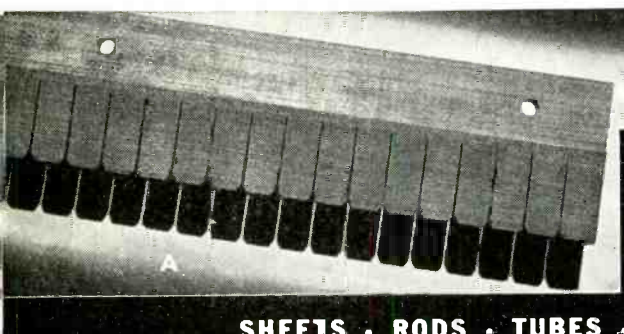

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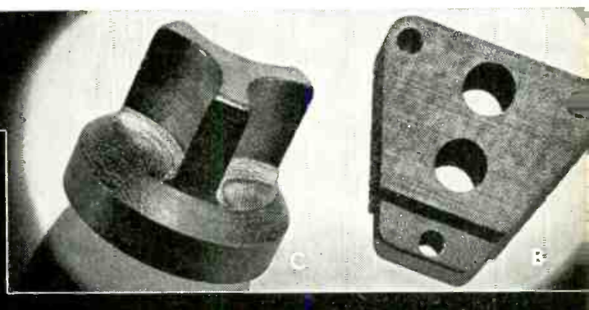

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alternate opaque and transparent sections, each section being calibrated to equal 0.1 square inch. A small motor drives a shaft holding this disc at a predeterminated rate of speed. When the cover of the cabinet is closed it acts as a reflector for the light beam which is transmitted through the transparent section of the disc to the photocell. Connected in circuit with the photocell are an amplifier and thyratron tube, with a ratchet motor for operating a counter. The counter revolves once for each operation of the ratchet motor.

To obtain a measurement of the desired regular or irregular surface, the operator places the plane surface to be measured on the disc, closes the cabinet cover and closes a switch which starts the disc revolution. After the disc has made one complete revolution the light source and photocell mounted on the shaft below operated by a coil spring is permitted to recede one notch toward the center and the second concentric circle is scanned. This procedure continues until the whole disc has been scanned with the exception of the small portion in the center of known area, and which is covered by the surface to be measured.

The operation permits the light source to count those sections on the disc not covered by the surface to be measured. In the model illustrated the known value of the disc is 100 square inches, and the counter is calibrated accordingly. Therefore, to obtain an accurate measurement, the counter is set at 100 and revolves backwards, giving at the end of the measuring cycle the measurement of that portion of the disc being covered by the surface being gone over. When the measuring cycle has been completed the power is automatically shut off. The cover of the cabinet can then be lifted and another surface measured. By refinement of the opaque and transparent sections on the measuring disc and by refinement of the light beam which is interrupted by these opaque sections, the accuracy of the device can be further increased.

In addition to applications in science and education, the device has a field in industries where irregular patterns are used to be laid out on irregular or regular material. Sets of shoe patterns, for example, could be measured, laid out for cutting and the waste also measured. It could then be determined by trial which layout of these irregular surfaces would give the best results with the minimum waste of material.

• • •

Mercury Used in G.E. Lamp

In the October issue of *Electronics* it was erroneously reported that the new high-pressure lamp, used as a source of illumination in the television studios of the General Electric Company in Schenectady, contained argon gas. The lamps contain mercury vapor at high pressure.

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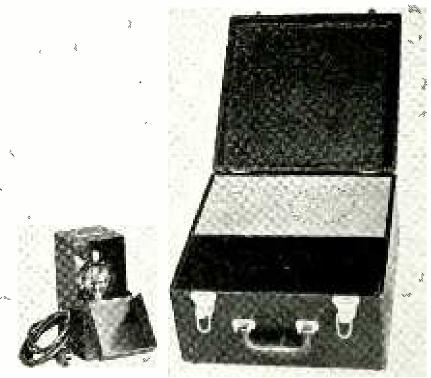
Three Phototubes Available for Ultraviolet Meter

A new meter for measuring the output of various sources of ultraviolet radiation has been developed in the Westinghouse Laboratories at Bloomfield, N. J. It is intended for use with any one of three ultraviolet sensitive phototubes: the tantalum phototube is used particularly for measuring the output of ultraviolet lamps; the titanium phototube for measuring the uv content of solar radiation, and the platinum phototube for radiation capable of producing ozone. In the new meter, the current passing through the phototube is integrated in a condenser charging circuit, and the condenser voltage is used to trip a counting circuit. The number of counts per second is a direct measure of the intensity of the uv radiation falling on the phototube. The trigger tube in the counting circuit is a grid-glow tube. A fullwave rectifier is also built into the unit to supply the necessary direct voltage to the phototube and counting circuit. The whole unit weighs about 30 pounds, is portable, and operates directly from a 115-volt 60-cps power source. The phototube is mounted in a separate housing so that it may be placed close to the radiation source. Among the uses of the device are the measuring of uv radiation in irradiation of food, sterilization, measuring of dosage in sun-lamp treatments, and the supervision of ozone sources in air conditioning and purifying equipment.



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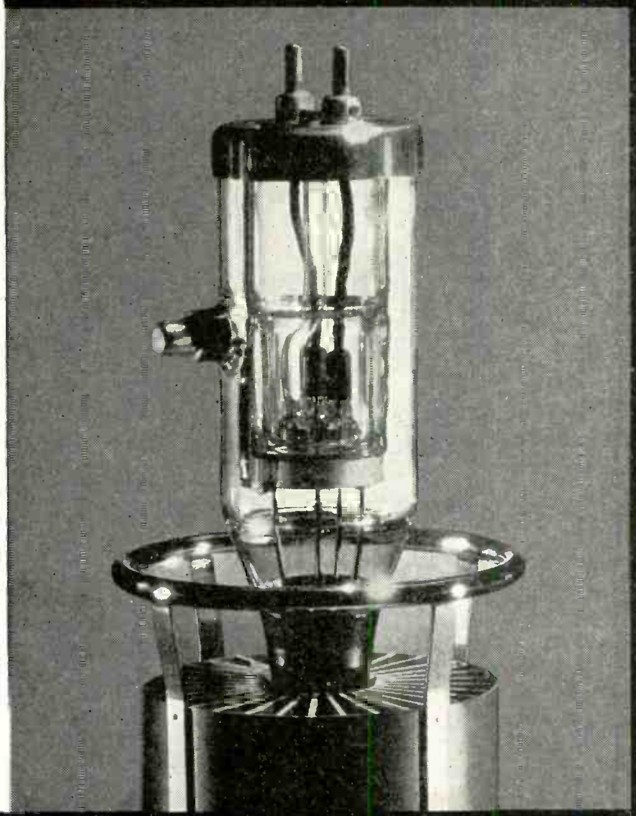

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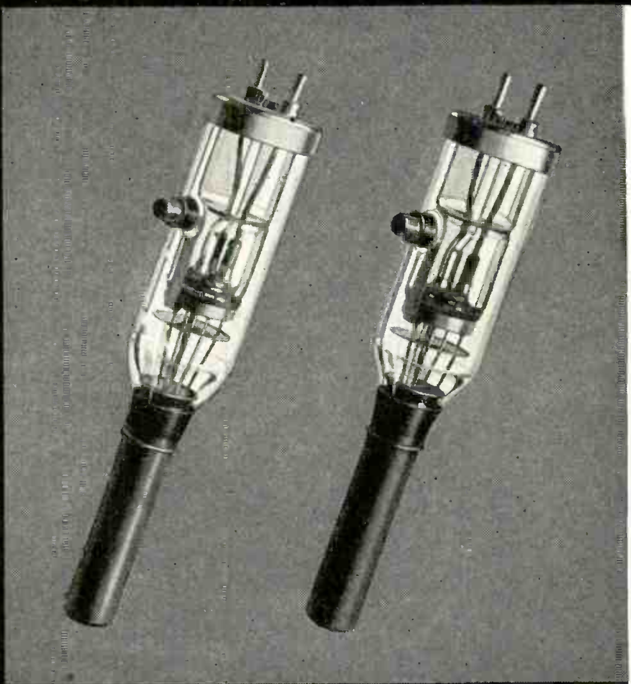

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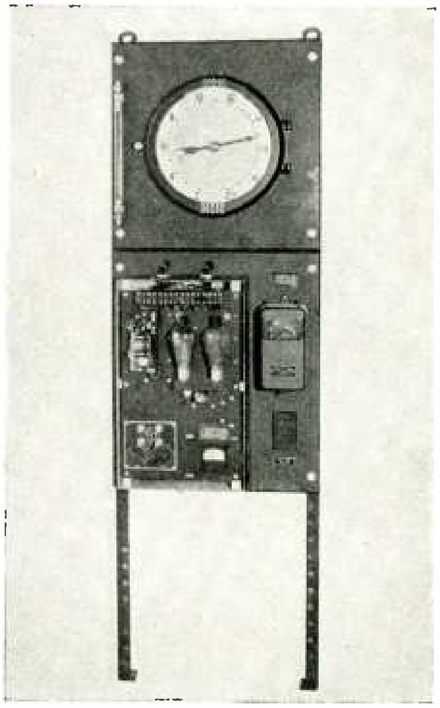
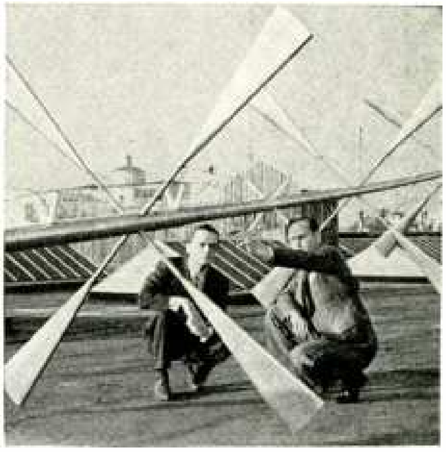


Reactrol control equipment

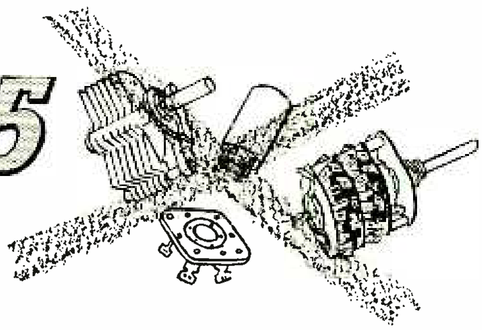
reactor is connected. The rectified current passing through the control tube determines the amount of flux in the saturable core, and the alternating current, passed through a separate winding on the same core, is thereby regulated. Similarly, a pressure indicator may be used, or for that matter any indicating instrument capable of supplying the necessary control voltage to the grid circuit. Proper proportioning of the control characteristic of the reactor makes it possible to exercise close control over the measured quantity with practically no hunting or overshooting.

PADDLE ANTENNA



Paddle shaped radiators designed to give greater definition to television pictures are an unusual feature of this sixty foot vertically stacked antenna of four elements built in Hollywood for the Don Lee broadcasting station W6XOA. Left to right are Thomas S. Lee and Harry R. Lubke, designers

why CHANGE 4 OR 5 COMPONENTS

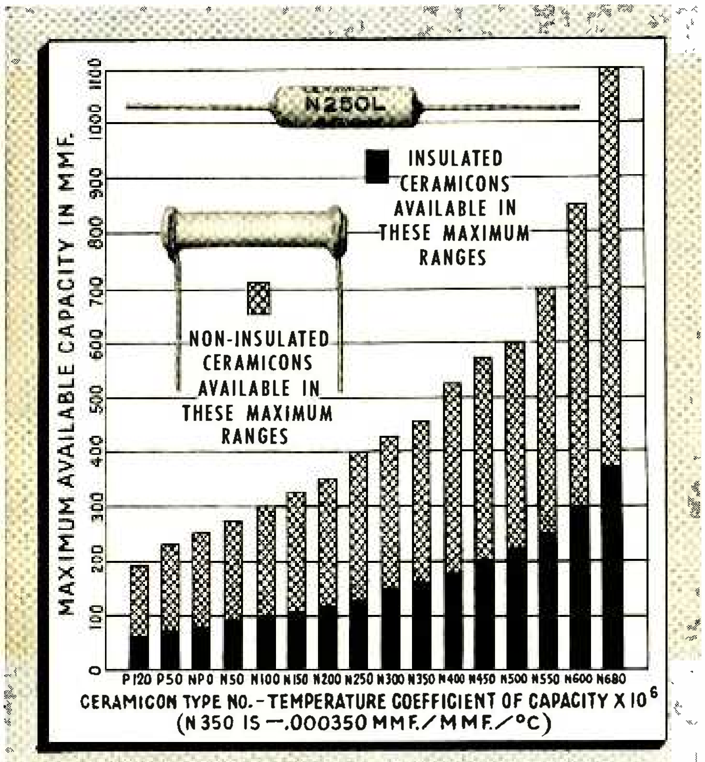


TO ELIMINATE FREQUENCY DRIFT

when 1 *Erie Ceramicon*

REG. U.S. PAT. OFF.

WILL COMPENSATE FOR IT?



NEW WIDE RANGE IN SINGLE UNITS

Frequency drift due to temperature variations may be caused by changes in inter-terminal capacity in coil forms, tube sockets and band change switches or by dimensional changes in coil forms and condenser stator mountings.

To eliminate this drift you can track it down in these various components and replace them with better quality material—a long and expensive process. Fortunately this procedure is unnecessary for, in most cases, an Erie Ceramicon inserted in the oscillator circuit will efficiently compensate for the summation of all the individual drifts present.

These ceramic-dielectric condensers have a definite and reproducable temperature coefficient that is unaffected by either temperature or humidity. Erie Ceramicons are available in insulated and non-insulated types in the ranges shown at the left. Our engineering department will be glad to work with any manufacturer in solving problems of this nature.

RESISTORS
SUPPRESSORS
CERAMICONS
SILVER-MICA CONDENSERS

Erie RESISTOR CORPORATION, ERIE, PA.

MOLDED BEZELS
PUSH BUTTONS AND KNOBS
POLYSTYRENE COIL FORMS

PATENTS

(Continued from page 13)

resistor patent No. 2,010,133.

The net sum and substance of the above remarks on the subject of claims is that they should be worded positively, should include nothing by inference and, if a whereby clause is used, it should be supported by sufficient structure in order that the function set forth in the clause follows as a matter of course.

It must be kept in mind that all *unnecessary* limitations should be omitted from claims when first presented. The inventor may leave it to the Patent Office to cite prior art which later will cause him to write in limitations in order to render the claims patentable. The greater the number of elements in a claim the greater the ease with which infringement may be avoided, since there is no infringement if an element of the claim is omitted in the alleged infringing device.

Method Claims

The courts have held that a true "method," which has for its object the making of a new composition of matter, the processing of an article, or the like, is independent of the apparatus disclosed and that, consequently, such apparatus should not be positively included in the claims.

If the application relates to an "art," such as a process for making a resistor the claims should be devoid of "apparatus" limitations. Following, are examples of good and bad method claims.

Bad: The method of making a resistor which comprises mixing ground glass and bakelite with a *spatula*, drying the mix in an *electric oven*, grinding the mix in a *ball mill*, coating the particles with carbon, thereafter using a *pill machine* to form rods from the coated particles, and baking the rods in a *muffle*.

Good: The method of manufacturing a resistor which comprises coating each of a plurality of particles of inert filler with polymerizable resin, superimposing a film of conducting material upon the resin coating, compressing the filmed particles into a coherent mass, and polymerizing the resin coating to lock the particles in place * * *. (From Claim 16, patent 2,010,133.)

General Considerations

Avoid the use of engineering slang. Use accepted terms and clear, expressive and accurate language.

Avoid the use of long and involved sentences. When such sentences are employed, the grammatical construction is likely to be the chief concern of the reader. In general, long sentences are neither clear nor expressive.

Make short paragraphs. If the subject does not change, make paragraphs arbitrarily. Each page should be sub-divided into at least three paragraphs and preferably more.

A good specification contains a full and accurate description of the various features of the invention and of the details comprised in its embodiment. The specification should be written as if the reader knew little or nothing about the subject-matter of the invention, but it may be assumed that the reader is acquainted with the general art to which the invention appertains. Matters which have a bearing on the relation of the various parts to each other should not be left to inference.

A poor specification is usually subject to the following criticisms:

The description is meager; that is, the person preparing it has hit only the "high spots."

The language is vague and indefinite and "continuity" is lacking.

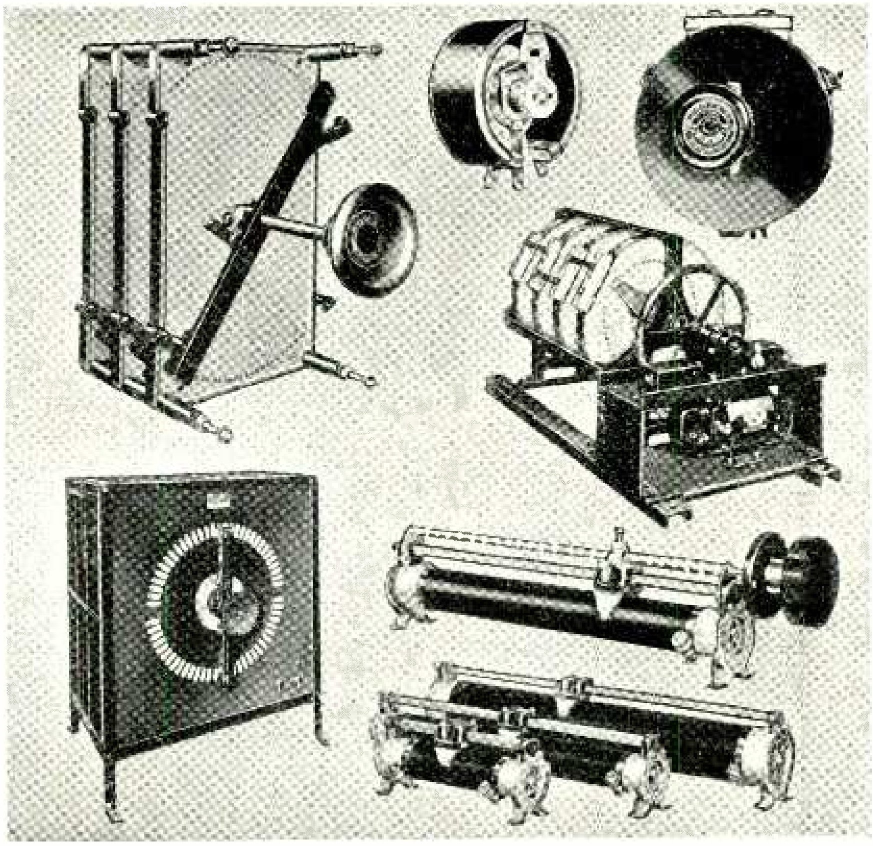
The description is insufficient to enable another to fully understand or to practice the invention set forth.

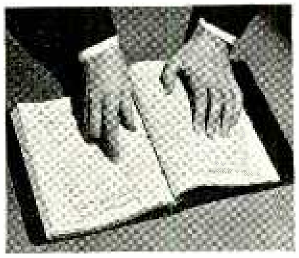
Reasons for the various occurrences are not stated and are not obvious in the device.

The considerations which enter into the invention are omitted, i.e. no background has been painted.

The writer has failed to grasp the full possibilities and breadth of the invention.

The reader, after carefully studying the Rules of Practice of the United States Patent Office, by following the suggestions contained herein should be able to write and file an application for patent that will "do in a pinch." The prosecution of the application subsequent to filing, however, is a highly technical procedure requiring extensive knowledge of patent law, patent practice and of decisions handed down by Patent Office tribunals and by the Courts. In most instances it is false economy for the inventor to prosecute his own application and if possible, he should secure the services of a patent attorney who has the required technical qualifications.





TUBES

The topic of discussion this month is hum as caused by current leakage between the heater and cathode of a tube. The list of tubes registered by the R.M.A. Data Bureau during December as well as March and April 1939 is presented

Heater-Cathode Leakage as a Source of Hum

ELECTRICAL LEAKAGE between an a-c operated heater and cathode of a vacuum tube can introduce low frequency voltage into audio amplifier circuits and cause objectionable hum when considerable gain follows this part of the circuit. High frequency circuits are also subject to hum, if they allow the low frequency voltage to modulate the signal. It is through the courtesy of the Tung-Sol Lamp Works, Newark, N. J., that the following discussion is presented.

The principal cause of this hum is a minute leakage current which flows between heater and cathode. The flow of this current through the self-biasing resistor or the parallel combination of resistor and by-pass condenser applies a hum voltage between the grid and cathode of the tube.

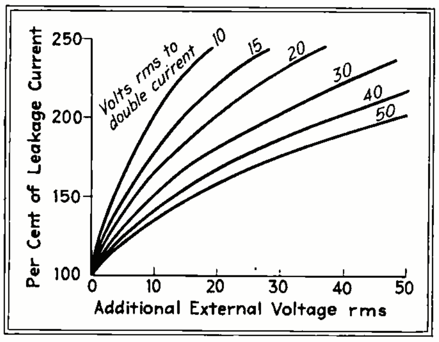
It was found that heater-cathode leakage current is essentially a thermionic emission phenomenon and that the flow of current is due to the negative charges (electrons) and positive charges (positive ions) from the insulation coating on the heater to the cathode sleeve. The capacitance between heater and cathode, being of the order of 10 $\mu\mu$f, is too small to constitute a leakage path.

If the heater varies in potential with respect to the other electrodes, the same phenomenon can cause hum, by emission of charges to these electrodes. Hum from this effect occurs most frequently in a-f amplifiers having a grid bias that is less than the highest voltage between heater and ground. The charges emitted to the grid flow through the grid coupling circuit to ground and the *IZ* drop in the grid circuit causes the hum voltage.

The heater-cathode leakage current is usually a very distorted wave when the applied voltage is a sine wave. This produces harmonics of the 60 cycle heater voltage at which the loud speaker is highly efficient. Under normal operating conditions, the impedance of the leakage circuit is much greater to dc than to ac. The ratio may be as much as 1000 to 1. This is a result of the fact that with a constant potential (dc) applied between heater and cathode, the current decreases rapidly with time, and when the potential is reversed the current will start at some new high value and again decrease with time. In this discussion the term leakage current refers to the a-c component, unless otherwise specified.

The characteristics of the leakage vary greatly, as the current may consist of the emission of negative charges only, positive charges only or a combination of both. The leakage is usually unstable and will increase or decrease with use.

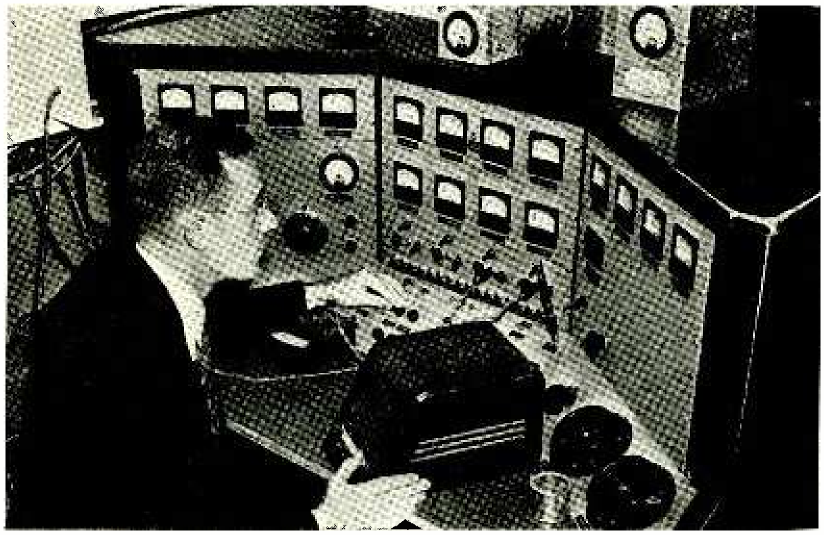
The impedance of the internal leakage circuit is always much greater than any external impedance across which hum voltage is developed. Therefore, in practical cases, the hum voltage varies directly with the impedance of the circuit through which the leakage current flows and can be calculated from the short circuit leakage current. The leakage current varies from 0 to about 3 microamperes (ac) for 6.3 volt heaters operated at normal voltage and no external voltage in the heater cathode circuit. The product of this current multiplied by the 60 cycle impedance of the cathode biasing circuit is the hum voltage. As an example, assume the leakage current of a type 6F5 tube is 2 microamperes and it is operated as an amplifier with a 3000 ohm cathode bias resistor, by-passed with a 0.1 μf condenser. The 60 cycle impedance is nearly 3000 ohms and the IZ drop or hum is 6.0 millivolts. With a 5 μf by-pass condenser, the 60 cycle impedance is 520 ohms and the hum voltage is then 1.0 millivolt. If the full input signal to the tube is 0.1 volt, the leakage hum in the latter case is 40 db down. The hum will be down 60 db if the leakage current is 0.2 microamperes.



Effect of additional alternating voltage between heater and ground

The effect, on hum, of additional alternating voltage between heater and ground is determined by the use of the diagram. The leakage current varies as the cube root of the entire voltage in the circuit. Part of this voltage is internal, depending on heater voltage and leakage characteristics and the remainder is the alternating voltage between heater and cathode. The internal voltage varies between tubes and to properly rate the leakage of a tube it is necessary to give the leak-

CONTROL PANEL FOR WORLD'S LARGEST ATOM SMASHER



Robert Cornog, working in the radiation laboratory of the University of California, is shown at the control panel of the 220-ton cyclotron. By means of the speaker at Cornog's right hand, he is able to communicate over the public address system with observers working with the cyclotron in another room of the laboratory

age current without external alternating voltage as well as the additional external alternating voltage necessary to cause the current to double. Each curve of the diagram is labeled for the voltage that will double the current. The average for most tubes is 25 volts. Taking this value to apply to the 6F5 in the above example, the increase of hum by raising the heater 3 times or 18.9 volts above ground, is determined from the diagram. Interpolate between the 20 and 30 volts at the 18.9 point on the "Additional External Voltage" scale. Reading the "% Leakage Current" scale, the hum is found to be 185% of its previous value.

The leakage current increases rapidly with temperature, as does all thermionic emission phenomena. A 6 per cent increase in heater voltage approximately doubles hum, or a 1 per cent change in heater voltage causes the hum to change about 1 db when the hum in the amplifier is due entirely to heater cathode leakage.

The instantaneous leakage current, measured with continuous voltage, saturates as the potential between heater and cathode increases. This characteristic makes it possible to reduce the hum in any tube to a very small value by biasing the heater with respect to the cathode so that the net potential between the two never reverses. Hum reaches a maximum with a small bias (sometimes positive, sometimes negative) between cathode and heater.

Operating Conditions to Minimize Heater-Cathode Hum

Heaters should not be operated above rated voltage, as hum doubles with a 6 per cent increase in heater voltage.

If self-biasing circuits are used, the 60 cycle impedance should be as low as possible. This is attained by the use of low cathode resistance and high capacity by-pass condensers and is particularly important in the early stages of a high gain a-f amplifier. Use of fixed-bias avoids this source of hum.

Tubes having comparatively small leakage, used as biased detectors, frequently hum as the cathode resistor is necessarily high and practical conditions require a small by-pass condenser. The most satisfactory method of avoiding this difficulty is to arrange the circuit to ground the cathode of the detector.

In series heater operation, the tube most critical to hum should be placed nearest ground. This is usually the detector tube in a-c d-c receivers. The next tube to be given the preferred position near ground is the converter, as this avoids modulation hum (not caused by heater-cathode leakage).

When a transformer is used, hum will be reduced by grounding the center of the heater winding.

Hum can be reduced to a negligible value by use of sufficient bias between heater and cathode to prevent the net voltage reversing. This condition occurs in infinite impedance detectors and certain cathode loaded circuits.

Hum, resulting from emission of charges from the heater to other electrodes, is reduced by decreasing heater temperature, by keeping the impedance of the electrode circuits low and by keeping the electrodes constantly biased with respect to the heater.

Balancing or bucking hum in a radio receiver is sometimes resorted to in minimizing total hum. Heater cathode leakage should not be given a part in hum balancing systems as it is too variable.

The two following test methods have been found useful in checking sources of hum:

To test for leakage hum use a 30 μf condenser or a battery whose voltage is equal to the cathode bias. Connect the condenser or battery across the cathode biasing circuit, making the cathode positive, and note the effect on hum. A noticeable reduction of hum indicates the source is heater-cathode leakage.

To test for hum caused by emission from heater to grid, first disconnect the coupling from the previous tube. If hum is not diminished, continue the test by grounding the grid. Disappearance of hum indicates emission from heater to grid.

Tube Registry

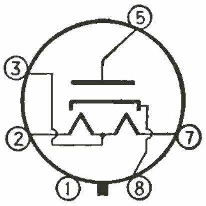
Tube Types Registered by R.M.A. Data Bureau During December 1939

40Z5/45Z5 (GT)

Identical with 45Z5 (GT)

BALLAST-RECTIFIER; heater type; (T-9) glass envelope; seated height 2¾ inches (max); 7 pin octal base.

E_h = 45 v
I_h = 0.150 amp
E_{ac} = 125 v (max)
I_{dc} = 100 ma (max)
I_{peak} = 600 ma
E_{drop} = @200ma = 16v
Basing 6-AD

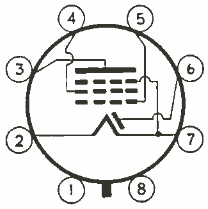


Tube Types Registered by R.M.A. Data Bureau During March and April 1939

Type 1N6 (G)

DIODE; power amplifier pentode; filament type; glass envelope; (T-9) octal base, 8 pins.

E_f = 1.4 v
I_f = .05 amps
E_p = 90 v
E_{c2} = 90 v
E_c = −4.5
I_p = 3.1 ma
I_{c2} = 0.6 ma
g_m = 800 μmhos
R_l = 25,000 ohms
P_o = .10 watts
Basing 7-AM

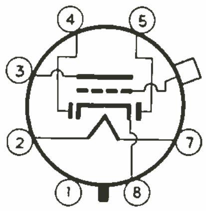


Type 12G7 (G)

Prototype 12G7 (GT)

DOUBLE diode, triode; heater type; (ST-12) glass envelope; 7 pin octal base.

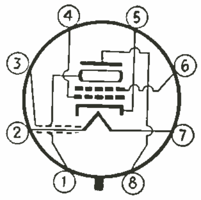
E_h = 12.5 v
I_h = 0.15 amps
e_p = 250 v
e_g = −3 v
g_m = 1200 micromhos
μ = 70
R_p = 58,000 ohms
Basing 7-V



Type 6AG7 (M)

VIDEO beam amplifier; heater type; (T-9) metal envelope; 8 pin octal base.

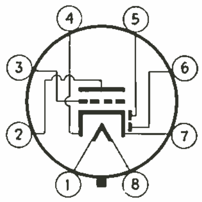
E_h = 6.3 v
I_h = 0.65 amps
e_p = 300 v
e_g = −10.5 v
g_m = 7700 micromhos
μ = 770
R_p = .1 megohms
Basing 8-Y



Type 7E6 (GL)

DOUBLE diode; medium mu triode; heater type; glass base-envelope; loktal base, 8 pins.

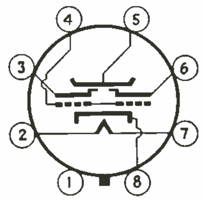
E_h = 7.0 v
I_h = .32 amps
E_p = 250 v (max)
E_c = − 9 v
I_p = 9.5 ma
g_m = 1900 μmhos
R_p = 8500 ohms
μ = 16
Basing 8-W



Type 6AF7 (G)

TWIN tuning indicator; heater type; (T-9) glass envelope; 8 pin, octal base.

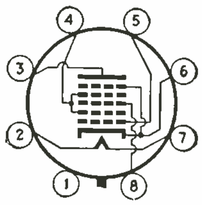
E_h = 6.3 v
I_h = 0.3 amps
Basing 8-AG



Type 12SA7 (GT)

PENTAGRID converter; heater type; bantam glass; octal base, 8 pins.

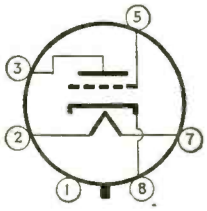
E_h = 12.6 v
I_h = .15 amp
E_p = 250 v
$E_{c2,4}$ = 100 v
E_{c3} = − 2 v
I_p = 3.4 ma
$I_{c2,4}$ = 8 ma
g_c = 425 μmhos
r_p = 0.8 megohms
Basing 8-AD



Type 6AF5 (G)

TRIODE; voltage amplifier; heater type; glass envelope; (ST-12) octal base, 6 pins.

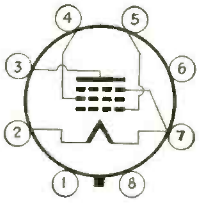
E_h = 6.3 v
I_h = .3 amps
E_p = 180 v (max)
E_c = − 18 v
I_p = 7 ma
g_m = 1500 µmhos
R_p = 4900 ohms
μ = 7.4
Basing 6-Q



Type 1A5 (GT)

POWER amplifier pentode; filament type; (T-9) glass envelope; octal base, 7 pins.

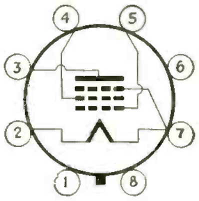
E_f = 1.4 v
I_f = 0.05 amps
E_p = 85 v
E_{c2} = 85 v
E_c = − 4.5 v
I_p = 3.5 ma
I_{c2} = 0.7 ma
g_m = 800 µmhos
R_l = 25,000 ohms
P_o = 0.1 watts (10%)
Basing 6-X



Type 1C5 (GT)

POWER amplifier pentode; filament type; (T-9) glass envelope; octal base, 7 pins.

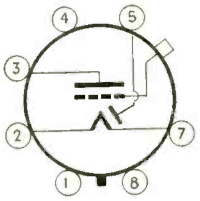
E_f = 1.4 v
I_f = 0.10 amps
E_p = 90 v
E_{c2} = 90 v
E_c = − 7.5 v
I_p = 7.5 ma
I_{c2} = 1.6 ma
g_m = 1550 µmhos
R_l = 8000 ohms
P_o = 0.24 watts (10%)
Basing 6-X



Type 1H5 (GT)

DIODE-TRIODE; filament type; (T-9) glass envelope; octal base, 8 pins.

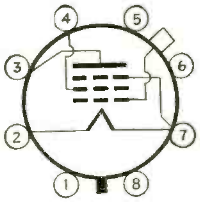
E_f = 1.4 v
I_f = 0.05 amps
E_p = 90 v
E_c = 0 v
I_p = 0.15 ma
g_m = 275 µmhos
R_p = 0.24 megohms
Basing 5-Z



Type 1N5 (GT)

R-f pentode; filament type; (T-9) glass envelope; octal base, 8 pins.

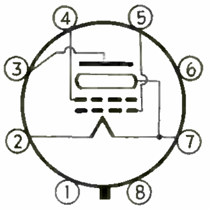
E_f = 1.4 v
I_f = 0.05 amps
E_p = 90 v
E_{c2} = 90 v
E_c = 0 v
I_p = 1.2 ma
I_{c2} = 0.3 ma
g_m = 750 µmhos
R_p = 1.5 megohms
Basing 5-Y



Type 1Q5 (GT)

BEAM power amplifier; filament type; (T-9) glass envelope; octal base, 7 pins.

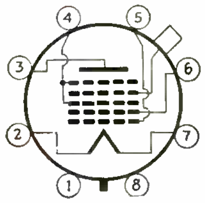
E_f = 1.4 v
I_f = 0.1 amps
E_p = 90 v
E_{c2} = 90 v
E_c = − 4.5 v
I_p = 9.5 ma
I_{c2} = 1.6 ma
g_m = 2100 μmhos
R_l = 8000 ohms
P_o = 0.27 watts
Basing 6-AF



Type 1A7 (GT)

PENTAGRID converter; filament type; (T-9) glass envelope; octal base, 8 pins.

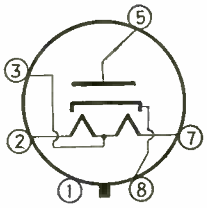
E_f = 1.4 v
I_f = 0.05 amps
E_p = 90 v
$E_{c3,5}$ = 45 v
E_{c2} = 90 v
E_{c4} = 0 v
I_p = 0.55 ma
$I_{c3,5}$ = 0.6 ma
I_{c2} = 1.2 ma
g_c = 250 μmhos
R_p = 0.6 megohms
Basing 7-Z



Type 45Z5 (GT)

BALLAST-RECTIFIER; heater type; bantam glass; octal, 7 pins.

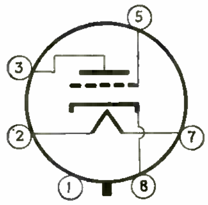
E_h = 45 v
I_h = .15 amp
E_{ac} = 125 v (max)
I_{dc} = 100 ma (max)
Basing 6-AD



Type 12J5 (G)

TRIODE; heater type; glass; octal, 6 pins.

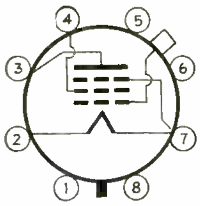
E_h = 12.6 v
I_h = .15 amp
E_p = 250 v (max)
E_c = − 8 v
I_p = 9 ma
g_m = 2600 μmhos
R_p = 7700 ohms
μ = 20
Basing 6-Q



Type 1P5 (G)

PENTODE; remote cutoff; filament type; glass; octal, 7 pins.

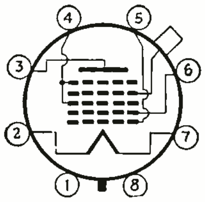
E_f = 1.4 v
I_f = .05 amp
E_p = 90 v
E_{c2} = 90 v
E_c = 0 v
I_p = 2.3 ma
I_{c2} = 0.7 ma
g_m = 800 μmhos
R_p = .8 megohms
Basing 5-Y



Type 1B7 (G)

PENTAGRID converter; remote cutoff; filament type; glass; octal, 8 pins.

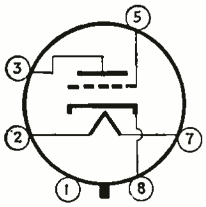
E_f = 1.4 v
I_f = .10 amp
E_p = 90 v
$E_{c3,5}$ = 45 v
E_{c2} = 90 v
E_c = 0 v
I_p = 1.5 ma
$I_{c3,5}$ = 1.3 ma
g_c = 350 μmhos
R_p = .35 megohms
Basing 7-Z



Type 6P5 (GT)

TRIODE; heater type; bantam glass; octal base, 6 pins.

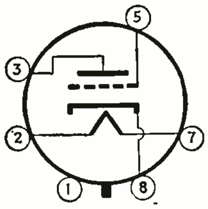
E_h = 6.3 v
I_h = .3 amp
E_p = 250 v
E_c = − 13.5 v
I_p = 5 ma
g_m = 1450 μmhos
R_p = 9500 ohms
Basing 6-Q



Type 6AC5 (GT)

POWER amplifier triode (positive grid); heater type; bantam glass; octal, 6 pins.

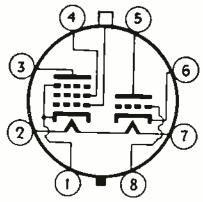
E_h = 6.3 v
I_h = .4 amp
g_m = 3400 μmhos
R_l = 2 (5000) ohms
P_o = 8 watts (10%)
Basing 6-Q



Type 25B8 (GT)

PENTODE; triode; heater type; bantam glass; octal base, 8 pins.

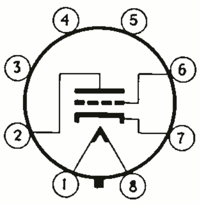
E_h = 25 v
I_h = .150 amp
TRIODE
g_m = 1500 μmhos
μ = 112
R_p = 75,000 ohms
PENTODE
g_m = 2000 μmhos
μ = 370
R_p = 185,000 ohms
Basing 8-T



Type 7A4 (GL)

TRIODE; heater type; glass envelope; loktal base, 8 pins.

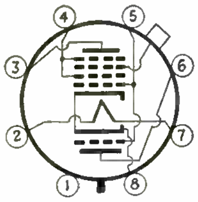
E_h = 7.0 v
I_h = .32 amps
E_p = 250 v (max)
E_c = − 8 v
I_p = 9 ma
g_m = 2600 μmhos
R_p = 7700
μ = 20
Basing 5-AC



Type 6K8 (GT)

TRIODE-HEXODE; remote cutoff; heater type; bantam glass, octal base, 8 pins.

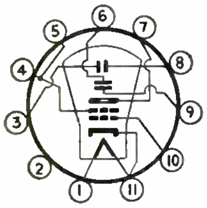
E_h = 6.3 v
I_h = .3 amp
g_c = 350 μmhos
R_p = .6 megohms
Basing 8-K



Type 5AP1

PICTURE tube; electrostatic focusing and deflection; soft glass; 11 pin, magnal base.

E_h = 6.3 v
I_h = .6 amps
E_{a2} = 1500 v
D_1 and D_2 = .23 mm/v
D_3 and D_4 = .28 mm/v
E_{a2} = 2000 v
D_1 and D_2 = .17 mm/v
D_3 and D_4 = .21 mm/v
Basing 10-A



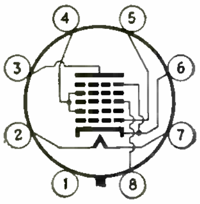
Type 5AP4

IDENTICAL with 5AP1 with exception of color as determined by phospor.

Type 6SA7 (GT)

PENTAGRID converter; heater type; bantam glass; octal base, 8 pins.

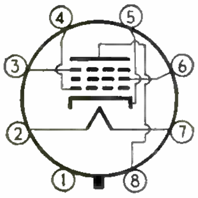
E_h = 6.3 v
I_h = .3 amp
E_p = 250 v
$E_{c2,4}$ = 100 v
E_{c3} = − 2 v
I_p = 3.4 ma
$I_{c2,4}$ = 8 ma
g_c = 425 μmhos
R_p = .8 megohms
Basing 8-AD



Type 6AC7 (M)

R-f pentode; sharp cutoff; heater type; metal octal, 8 pins.

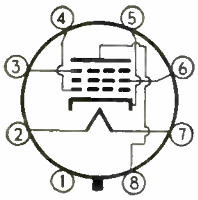
E_h = 6.3 v
I_h = .45 amp
g_m = 9000 μmhos
R_p = .75 megohms
μ = 6750
Basing 8-N



Type 6AB7 (M)

R-f pentode; remote cutoff; heater type; metal octal, 8 pins.

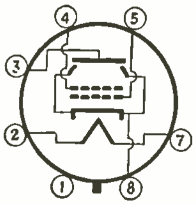
E_h = 6.3 v
I_h = .45 amp
g_m = 5000 μmhos
R_p = .7 megs
μ = 3500
Basing 8-N



Type 50L6 (GT)

BEAM power amplifier; heater type; bantam glass; octal base, 7 pins.

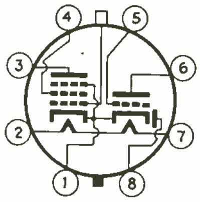
E_h = 50 v
I_h = .15 amp
E_p = 110 v (max)
E_{c2} = 110 v (max)
E_c = − 7.5 v
I_p = 49 ma
I_{c2} = 4 ma
g_m = 6800 μmhos
μ = 68
R_l = 2000 ohms
P_o = 1.75 (10%)
Basing 7-AC



Type 25D8 (GT)

DIODE; triode; pentode; remote cutoff; heater type; bantam glass; octal base, 8 pins.

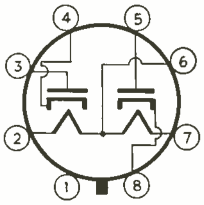
E_h = 25 v
I_h = .15 amp
TRIODE
g_m = 1100 μmhos
R_p = 91,000 ohms
PENTODE
g_m = 1900 μmhos
R_p = .2 megohms
Basing 8-AF



Type 25X6 (GT)

FULLWAVE rectifier-doubler; vacuum; heater type; bantam glass; octal base, 7 pins.

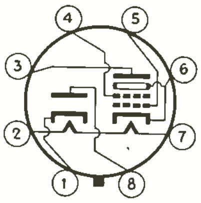
E_h = 25 v
I_h = .15 amp
*E_{ac} = 250 v per plate (max)
I_{dc} = 60 ma (max)
*With 100-ohm series resistors
Basing 7-Q



Type 70L7 (GT)

RECTIFIER-BEAM power amplifier; heater type; glass envelope; octal base, 8 pins.

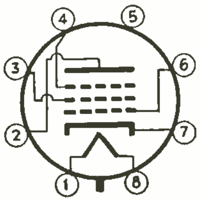
E_h = 70 v
I_h = .15 amp
BEAM POWER AMPLIFIER
g_m = 7500 μmhos
R_l = 2000 ohms
P_o = 1.8 watts (9.5%)
RECTIFIER
E_{ac} = 125 v (max)
I_{dc} = 70 ma (max)
Basing 8-AA



Type 7C7 (GL)

R-f pentode; sharp cutoff; heater type; glass loktal envelope base, 8 pins.

E_h = 7 v
I_h = .16 amp
E_p = 250 v (max)
E_{c2} = 100 v (max)
E_c = − 3 v
I_p = 2.0 ma
I_{c2} = 0.5 ma
g_m = 1300 μmhos
R_p = 2 megohms
Basing 8-V



THE ELECTRON ART

Among the subjects from the technical press reported here are an ignitron welding timer, cutoff-frequency calculation of resistance-coupled amplifiers, Orthacoustic recording and antennas for duplex operation

Welding Timer Control

An interesting article on welding timers appears in the December, 1939 issue of the *General Electric Review.* It is "Ignitron Contactor Control of Resistance Welding" by Warren C. Hutchins. The ignitron contactor is ideally suited for rapidly closing and opening primary circuits of resistance welders used for spot projection, and butt-welding or flash welding where the duration of current flow is short. Its advantages are quiet operation, low maintenance expense, freedom from shutdowns for repairs and dependability. Even in applications which do not require the precise control offered by synchronous timing, these contactors retain their inherent operating advantages.

The most undesirable instant for closing primary circuits of a resistant welder is at the zero point of the voltage wave, for this will result in maximum transient current. With an ignitron contactor, the circuit cannot be closed at this point because the voltage must be above certain minimum value before the tube will pass current.

The three essential parts of the ignitron contactor are a mercury pool (cathode) a carbon anode and an igniter, all inclosed in a sealed metal container. When the timing contacts are closed current passes through the igniter and ionizes the mercury vapor in less than 0.000003 second. The welding circuit is now closed because the ionized vapor easily conducts the heavy welding current through the tube and on to the welding machine. When the timing contacts open, current to the igniter stops. When the wave of the alternating current reaches zero, the vapor becomes deionized and the welding current stops until the timing mechanism again sends current to the igniter and repeats the cycle. In this way welding time as short as one-half cycle is possible. If the timing mechanism is set for longer welding, the prescribed cycle is repeated over and over. Throughout the operation the welding current is started and interrupted without noise and without moving parts. When used with an a-c supply, the ignitron tube will pass current in each half cycle that the voltage on the anode is positive. A second ignitron tube is inversely connected to pass current to the other half cycle.

Several available models of ignitron contactors are described and the ratings and water-cooling requirements are discussed.

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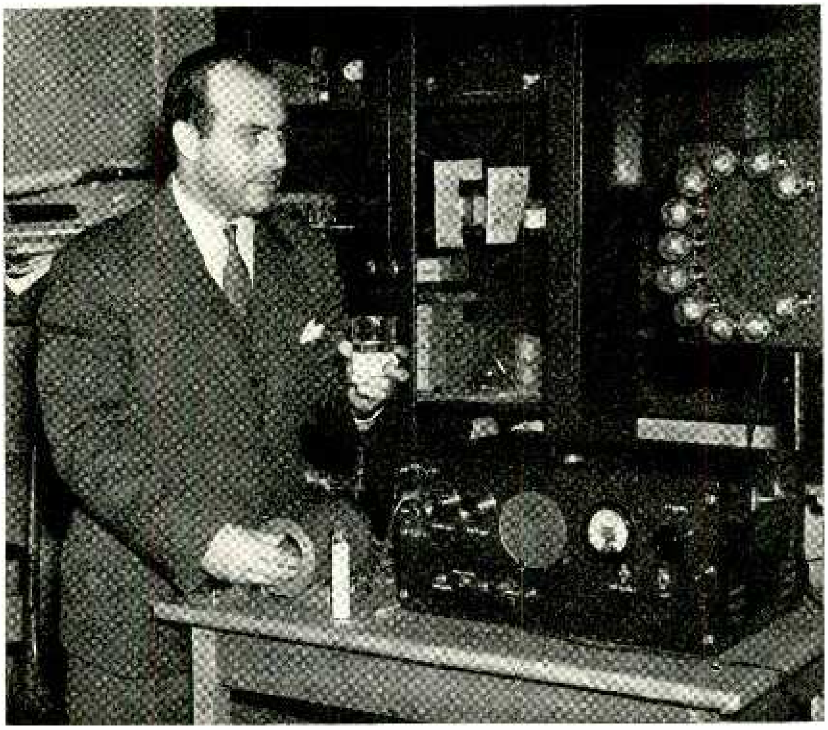
SHOWS HOW BODY MAY BECOME RADIOACTIVE



By means of the cyclotron a small amount of table salt was bombarded by neutrons until it was made artificially radioactive. By dissolving the salt in water and drinking the solution, Prof. John D. Dunning of Columbia University, was able to demonstrate that the radioactive solution could be traced through the human body.

Calculation of the Low Frequency Cut-off of Resistance-Coupled Amplifiers

A simple and straightforward treatment of the problem of low frequency limits of resistance-coupled amplifiers is contained in the July issue of *Funtechnische Monatschefte* in an article by Helmut Pitsch entitled, "The Calculation of the Low Frequency Limits of Resistance Coupled Amplifiers".

The method used depends on the relationship existing between the plate resistance and the coupling network of the following amplifying tube. The voltage u_a in Fig. 1 can be considered constant over the frequency range covered and not dependent on grid-input resistance. This voltage is fed into a resistance-capacitance net-work shown in Fig. 2 where the inherent 90° phase relationship of the voltages in the respective elements is shown by the diagram. The corresponding vector diagram is shown in Fig. 3.

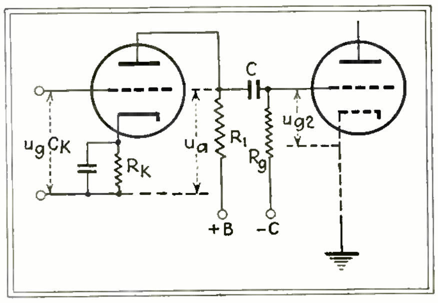


Fig. 1—Circuit diagram of the amplifier used in the calculation of the cutoff frequency

The point *P* moves along the arc of a semicircle, its position depending on the frequency imposed on *C* and its corresponding reactance at this given frequency. If the lowest frequency passed by the amplifier is limited to an attenuation of 30 per cent, the dotted vectors in Fig. 3 representing the lowest frequency passed are equal to 0.7 u_a. When the applied frequency is double the lowest frequency, the capacitive reactance is one-half the resistive value and the corresponding values of voltages u_c and u_{g2} are shown by the solid lines in Fig. 3. Under these conditions u_{g2} is 0.9 u_a.

At the low frequency limit of the amplifier, denoted by f_u,

$$R_g = 10^{12}/2\,\pi\, f_u\, C$$

and

$$f_u = 10^{12}/2\,\pi\, CR_g$$

For an input resistor of one megohm and a coupling condenser of 5000 $\mu\mu$f;

$$f_u = 10^{12}/2\,\pi\, 5000 \times 10^{6} = 32 \text{ cps.}$$

If it is desired that the limiting frequency strength be 0.9 instead of 0.7 of

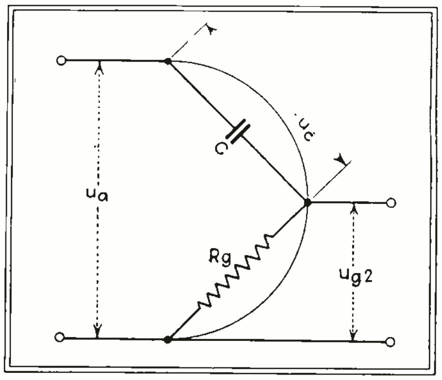


Fig. 2—Resistance-capacitance network with the inherent 90° phase relationship of the voltages in the various elements indicated

the input voltage, i.e. the attenuation be reduced, then the coupling condenser must be doubled in value or 10,000 $\mu\mu$f.

The author proves the generality of his method by demonstrating that the anode resistance and internal resistance of the tube have a negligible effect on

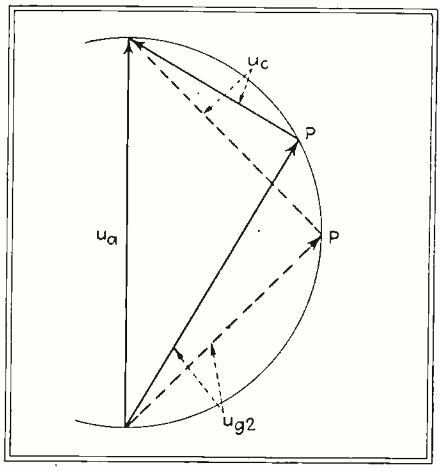


Fig. 3—Vector diagram of the network shown in Fig. 2

the results. He points out their effect is in general beneficial because they give rise to a somewhat smaller theoretical frequency range than is actually attainable from the equipment.

It is important to note that the cathode bypass network influences the lowest-frequency value and that in a pentode it is necessary to have a sufficiently large condenser as a bypass from screen-grid to ground. If this is not done, an opposing voltage is developed on the screen-grid which increases with the screen-grid resistance and inversely with the capacity. If the condenser is omitted, this voltage will exist for all frequencies.

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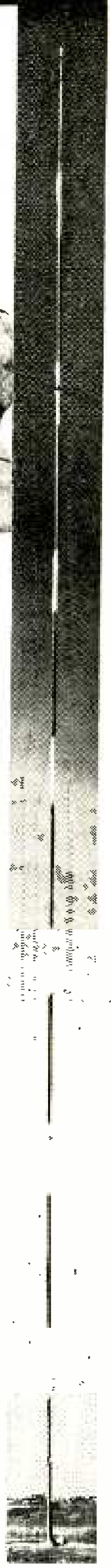
Orthacoustic Recording

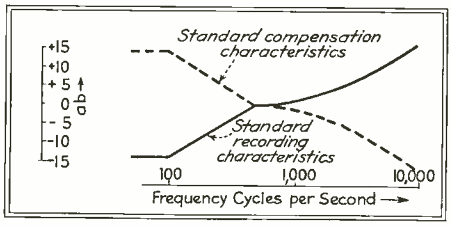
In the December 1939 issue of the Association of Technical Employees' Journal, Robert M. Morris describes the new RCA-NBC Orthacoustic Recording System. Up to this time there has been no means of calibrating playback turntables, and the Orthacoustic recording system provides this in a standard method by which the maximum amount of quality may be obtained from a transcription. The recording characteristics of the Orthacoustic system are given in the diagram along with the characteristic of the reproducing unit to give the desired quality of reproduction. Consideration which enters into the development of these characteristics are: (1)

NEON SIGNS ON BLIMPS

Detail of the neon signs on the blimps which have flown over various cities on the Atlantic Coast last summer. Ten units are attached to the side of the ship, each unit of which can be lighted to form any letter or numeral. By means of a punched tape strip, prepared by the ground crew, any word of ten letters or less can be produced by the neon signs to spell out any desired message for advertising or publicity purposes. Here the individual letter panels are being attached to the side of the blimp by the ground crew



Desire for a minimum background noise and maximum signal to noise ratio; (2) desire for a minimum of distortion particularly in the high frequency; (3) the necessity for recognizing previous standards; (4) a desire



Recording and reproducing (dotted line) characteristics of the Orthacoustic system

to achieve the recording and compensating characteristics as simply and economically as possible; (5) a desire to employ engineering information gathered in the development of other arts to the improvement of recording.

It is to be emphasized that the reproducer is as important to the quality of the results achieved as any other single element in the system. Accordingly, a reproducer of a quality in keeping with the rest of the broadcast station equipment is necessary if good results are to be achieved. A reproducer must therefore be light in pres-

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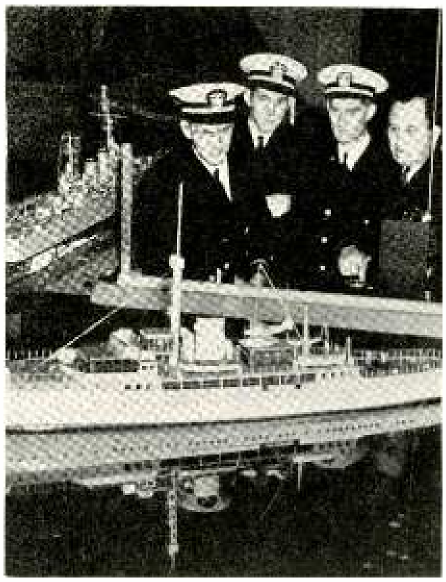
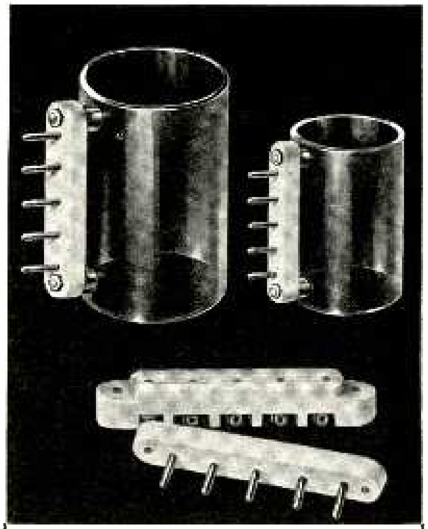
DEMONSTRATE RADIO CONTROLLED SHIP



Howard Maroon demonstrates control by radio of the model of the motor ship North Star during a demonstration at the marine transportation section of the Franklin Institute. The five foot model is steered around the tank by the use of a telephone dial which sends short impulses to a selector mechanism whose purpose is to properly actuate the ship's operations



sure on the disk (not exceeding 2 oz). Otherwise, the high frequencies will not be reproduced, especially near the center of the record. The frequency response of the reproducer should be flat to 7,000 or 8,000 cps. The mechanical impedance of the reproducer stylus must be low. An important factor in the life of the disk is pressure of the playback stylus. As previously mentioned the pressure should not exceed 2 oz and a desirable value is about 1.5 oz.

The author discusses filter circuits with which this characteristic may be obtained and how conventional transcription may be reproduced on the same equipment by simple switching.

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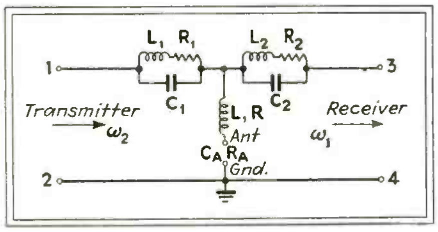
Antennas for Duplex Operation

SIMULTANEOUS TRANSMISSION and reception of signals on a single antenna is described in an article by Geoffrey Builder, entitled "Duplex Operation on a Single Aerial," in the A.W.A. (Australia) Technical Review, Vol. 4, No. 3, which was issued on Nov. 17, 1939. Duplex operation on a single antenna is often useful, particularly in locations so limited that it is difficult or uneconomical to erect more than one satisfactory antenna. For example, an automobile fitted for duplex operation can rarely carry two satisfactory antennas for high frequency reception and transmission, especially in the frequency range from 1.5 to 5 megacycles.

The author gives the several requirements which must be fulfilled by a single duplex antenna system. They are as follows: (1) Adequate filtering must be provided to prevent transmitter energy causing interference in the receiver. (2) Any considerable loss of transmitter power must be avoided. (3) A loss of received signal energy must be avoided as far as possible, or as far as may be necessary, to insure that the weakest received signals are sufficient to override interference and internal receiver noise.



Basic circuit for the duplex operation of a single antenna

The circumstances requiring the use of a common antenna for transmission and reception also generally restrict the size of the antenna which can be used. Therefore, the author considers in some detail antennas which are very short compared with the operating wave length. The design data for the short antenna is generally applicable to longer antennas for which the design is generally simpler. The basic circuit for duplex operation on a single antenna is shown in the figure. The lefthand branch circuit $L_1C_1R_1$, LR and C_AR_A is resonant at the transmitting frequency, the righthand branch $L_2C_2R_2$, C_AR_A and LR is resonant at the receiving frequency, and the two circuits are anti-resonant to the receiving and transmitting frequencies ω_1 and ω_2, respectively. The various factors involved in the design of such an antenna are discussed, together with the network losses and discrimination. The practical application and methods of adjusting such networks are also described.

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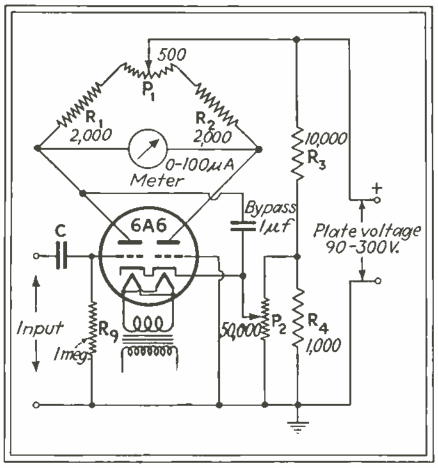
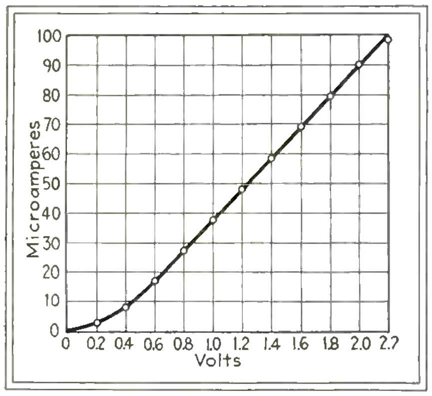
Vacuum Tube Voltmeter

A BRIDGE TYPE OF VACUUM tube voltmeter employing two triodes in a Wheatstone bridge has several advantages over the single tube bridge voltmeter and the ordinary vacuum tube voltmeter. Such a device is described in "A Duo-Triode Bridge Voltmeter," by Richard E. Vollrath, in the December, 1939, issue of the *Review of Scientific Instruments*. As shown in the circuit diagram, the two triode units are connected to form two branches of a Wheatstone bridge, while the other two branchs are formed by resistors. Because of variations in tube characteristics, the potentiometer P_1 is provided so that the resistance ratio of the upper branches of the bridge can be made equal to the ratio of the plate resistances of the corresponding triode elements. Grid bias is obtained from the voltage divider across the power supply. The calibration curve shown here was obtained with a voltage of 120 volts on the plate of the 6A6. The voltmeter was used for frequencies of 50 and 1,000 cps, for which the calibration curves were identical. While no tests were made at higher frequencies, there is no reason to suspect that this voltmeter should behave any differently than other vacuum tube voltmeters. No



Circuit Diagram of the double-triode vacuum tube voltmeter



Vacuum tube voltmeter calibraton curve

significant change of calibration was noted after two months of constant use. If this instrument is to be used for direct voltages the condenser *C* at the input should be shorted out.

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DuMont Proposals

(*Continued from page 23*)

number of lines is increased from, say, 441 to 735, is a change in the size of the picture which may be corrected by manual adjustment of the width and height controls. The type of synchronizing pulse proposed for this purpose is shown in the accompanying sketch. It consists of a number of 500 kc sine waves, from 160 to 240 waves being included during the vertical pulse. At the receiver, this 500-kc signal is separated from the rest of the wave by a sharply tuned circuit and the output of the circuit is integrated to form the vertical synchronizing pulse which is applied to control the vertical scanning generator. The horizontal synchronization impulses remain the same as those standardized by the R.M.A. and they are separated in the conventional manner.

It was shown at the demonstration that the proposed video signal shown in the diagram was capable of synchronizing a standard R.C.A. receiver designed for the R.M.A. signal, and this fact was offered as evidence that the proposed signal could be used in place of the R.M.A. signal without affecting the usefulness of the equipment now in the hands of the public. Further it was shown that standard receivers were capable of following changes in number of lines and number of frames per second, with the new signal, provided that the oscillation range of the scanning generators was sufficiently wide to accommodate the new frequencies. The demonstration showed that considerably more flexibility might be obtained in transmission standards than had formerly been generally admitted. The question remaining was the degree to which such flexibility might properly be made a part of a public service. This matter, it was agreed, is one requiring considerable study and test before judgment on the proposal may be passed.

The demonstration was one of the most complete ever offered in the television field, and it was attended by practically all of the engineers who have an executive capacity in television development at present. The N.B.C. transmitter in the Empire State Building cooperated by sending images on the standard R.M.A. system so that they might be compared directly with the same subject transmitted on 625 lines at 15 frames per second. A 20-inch cathode ray tube, producing a picture about 12 by 16 inches in size was demonstrated using the standard R.M.A. system, to show the desirability of having a larger number of lines in large pictures. A film short subject was broadcast by N.B.C. and shown on a 8-by-10 inch screen, next to which the same film was projected at the same size directly from a motion picture projector. This direct comparison of the original and the televised reproduction showed the loss of detail, and it showed also a considerable degradation in the contrast range of the television image, which seemed equally important. Many of the spectators expressed the feeling, however, that the television system was doing a remarkably good job when subjected to such a critical test. The demonstration concluded with a field test of the proposed system, using the DuMont transmitter W2XVT and receiver located at Mr. DuMont's home, some 6 miles distant. These tests showed that the laboratory demonstration could be duplicated readily under service conditions.

What action may be taken in regard to the proposals has not yet been indicated by the F.C.C., presumably because no definite report has yet been rendered by the Committee which viewed the demonstration—D.G.F.

THE INDUSTRY IN REVIEW

Automatic Curve Tracer

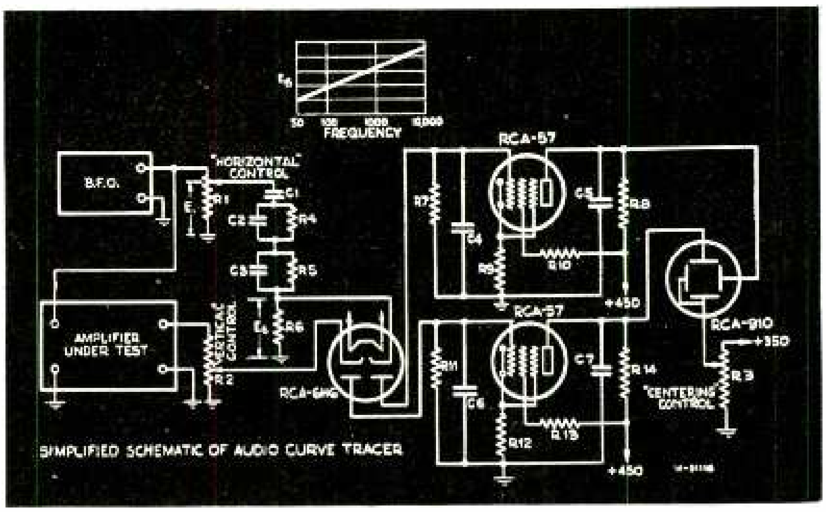


Fig. 1—Circuit diagram of the automatic curve tracer. The rectified input and output of the amplifier are fed into the deflecting plates of an oscilloscope

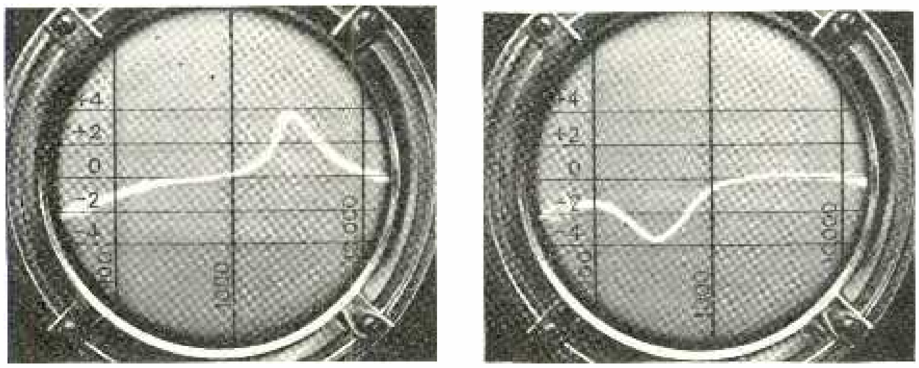
THE frequency response characteristics of audio amplifiers and the effects of various amplifier circuit adjustments may now be more easily and conveniently observed through the use of an automatic curve tracer developed by the Photophone Service Division of the RCA Mfg., Co., Camden, N. J. When used in conjunction with an audio oscillator or other signal generating device, this instrument traces the response curve of the amplifier under test on the screen of an RCA 910 cathode ray tube. The intensity and duration of the visible trace are sufficient to permit several curves to be superimposed on the screen for comparison or photographing.

The source of audio signal is fed into a discriminating network, shown in Fig. 1 as $C1$, $C2$, $C3$, $R4$, $R5$, and $R6$. The characteristics of this network are such, that with a constant voltage $E1$ impressed across the network, the voltage developed across $R6$ varies directly as the logarithm of the frequency impressed. This is shown in the small curve in Fig. 1. The voltage $E6$ is impressed across the diode section of the 6H6 tube and is rectified. This rectified signal is amplified and impressed across the horizontal plates of the RCA 910 cathode ray tube. The effect of this voltage on the electron beam is to move the beam from left to right across the screen as the frequency of the audio source is increased from zero upward thruout the audio range.

By rectifying and amplifying the output signal from the amplifier under test and impressing this d-c voltage across the vertical plates of the cathode ray tube, the beam is deflected vertically in accordance with the output level at the particular frequency under observation. The combination of the two deflection voltages results in the audio frequency curve of the amplifier being traced on the screen as the audio signal is varied thruout the audio range. Because of the long persistence characteristics of the 910 screen, the trace is held long enough for observation or photographing. A two-stage amplifier is also incorporated in the instrument so that the low level output of a soundhead as used in theatre sound reproducing equipments can be amplified and used as the signal generator. A continuously variable frequency test film being run through the soundhead acts as a source of signal.

The instrument is completely a-c operated, portable, and self-contained. It is particularly useful in making production and service tests on audio frequency amplifiers.

A celluloid scale is used in front of the cathode-ray tube screen to indicate db level and frequency; the horizontal lines being in steps of 2 db, and the vertical lines 100, 1,000, and 10,000 cycles.



Figs. 2 and 3—Typical frequency response curves traced by this apparatus. The screen has a long persistence characteristic suitable for observation and photography

News

✦ Jensen Radio Mfg. Co., Chicago, Ill., announced several organizational changes. W. E. Maxson becomes President and General Manager. Hugh S. Knowles and Thomas A. White have been elected Vice-Presidents while continuing as Chief Engineer and Sales Manager, respectively. A. Leslie Oliver, is now Chairman of the Board of Directors. Peter L. Jensen, former President and Chairman has resigned the position. All of the men appointed to fill new positions have been with the corporation practically since its inception . . . Tinnerman Stove & Range Co., Cleveland, Ohio, has found it necessary to discontinue the manufacture of stoves and ranges due to the growth of the Speed Nut Division of the company. Tinnerman Products, Inc., is now the new name of the company which will be devoted to the manufacture of Speed Nuts and Speed Clips . . . Heyer Products Co., Inc., manufacturers of battery chargers, testers, etc., are now located in their new plant at 471 Cortlandt St., Belleville, N. J. . . . The sale and manufacture of Cinaudagraph loud speakers have been transferred to a new company known as the United Teletone Corp., which is managed by I. A. Mitchell and S. L. Baraf of United Transformer Corp. . . . Transducer Laboratories announces that it has assumed all the manufacturing and experimental facilities of Transducer Corp. New experimental work will be done in the electro-acoustic and allied fields. Transducer Labs, under the direction of B. Eisenberg, are located at 42 West 48th St., New York City . . . Ansley Radio Corp., New York City, is now making its own radio chassis under a license from RCA and Hazeltine . . . Ernest J. Adams has recently been appointed Vice President and General Manager of Ansley Radio Corp . . . William Brand and Company, 268 Fourth Ave., New York City, announced the establishment of its own manufacturing plant, located at Willimantic, Conn.

Thomas A. White, Vice President, Jensen Radio

The company will continue to manufacture saturated sleeving and flexible tubing known under the trade name of "Turbo" . . . Radio Club of America, founded in 1909, has elected officers for the year 1940 as follows: President, Keith Henney; Vice President, John L. Callahan; Recording Secretary, Carl Goudy; Corresponding Secretary, C. E. Dean; and Treasurer, J. J. Stantley . . . Finch Telecommunications, Inc., have leased, under a long time contract, a 3 story building at 4th and Virginia Sts., Passaic, N. J. for the manufacture of facsimile equipment for broadcasters, aviation, police, industrial and shipping use . . . George S. De Sousa, Treasurer of Radio Corp. of America, was recently elected Vice President and Treasurer . . . William Miller Corp., have moved to 362 W. Colorado St., Pasadena, Cal. . . . Dr. William A. Mudge has joined the staff of the Technical Service Div., of International Nickel Co., Inc., New York City . . . A competition for the design of an ideal building in which to house a 1,000 watt radio broadcasting transmitter has been launched by the Beaux Arts Institute of Design. It is open to students of all architectural schools and ateliers in the country. Announced purpose of the competition, which is sponsored by the Western Electric Company, is the stimulation

Hugh S. Knowles, Vice President, Jensen Radio

of interest in the design of specialized structures for radio broadcasting purposes. By offering three cash prizes of $250, $100 and $50, the sponsor hopes to attract the best undergraduate talent and plans to make the final designs available generally to the broadcasting industry. The competition opened on January 8th and the prize winners will be announced on May 15th. . . . Mr. George A. Scoville, Vice President and General Manager, of the Stromberg-Carlson Telephone Mfg. Co., died in Rochester, N. Y. recently. He was a member of the A.I.E.E. and of the Rochester Engineering Society and had been active in industry associations . . . C. R. Cox, formerly of Bell

& Howell Co., Chicago, is now Chief Engineer with Victor J. Andrew Co. . . . W. A. Wolff has been appointed Information Manager of Western Electric Co. and its subsidiary Electrical Research Products, Inc. . . . Utah Radio Products, Chicago, announces the association of Peter L. Jensen as Vice-President of the company. Mr. Jensen is an old timer in loud speaker history and comes to Utah with a long background of engineering, sales and executive experience.

Literature

Television Receivers. Two recent issues of "Research Worker" are devoted to a description of television receivers by the Engineering Dept. of Aerovox Corp., New Bedford, Mass.

1939–40 Catalog. Condensers, dials, flexible couplings, tuned exciter tanks, coil forms, relays, transformers, antenna devices, etc., are described and illustrated in a catalog issued by James Millen Mfg. Co., Inc., 150 Exchange St., Malden, Mass.

Synchronous Motors. Catalog MI-5 contains diagrams and descriptions of Telechron self-starting synchronous motors and instrument movements. Available from Warren Telechron Co., Ashland, Mass.

Testing Instrument. "Vibrotest" insulation testing instrument, Model 201, a-c and d-c voltmeter, megohmmeter, ohmmeter, is described in a 6-page leaflet issued by Associated Research, Inc., 16 N. May St., Chicago.

Coil Winder Driver. Model 210 coil winder driver is described in a bulletin available from Ideal Commutator Dresser Co., Sycamore, Ill.

Technical Journal. Associated Electric Labs, Inc., 1033 W. Van Buren St., Chicago, issue a journal called "The Strowger Technical Journal". A recent issue contains the following articles: "Voice Frequency Dialing for Toll Circuits", "Transmission Characteristics of Types 40 and 50 Monophones", and "Automatic Network in Aquila Province". The journal is published in the interest of progress in communication engineering.

Disc Record Noise Reduction. "Brush Strokes", a house organ, of The Brush Development Co., 3322 Perkins Ave., Cleveland, devotes a complete issue on the subject of noise reduction in disc records through constant amplitude recording.

Weld Recorder. General Electric Co., (Schenectady, N. Y.) Bulletin GEA-3313 describes a weld recorder that records the character of the electrical input for every weld, as compared with allowable limits.

Capacitors. Catalog 10, a 33-page booklet, gives full information on capacitors for radio and television products manufactured from Solar Mfg. Corp., Bayonne, N. J.

Portable Vacuum Pumps. Bulletin 73 describes portable vacuum pumps for laboratory and test work. Beach Russ Co., 50 Church St., New York City.

Capacitor Manual. A 1939–40, Edition No. 1, of the Capacitor Manual for Radio Servicing is now available from Cornell-Dubilier Electric Corp., S. Plainfield, N. J. The manual is paper bound and contains 256 pages.

Vinylite Resins. An article on "Versatile Vinylite Resins" is contained in the recent issue of "Bakelite Review" a house organ of Bakelite Corp., 247 Park Ave., New York City.

GR Experimenter. Two recent issues contain the following articles of interest to our readers. "Network Testing with Square Waves", "A Broadcast Frequency Monitor for the 20-cycle Rule" and "One Cps from the Inverse Feedback Oscillator". General Radio Co., Cambridge A, Mass.

Resistance Handbook. A beautifully bound and well edited 108-page handbook of resistance alloys for engineers in radio, electrical, automotive, mechanical and chemical industries, is available from Wilbur B. Driver Co., Newark, N. J.

Transformer Encyclopedia. A new replacement transformer encyclopedia and service guide, No. 352-E, has been published by Thordarson Electric Mfg. Co., 500 W. Huron St., Chicago.

Microphones. Three new handy accessories to make microphones easier to handle are described in a bulletin available from Shure Bros., 225 W. Huron St., Chicago.

Elastic Stop Nuts. Twelve new types of elastic stop nuts are described in sheets available from Elastic Stop Nut Corp., 1001 Newark Ave., Elizabeth, N. J.

Rheostats. Catalog R contains a description and illustrations of rheostats manufactured by Rex Rheostat Co., 37 West 20th St., New York City. Diagrams of connections are also included.

New Products

Photoelectric Relay

A NEW COMPACT photoelectric relay for counting, sorting, weighing, measuring, signalling, and other similar functions, has been announced by the Westinghouse E. & M. Co.

This device (the RQ Photo-Troller) is especially designed for low operating expense, low initial cost, and ease of installation. It has two normally open and two normally closed contacts, each rated at 10 amps. on 115 volt a-c circuits. It operates on a change of 40 ft. candles, if not more than 15 ft. candles of extran-

eous light is present. Increased sensitivity is obtainable by means of a condensing lens. The unit may be wall or bench mounted with open wiring, or with concealed or exposed conduit.

H-F Radio Chassis

THE ANSLEY RADIO CORP., 4377 Bronx Blvd., New York City, announces two new high fidelity radio chasses in their Dynaphone combinations. One covers the broadcast band only, while the other covers three wave bands. Both use variable selectivity to adapt the set to local conditions. Both are made in a-c or a-c and d-c types. The a-c amplifier uses triode tubes with 2A3's in push-pull in the output. A fixed bias arrangement gives approximately 15 watts output with low distortion. The a-c and d-c type uses four 25L6 tubes for an output of about 10 watts. A heavy high fidelity speaker is used.

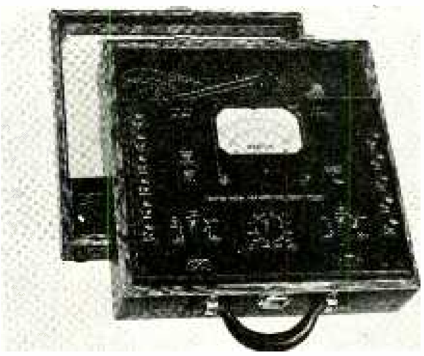
VU Meter

FOR BROADCAST MONITORING and use with public address systems, General Electric, Schenectady, N. Y., has produced a new VU volume-level indicator, Type DO-61, which meets the electric, dynamic, and mechanical specifications formulated as a result of the combined efforts of the N. B. C., C. B. S., and the Bell Telephone Laboratories. The new VU instrument was developed to eliminate the confusion caused by the great variety of volume indicators in use throughout the communications industry. Previously, it was impossible to correlate the results from the various types of instruments since they differed in so many characteristics. For description of the VU and the background for this instrument see *Electronics*, February, 1939.

The instrument is available either with or without internal scale illumination, for semiflush mounting and may be had with or without antiglare glass.

Circuit Tester

A NEW CIRCUIT TESTER, for use in individual measurements on all types of control and signal equipment, and electronic apparatus, has been announced by Weston Electrical Instrument Co., Newark, N. J. Known as Model 785, this circuit tester has 27 complete ranges for voltage, current and resistance measurements. Some of its applications include measuring photocell currents, cathode ray tubes, PA systems, electronic circuit values, etc. The sensitivity of the instrument permits voltage, current and resistance measurements on oscilloscope circuits.



The Model 785 circuit tester provides d-c voltage measurements at a sensitivity of 20,000 ohms per volt in ranges of 0-1, 0-10, 0-50, 0-200, 0-500 and 0-1000 volts; a-c voltage measurements at a sensitivity of 1,000 ohms per volt in ranges of 0-5, 0-15, 0-30, 0-150, 0-300, and 0-500 volts; d-c current measurements in ranges of 0-50 microamperes; 0-1, 0-10, 0-100 ma.; 0-1, and 0-10 amps; a-c current measurements (available through a self-contained current transformer) in ranges of 0-0.5, 0-1, 0-5, and 0-10 amps; and resistance measurements in ranges of 0-3000, 0-30,000, and 0-300,000 ohms; 0-3, and 0-30 megohms. Resistance measurements are obtained in conjunction with self-contained stock batteries. The instrument accuracy on direct voltage and current measurements is within 2%, excluding the 1000 volt range, which has an accuracy of 3%. Because of the new temperature-compensated rectifier circuit employed, an accuracy of 3% on alternating voltage is attained.

New GR Generators

General Radio Co., Cambridge, Mass., announce Type 804-A signal generator for use in testing radio receivers in the u-h-f range. The characteristics of the signal generator are: carrier frequencies from 7.5 to 320 Mc; output voltage range, 10 to 20 μv; direct reading in both frequency and output voltage; internal 400 cycle modulation up to 60% is provided (external modulation can also be used); a voltage-regulated a-c power supply is included. Modulation percentage and carrier level are indicated directly on easily-read, fan-shaped meters on the panel.

Type 769-A square-wave generator can be used to determine the frequency response, particularly under transient conditions, of amplifiers and other networks. This generator is particularly useful for measuring the low-frequency response of television systems.

The output voltage can be obtained either unbalanced or balanced to ground. The plate-to-plate output voltage is 150 volts balanced, 75 volts unbalanced. Minimum output voltage is 10 microvolts. Output impedance is 500 ohms balanced, 250 ohms unbalanced. The impedance is independent of frequency down to d-c.

Square waves with fundamentals from 10 to 5000 cycles per second can be produced. The output circuit will pass frequencies between 0.1 cycle and 250,000 cycles.

The waveform is very close to a true rectangular shape. At low frequencies, the entire rise in voltage takes place in 0.001 cycle.

Reproducing Needle

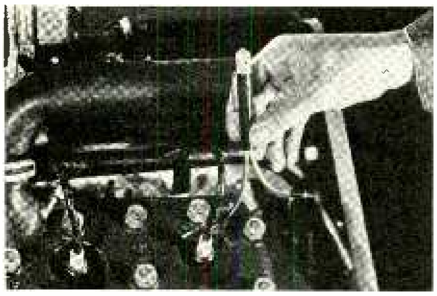
Permo Products Corp., 6415 Ravenswood Ave., Chicago, offer an improved, high fidelity, transcription type, play-back phonograph needle. The Permo alloy forming the tip of the needle is produced under 5000° heat, and after careful processing and inspection under microscopes throughout production, is made into pellets which are welded to specially drawn and tempered shank material. The shape of the conical tip section is compressed in rotary swage dies to give good transmission of h-f without adding mass. Special characteristics are: a lubricating action which does not wear nitrate or commercially pressed records and long life without distortion.

U-H-F Receiver

RADIO Manufacturing Engineers, Peoria, Ill., announce Model HF-30X which is an 11-tube superhet receiver providing precision reception of signals located in the u-h-f range 27.8 to 41.5 and 40.8 to 60.3 Mc. The unit is complete and compact. A 4-page descriptive folder which includes a circuit diagram is available.

Circuit Tester

A SAFE, CONVENIENT tester and polarity indicator for electrical and radio circuits from 80 to 550 volts, ac or dc, called "Saftest" has been introduced by M. M. Fleron & Sons, Inc., of Trenton, N. J. This device makes obsolete the pigtail socket and lamp method of finding open or dead circuits; and there is no need to change to higher voltage bulbs when testing up to 550 volts. The neon indicator bulb is enclosed in a Bakelite polystyrene housing, water-white in color, clear, and non-fragile. The test lead tips are fully insulated and the indicator bulb is protected against higher voltages with a special resistor.



Aerovox Products

BAKELITE-MOLDED mica condensers provided with handy meter-mounting brackets, for the purpose of r-f shunting of meter windings, are announced by Aerovox Corp., New Bedford, Mass. Long slots in the brackets permit attachment to the terminals of any of the standard panel-mounting meters.

TWO ACCESSORIES for the L-C checker are also available from Aerovox: mounting brackets which serve to mount the checker on the test panel of the service shop, and 0.001 μfd mica condensers used in measuring inductance values with the L-C checker.

Mercury Switch

DURAKOOL METAL MERCURY Switch, and the "Double Reduction" are silent, unbreakable, and non-inflammable switches designed by Durakool, Inc., (Elkhart, Ind.) which use reducing agents to prevent deterioration of the

mercury and to increase efficiency and reliability in operation. The switches may be used for many applications from wall switching to motor starting or on devices requiring as many as 2400 contacts per minute.

Tube Tester

MODIFICATIONS IN the Model 9000 dynamic conductance tube tester permit accurate testing of the new 117 volt tubes as well as the newest single-ended loktals. This counter or portable tester permits simple testing with easy-reading tube chart indicating tester settings. It compensates line variation for the spread between 90 and 130 volts. Consolidated Wire and Assoc. Corp., 520 S. Peoria St., Chicago, are the manufacturers.

F-M I-F Units

F. W. SICKLES CO., Springfield, Mass., has developed an intermediate frequency unit for frequency modulation receivers; and a circuit with a list of component parts is available from which one may construct a complete receiver. Methods for alignment are given in the bulletin. The receiver employs 7 tubes, not including the power supply, has one r-f stage, two i-f stages, a converter, a limiter, a discriminator and a 6F6 amplifier. The overall gain in the i-f system is roughly 2700 times; it delivers 4.2 peak volts to the limiter grid, the i-f peaking at 3000 kc.

Condensers

TYPE J SILVER mica condensers are available from Erie Resistor Corp., Erie, Pa. These condensers measure 13/64 x 7/16 x 1 1/32 inch. Average temperature coefficient (20 to 80°) is $+.000025\mu\mu f/\mu\mu f/°C$. Maximum power factor at 1000 kc is less than .04%. The construction of Type J is similar to the smaller Erie Type K unit. They are made with capacities of from 15 to 1000 $\mu\mu f$. Good stability of these condensers make them ideal for use in tuned oscillator circuits where the LC product must be kept constant under all operating condition.

Cable-Type Transformer

A NEW HANDY, cable-type transformer to match 35-50 and 200-250 ohm low-impedance dynamic microphones (or lines) to a high impedance amplifier input is now offered by Shure Brothers, Chicago. This new A86A transformer may be located in any convenient place within 25 ft. of the amplifier.

Microphone

NEW HAND PHONES, known as Models 875 and 820, are replacing Fimer and Fimex microphones of Universal Microphone Co., Inglewood, Cal. These new models are just as adaptable for 5 meter transmitters and 5 meter receivers, and in addition are suitable for remote work, recording purposes, intercommunicating studios, and especially for amateurs who make car, boat or other mobile installations. Six ft. of 4 conductor cable accompanies each assembly.

Prefinished Bonded Metals

TWO NEW PRODUCTS, Nickel Aluminum and Chrome Aluminum, are being offered to the public for the first time by American Nickeloid Co., Peru, Ill. These two metals are formed by a surface of chromium or nickel bonded by an electrolytic process to an aluminum base metal, using the Krome Alume process patent. The two metals are available in sheets in sizes up to 36 x 96 ins., in a full range of tempers, and in gauges from 0.010 up to 0.064 ins. A choice of bright or satin finished and striped, crimped, or corrugated patterns adapts the new prefinished metals to many uses and designs.

High Current Tap Switch

MODEL 111, IS A new addition to the high current tap switches available from Ohmite Mfg. Co., 4835 Flourney St., Chicago. It is a multi-point, load-break, non-shorting, single-pole rotary selector particularly designed for a-c lines. Ratings are 5 amps at 120 volts and 3 amps at 240 volts. The switch has a maximum number of 11 taps.

Other New Products

RCA Mfg. Co., Camden, N. J., introduces a new "Long Life" needle capable of 1000 playings under normal conditions. It is packaged in a unique crystal-clear plastic package . . . A miniature instrument which combines the functions of an all-purpose meter with those of a trouble tracer, and yet requires little room in the kit, is the Model 456 of **Radio City Products** Co., 88 Park Place, New York City . . . **Andrea Radio** Corp., 48-20 48th Ave., Woodside, N. Y., has introduced a 12 inch tube television receiver with radio and with or without automatic phonograph accommodation.

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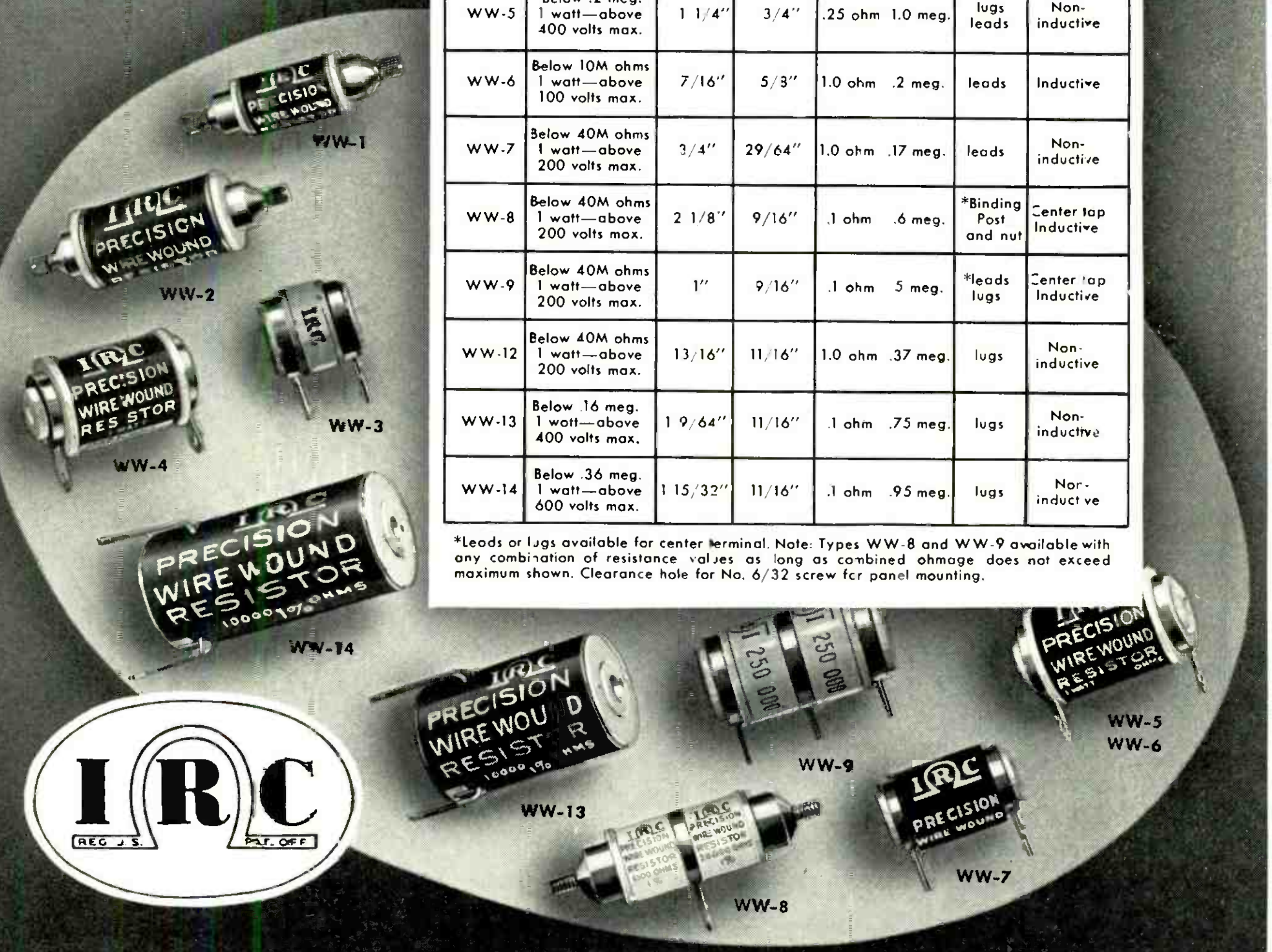
PRECISION WIRE WOUND RESISTOR SPECIFICATIONS

Type	Wattage	Length	Diameter	RANGE Minimum	RANGE Maximum	Terminal	Winding
WW-1	Below .36 meg. 1 watt—above 600 volts max.	2 1/8″	9/16″	.1 ohm	600,000 ohms	Binding Post and nut	Non-inductive
WW-2	Below 1 meg. 1 watt—above 1,000 volts max.	2 15/16″	7/8″	.5 meg.	2.5 meg.	Binding Post and nut	Non-inductive
WW-3	Below 40M ohms 1 watt—above 200 volts max.	9/16″	9/16″	1.0 ohm	150,000 ohms	lugs leads	Non-inductive
WW-4	Below .16 meg. 1 watt—above 400 volts max.	1″	9/16″	.1 ohm	600,000 ohms	lugs leads	Non-inductive
WW-5	Below .2 meg. 1 watt—above 400 volts max.	1 1/4″	3/4″	.25 ohm	1.0 meg.	lugs leads	Non-inductive
WW-6	Below 10M ohms 1 watt—above 100 volts max.	7/16″	5/3″	1.0 ohm	.2 meg.	leads	Inductive
WW-7	Below 40M ohms 1 watt—above 200 volts max.	3/4″	29/64″	1.0 ohm	.17 meg.	leads	Non-inductive
WW-8	Below 40M ohms 1 watt—above 200 volts max.	2 1/8″	9/16″	.1 ohm	.6 meg.	*Binding Post and nut	Center tap Inductive
WW-9	Below 40M ohms 1 watt—above 200 volts max.	1″	9/16″	.1 ohm	5 meg.	*leads lugs	Center tap Inductive
WW-12	Below 40M ohms 1 watt—above 200 volts max.	13/16″	11/16″	1.0 ohm	.37 meg.	lugs	Non-inductive
WW-13	Below .16 meg. 1 watt—above 400 volts max.	1 9/64″	11/16″	.1 ohm	.75 meg.	lugs	Non-inductive
WW-14	Below .36 meg. 1 watt—above 600 volts max.	1 15/32″	11/16″	.1 ohm	.95 meg.	lugs	Non-inductive

*Leads or lugs available for center terminal. Note: Types WW-8 and WW-9 available with any combination of resistance values as long as combined ohmage does not exceed maximum shown. Clearance hole for No. 6/32 screw for panel mounting.



PRECISION WIRE WOUND RESISTORS

INTERNATIONAL RESISTANCE COMPANY

403 NORTH BROAD ST. PHILADELPHIA, PENNA.