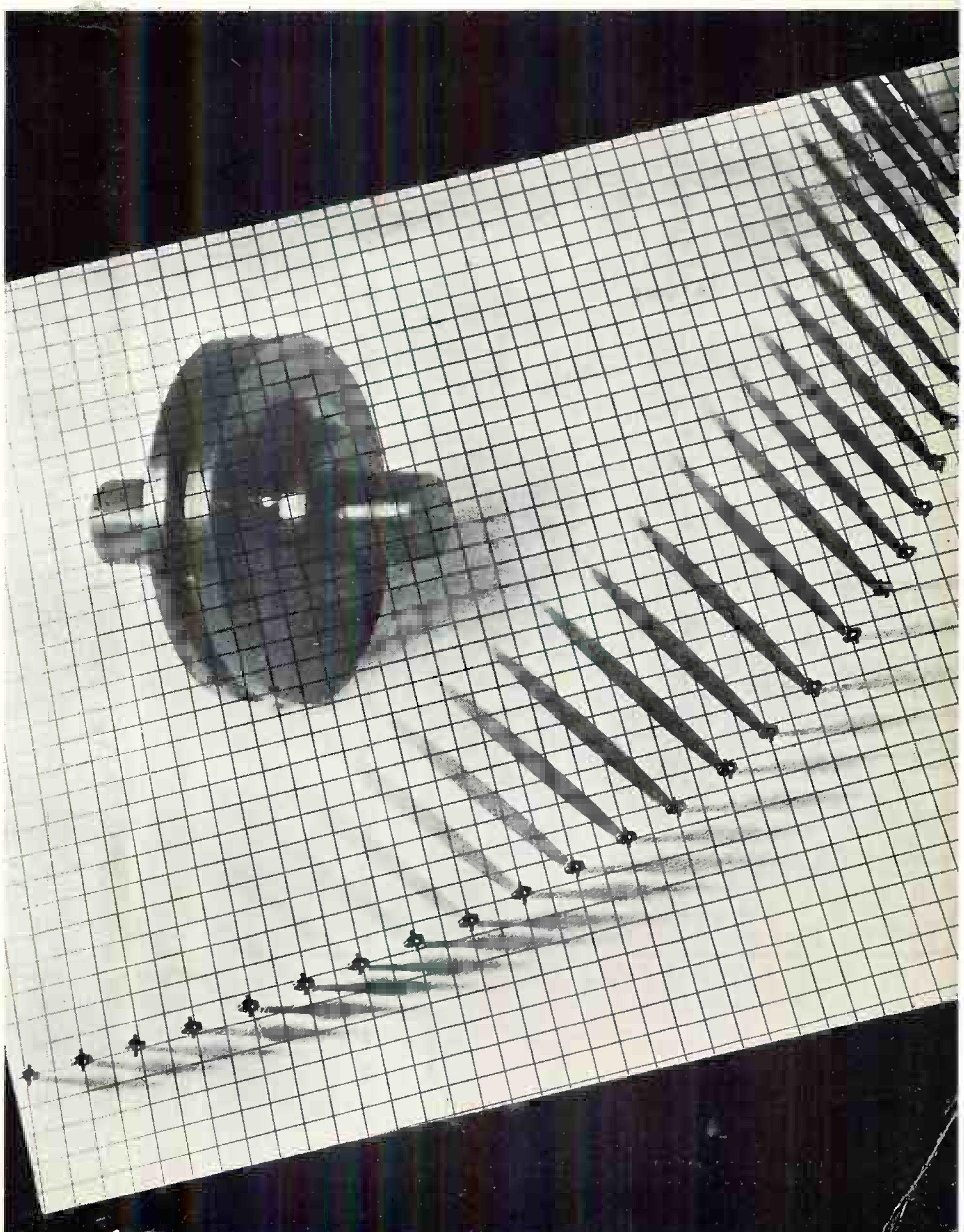
COMMUNICATIONS

including

TELEVISION ENGINEERING



MARCH 1939

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1 — 10 mfd.
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.001 — .01 mfd.
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MARCH 1939

COMMUNICATIONS

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VOLUME 19
NUMBER 3

RAY D. RETTENMEYER
Editor

•Editorial Comment•

JUDGE EUGENE O. SYKES of the Federal Communications Commission has tendered his resignation to President Roosevelt. Judge Sykes, who from the point of service is the oldest member of the Commission, first took office as Vice-Chairman of the old Federal Radio Commission in 1927. Well liked, it would seem that, if his resignation is accepted, the Commission stands to lose a valuable member.

A PLACE and date has been set for the annual convention of the National Association of Broadcasters. This gathering will be held at the Ambassador Hotel, Atlantic City, N. J., from July 10th through 13th. Among the problems which will be discussed by the Broadcasters at this meeting will be copyright and program standards. Further information will, of course, appear in later issues of COMMUNICATIONS.

IN line with the joint NAB-RMA radio campaign, discussed in our January editorial, the NAB have published two booklets to be distributed nationally: "The A B C of Radio" and "How to Use Radio in the Classroom". The first booklet has been presented to inform the radio listener of the workings of radio, while the second is expected to help educators adapt radio broadcasts to the classroom. Although it is not our usual practice to review books here, we believe these two are at least worthy of mention. There has been a distinct need for materials of this type, and we believe they should do much to further the aims of the campaign.

AS we pointed out in our January editorial, frequency modulation is assuming considerable importance. At the present time, two experimental stations are in operation and six are under construction. In addition, production will soon be started on receivers which will be capable of handling frequency-modulated as well as amplitude-modulated signals. While the full significance of frequency modulation cannot as yet be fully appreciated, it would seem to have a promising future.

•Contents•

COVER ILLUSTRATION

An interesting photo of a number of small wheels rolling up a calibration curve. Such wheels are used in the inductance-tuned oscillator described in the article on page 34.

Published Monthly by the
BRYAN DAVIS PUBLISHING CO., Inc.
19 East 47th Street
New York City
New York Telephone: PLaza 3-0483

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Entered as second class matter October 1, 1937, at the Post Office at New York, N. Y., under the act of March 3, 1879. Yearly subscription rate: $2.00 in the United States and Canada, $3.00 in foreign countries. Single copies: twenty-five cents in United States and Canada, thirty-five cents in foreign countries.

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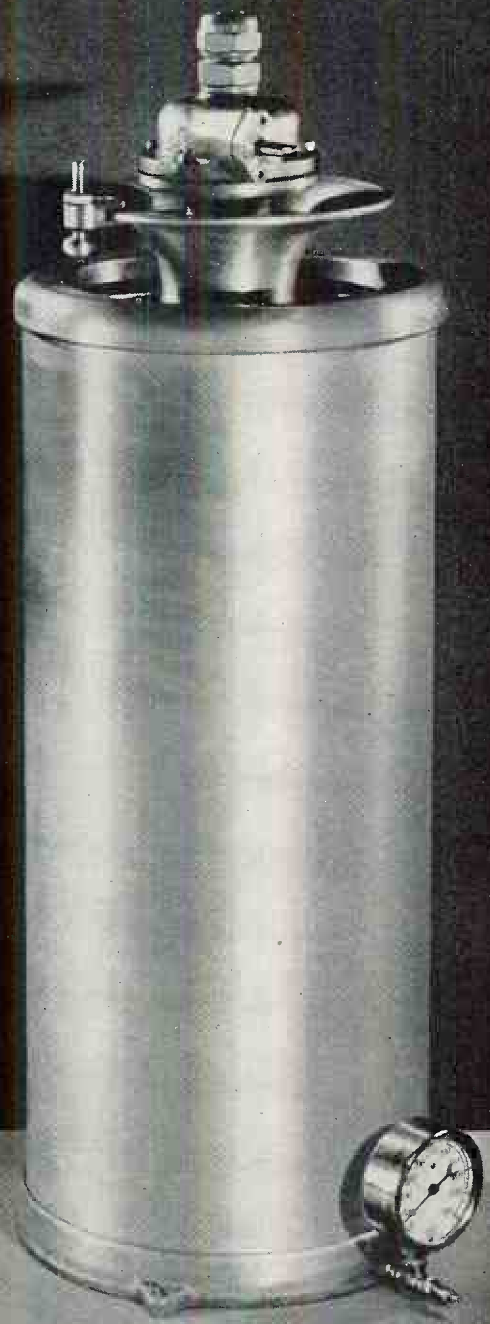
AS LONG AS YOU ARE ON THE AIR . . .

THIS LAPP CONDENSER WILL DELIVER UNIFORM PERFORMANCE . . .



There's no need for compensating adjustments while the condenser "warms up" when a Lapp Gas-Filled unit is on the job. Add these other real advantages: You get your full power into the antenna—a single porcelain bowl is the only loss-producing dielectric in the unit; you save space—the Lapp condenser packs into the same volume more capacitance for given voltage than any other condenser; you'll never have a blow-out—the Lapp condenser has no solid dielectric to puncture; you'll get month-in and month-out service without gas leak or cause for worry. And there you have the reasons why more and more engineers are replacing condensers in their circuits with Lapp Gas-Filled units—and are specifying Lapp condensers in new equipment. *Write for descriptive data.*

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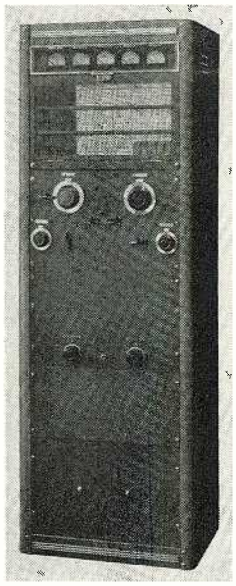
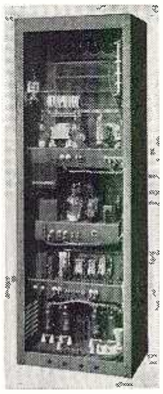
POINT-TO-POINT COMMUNICATIONS

—TWO NEW GATES TRANSMITTERS—





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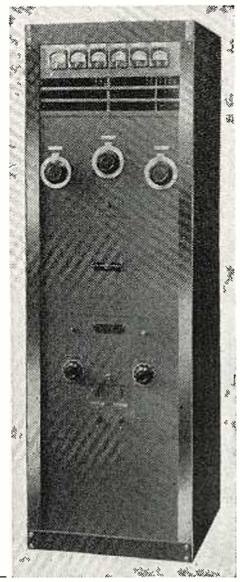
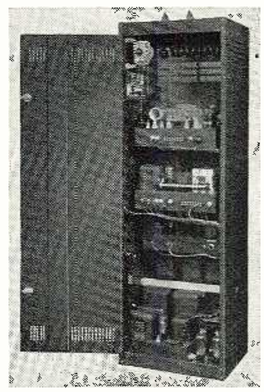
In medium power communications equipment the Gates American 350-CP offers continuous operation at 350* watts or intermittent operation at 500 watts fully voice modulated, high level and with the well known CM44 Peak Limiter adding to the modulated signal strength. The 350-CP may be had for any frequency or combination of frequencies up to 38 megacycles making it ideal for nearly every type of communications service whether it be ship-to-shore, airport, police or private. It may also be had for C. W. operation only at a proportionate reduced cost. Every part in this transmitter has been rigorously tested for its ability to stand up under all types of weather, humidity and to withstand certain abuse that might arise where emergency would demand greater power output by overloading.

The 1-A Transmitter pictured below is ideal for all general communications where 100* watts continuous or 200 watts intermittent service is desired. Fully high level voice modulated through the famous Gates CM44 peak limiting speech amplifier which adds more to the signal strength. The 1-A may be had for any frequency up to 38 megacycles, operating with complete freedom of carrier noise or distortion. The use of only the highest quality components assures top efficiency and elimination of break downs caused by humidity conditions. The 1-A is distinctly that type of equipment that can be operated 24 hours a day, year in and year out, with assured satisfaction.



GATES MODEL 1-A



**Power ratings are carrier power and not input power.*

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COMMUNICATIONS

FOR MARCH, 1939

Frequency Response Characteristic of Amplifiers

EMPLOYING NEGATIVE FEEDBACK

By FREDERICK EMMONS TERMAN & WEN-YAUN PAN

STANFORD UNIVERSITY

NEGATIVE FEEDBACK is widely used in audio amplifiers for reducing distortion, improving frequency response, minimizing hum, etc. It is not commonly realized, however, that although negative feedback will improve the frequency response in what is the normal range of the amplifier, it may at the same time introduce peaks of response at very high and very low frequencies that give rise to noticeable distortion, particularly when handling transients.

It is the purpose of the present paper to consider briefly the types of frequency response characteristics that can be expected when negative feedback is employed. This will be done by first considering qualitatively a number of crucial and somewhat idealized cases, and then presenting the mathematical analysis of the phenomena involved.

SINGLE-STAGE AMPLIFIER

In the absence of feedback, a single-stage resistance, impedance, or output-transformer coupled amplifier has a frequency response such as shown by *a* in Fig. 1, assuming the screen and cathode bypassing is adequate. A voltage amplifier with interstage transformer coupling is excepted from the cases discussed in this paper. For purposes of reference, the low and high frequencies at which the amplification has dropped to 70.7 percent of the mid-frequency amplification will be termed f_1 and f_2 respectively. If now feedback is introduced into such an amplifier by a resistance network, the resulting response curve will be given by *b, c,* or *d* in Fig. 1 with progressively increasing feedback. It will be noted that these new curves have exactly the same shape as *a* except that the 70.7 percent points have been shifted to higher and lower frequencies. *Consequently the introduction of feedback in a typical single-stage amplifier has the same effect upon the frequency response as though the stage were redesigned by conventional methods to have a flatter frequency response.* The factor by which the flatness of response is improved by feedback depends upon the feedback factor $A\beta$ and is

$$\left.\begin{array}{l}\text{Flatness factor pro-}\\ \text{duced by feedback}\\ \text{in a single-stage}\\ \text{amplifier}\end{array}\right\} = 1 - A\beta \qquad (1)$$

where A is the midrange amplification in the absence of feedback, and β is the fraction of the output voltage fed back (β is always negative). The significance of Eq. (1) is made clear by considering a specific case. Thus if $A\beta = -4$, the flatness factor is 5, which means that with feedback, the 70.7 percent response points at low

Calculated and experimental amplification characteristic for two-stage feedback amplifier.

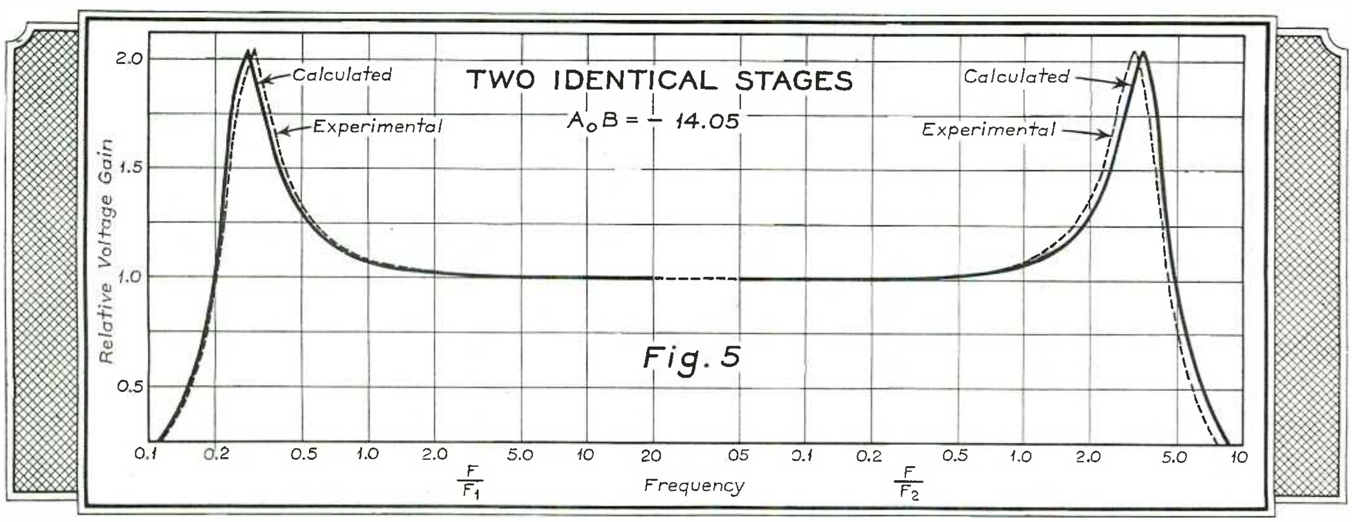
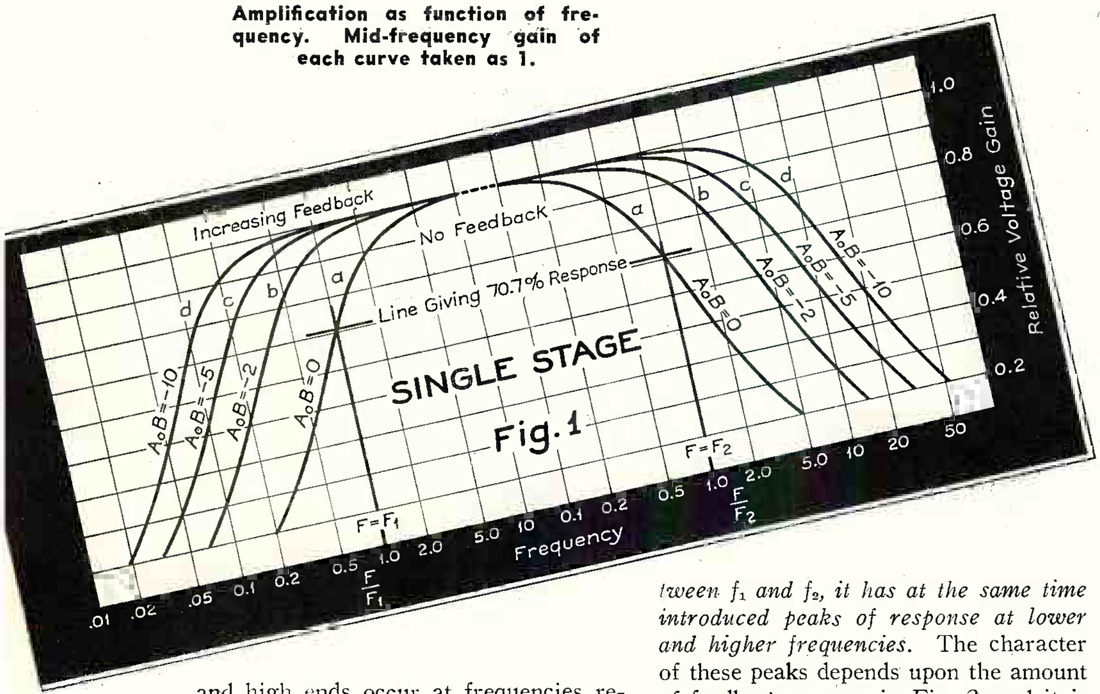


Fig. 5

Amplification as function of frequency. Mid-frequency gain of each curve taken as 1.



and high ends occur at frequencies respectively 1/5 and 5 times the corresponding frequencies for the amplifier without feedback.

TWO-STAGE AMPLIFIER

The frequency response of two identical amplifiers without feedback has the shape shown by *a* in Fig. 2, and is the product of two corresponding curves such as *a* in Fig. 1. If feedback is now introduced from the output of the second tube back to the input of the first tube by means of a resistance network, the frequency response takes the form shown by curves *b, c, d* and *e* of Fig. 2 as the amount of feedback is progressively increased. *It is seen that although the addition of feedback has flattened the response in the range between f_1 and f_2, it has at the same time introduced peaks of response at lower and higher frequencies.* The character of these peaks depends upon the amount of feedback as seen in Fig. 2, and it is apparent that the peaks are large and not far removed from the normal response range of the amplifier.

The peaks of response shown in Fig. 2 are caused by regeneration arising from the fact that at high and low frequencies there is sufficient phase shift in the amplifier to transform what is negative feedback in the mid-frequency range into what tends to be positive feedback.

Curves of phase shift are also given in Fig. 2. It is seen that although feedback reduces the phase shift and phase distortion in the range where the amplification characteristic is flat, the phase shift changes very rapidly with consequent large phase distortion at frequencies corresponding to the peaks of response.

In Fig. 2 the individual stages are identical. Very much the same result occurs however if one of the stages initially has a flatter response than does the other. This is illustrated in Fig. 3, which shows that although flattening one of the stages displaces the peaks farther away from the normal mid-range as might be expected, the peaks are still present.

THREE-STAGE AMPLIFIER

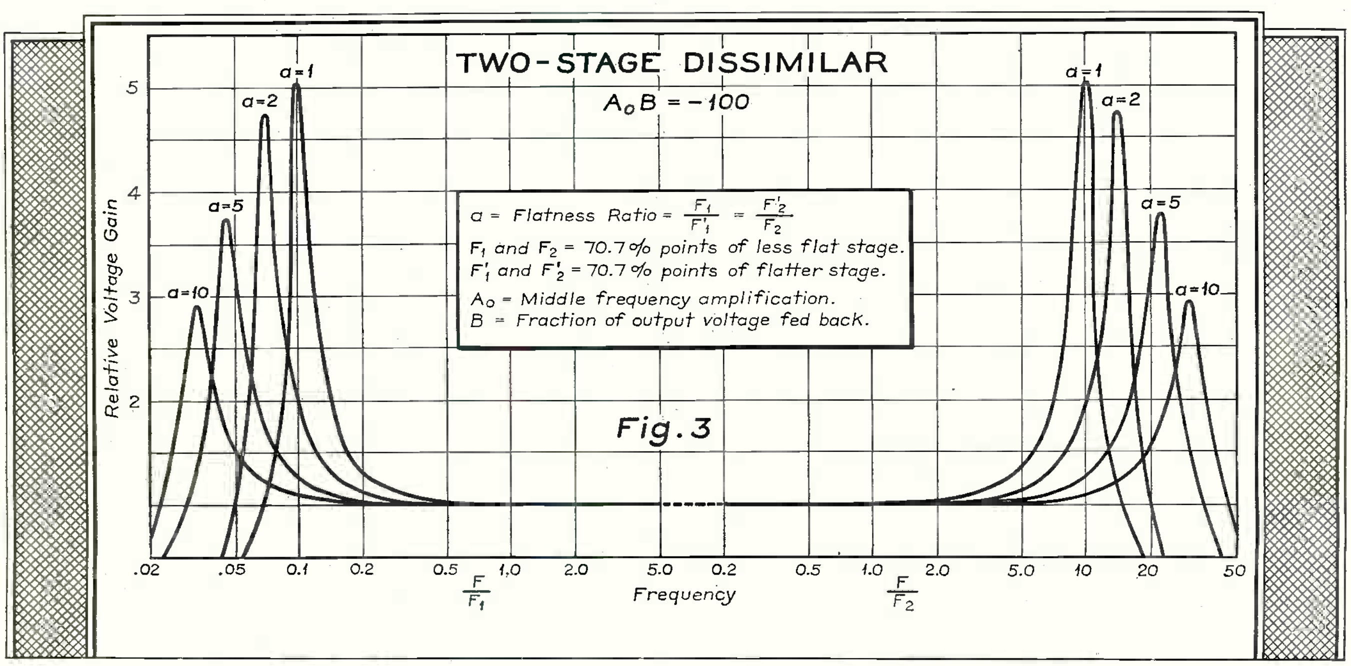
A three-stage amplifier employing feedback from the output of the final stage to the input of the first stage acts in much the same way as does a two-stage amplifier, although there are certain differences in detail. In particular a three-stage amplifier will always oscillate if the feedback exceeds a certain critical value, while a two-stage amplifier will not if adequate screen and cathode bypassing is used.

Although there are many combinations possible in a three-stage amplifier, the important practical case is when two stages are identical and the third stage is much flatter than the pair of identical stages, as this arrangement makes it possible to employ more feedback than if all of the stages were identical.[1] With such an arrangement the maximum allowable feedback factor $A_o\beta$ is given by the equation

$$\left.\begin{matrix}\text{Maximum allowable feedback factor } A_o\beta \text{ in three-} \\ \text{stage amplifier}\end{matrix}\right\} = \frac{2(n+1)^2}{n} \qquad (2)$$

[1]See F. E. Terman, "Feedback Amplifier Design," *Electronics*, Vol. 10, p. 12, Jan., 1937.

Amplification of two-stage feedback amplifier vs. frequency. Two stages dissimilar.



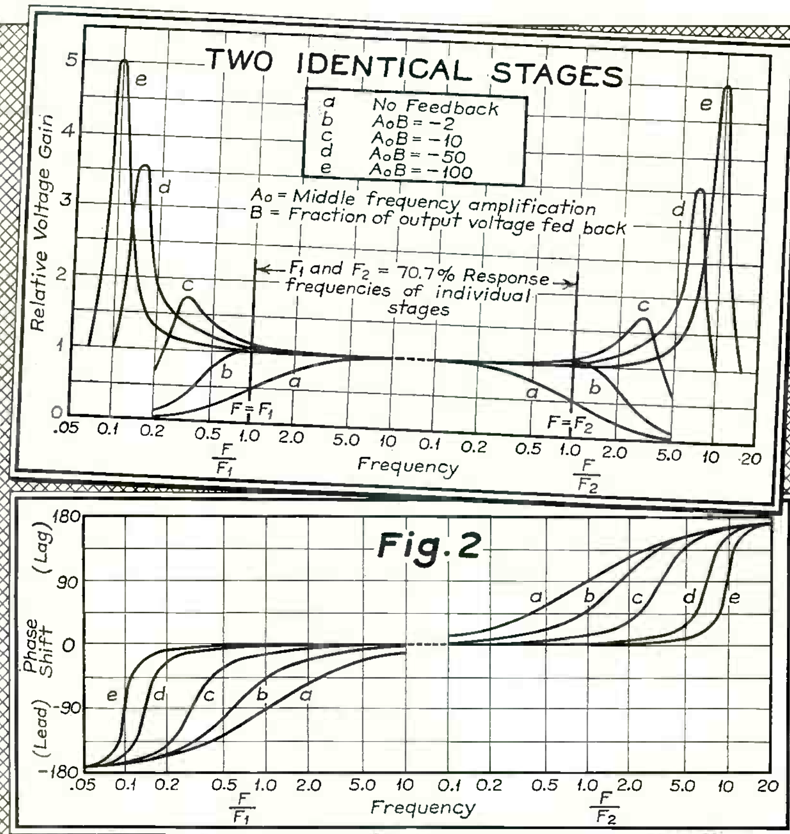


Fig. 2. Amplification and phase shift as a function of frequency for two-stage amplifier with various amounts of feedback. Mid-frequency gain of each curve taken as 1.

where A_o is the mid-frequency amplification of the entire amplifier in the absence of feedback, β is the fraction of the output voltage that is fed back, and n is the factor by which the flatness of the flat stages exceeds the flatness of the identical stages (i.e., if f_1 and f_2 are the 70.7 percent points at low and high frequencies for the identical stages, then the corresponding points for the flat stages are respectively f_1/n, and nf_2).

The frequency-response characteristics of a typical three-stage amplifier with various amounts of feedback up to the point where oscillation is approached are shown in Fig. 4 for two values of n. It will be noted that the peaks in the response become progressively more pronounced as the feedback approaches the amount given by Eq. (2), and that in general the peaks for a given amount of feedback are greater than with the two-stage amplifier.

CONCLUSION

It is seen from the preceding discussion that the reduction in distortion, and also the improvement in flatness of response in the middle-frequency range, that result from the use of negative feedback, are accompanied by peaks of response at high and low frequencies if the feedback takes place over two or more stages. It is only in the single-stage case that the use of feedback gives an effect equivalent to a simple flattening of the amplification characteristic. The peaks of response that are present when feedback takes place over more than one stage explain the peculiarities in quality sometimes observed when feedback amplifiers reproduce transients. If such troubles are to be avoided too much dependence must not be placed upon feedback to widen the frequency response. Rather, the response without feedback should be made as satisfactory as practicable, and then feedback introduced only to give a necessary final improvement.

While the discussion in this paper has been concerned only with audio amplifiers, peaks of similar character also occur at high frequencies in radio transmitters employing negative feedback.

(*Continued on page* 42)

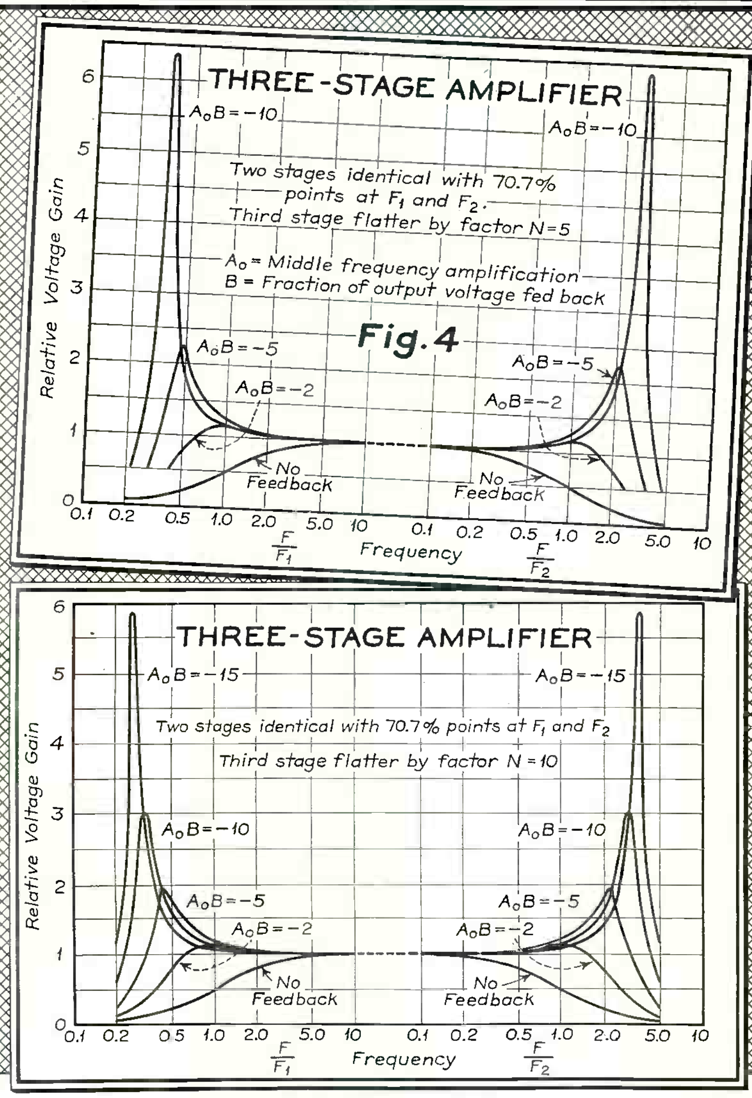


Fig. 4. Amplification as function of frequency for typical amplifier with various amounts of feedback. Mid-frequency gain for each curve taken as 1.

THE RADIO RECEIVER AS PART

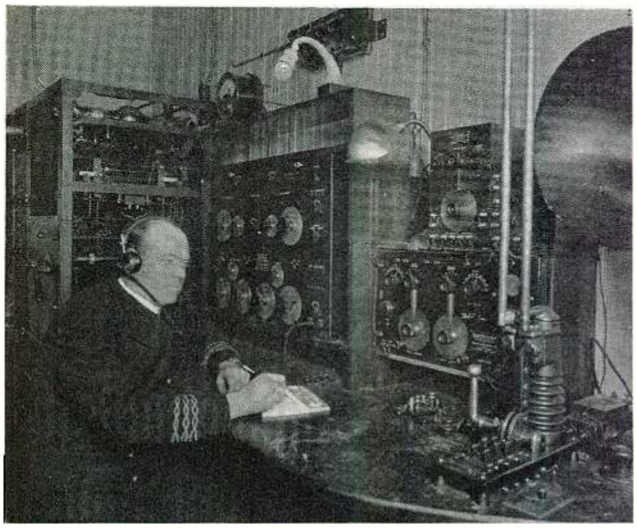


Fig. 2.. Ship radio installation 1921.

INTRODUCTION

SOUND BROADCASTING is approaching its twentieth birthday anniversary, so that we can say no longer, as has been said so often, that it is in its infancy. *New* infants are being added to the broadcasting family, by name facsimile and television, and sound broadcasting, being nearly twenty years old, is past the infant and adolescent stages, has had its growing pains, and has passed through the critical formative years. It has now reached maturity and is settling down to its serious life work. It is therefore fitting that sound broadcasting should examine itself critically to see wherein it may improve or better fit itself for greater usefulness in the future.

I look at the Broadcast Engineering Conference as such an examination and analysis. In that view, it is particularly fitting that special attention should be directed to the receiving end of the system. It is trite to say that the transmitter is useless without receivers, or that receivers are useless without transmitters. It may be equally trite to say, but I do not think it is as generally appreciated as it should be, that the greatest usefulness and benefits of the broadcast system can not be realized until the maximum of coordinated operation of transmitters and receivers has been effected. There has been very little of such coordination during the past years of sound broadcasting. Of course, only a little has been necessary to provide even the large and effective public service which sound broadcasting has become, since the essential requirements of coordination have been merely those of radio and audio-frequency ranges, and these have been susceptible to simple specification and accomplishment. Furthermore, these requirements have not included serious technical difficulties or conflict of interests.

However, at this time of relatively advanced development of the service, it may be that further improvement, refinement, or extension, may be found by a greater degree of coordination between the transmitter and the receiver. It may be that possibilities can result from a combined effort which have not appeared under the independent development course which has been followed so far. The object of this paper is to explore this hypothesis, and to set down suggestions which appear to have possibilities of service improvement through combined study and action of transmitter and receiver interests. In relation to this idea, it is interesting and

Presented Before the Second Annual Broadcast Engineering Conference

should be very helpful, that recently the National Association of Broadcasters and the Radio Manufacturer's Association have formed a joint committee assigned the duty of developing ways and means for improvement of industry welfare as a whole. This committee, and

By
Arthur Van Dyck
Manager, RCA License Laboratory

others of more technical make-up, may be the instruments by which successful coordination can be effected.

This paper is to deal primarily with the receiver part of the system, and it will be useful in the study to examine first the history of receiver development, in respect to those phases which have had important effect upon system matters, such as growth of the service, quality of service, cost of operation, listening habits, social value.

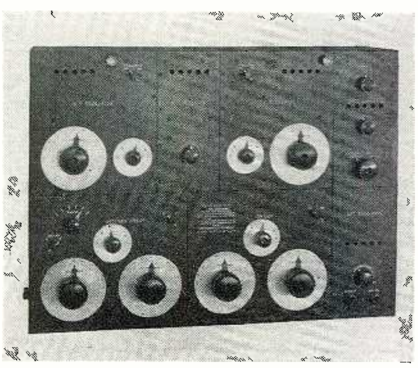
HISTORY OF SOUND RECEIVER DEVELOPMENT

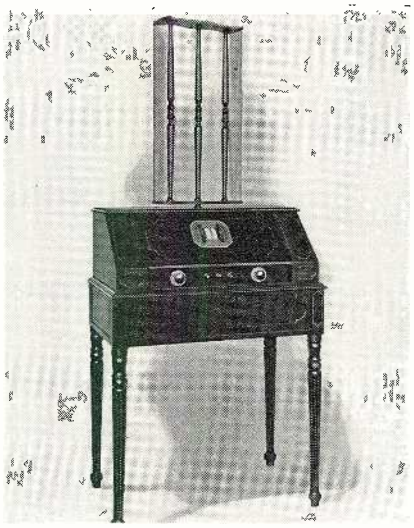
The first receivers produced for sale to the public were extremely simple. This was not because more complex and more efficient ones were not known to radio engineers, but because they were the best suited to the new purpose. Fig. 1 shows a good commercial receiver of that time, which incidentally, used the superheterodyne circuit which was first introduced into broadcast receivers only after several years. Fig. 2 shows a large merchant ship receiver installa-

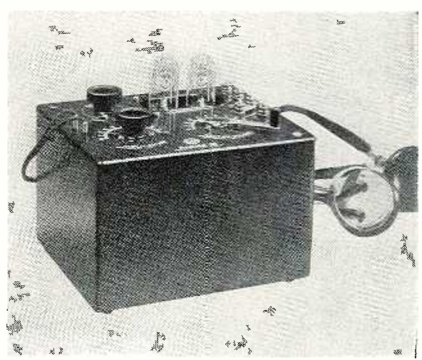
Left: Fig. 1. A commercial radio receiver of 1921.

Below: Fig. 12. A superheterodyne of 1925.

Right: Fig. 3. The first popular vacuum-tube receiver.







OF THE BROADCAST SYSTEM

Held at The Ohio State University, Columbus, Ohio, February 6-17, 1939

tion. In contrast, Fig. 3 shows the first highly popular vacuum-tube broadcast receiver. Simplicity was a paramount requirement because operation was to be effected by laymen, not by trained radio operators. Radio engineers did not know at that time how to build

An historical analysis of radio receivers, to be followed by a second article, covering present equipment and pointing the way toward future development.

complex high-performance circuits with simple operating features. That had to be learned, and it took years to accomplish. Today, home broadcast receivers have circuits which are vastly more complex than those of the commercial receivers of 1920, and yet their controls are simple enough for the layman to understand. This evidences a difference between receiver and transmitter engineering which has existed from the beginning, and still is present, namely, that where the receiver designer must so utilize new developments as not to add unduly to the operating skill required, and as a matter of fact where he actually has succeeded in reducing the skill required to a "push-the-button" stage, the transmitter engineer has been free to utilize new developments with little thought to operating skill. The transmitter operator can be depended upon to read meters, watch gauges, pull switches, and even if push-buttons are given him, he can be depended upon to exercise skill in the order of pushing them. The receiver designer not only supplies the push-buttons, but has to arrange them so that if the user pushes all of them at once nothing untoward will happen.

Considered with relation to other appliances in the home, the broadcast receiver has some remarkable characteristics. It is at once the most complex, the most sensitive, and the most precise device, which has entered the home. It operates on inputs measured in millionth parts of one volt, it includes generation of voltages of hundreds of volts, and it maintains frequency acceptance conditions to one part in many thousand throughout years of use without attention. If we did not today so quickly accept and become accustomed to the marvels of the age, we would find interest and romance in the story of this development by tracing the step-by-step contributions from hundreds of engineers which have made possible the refined product we now have.

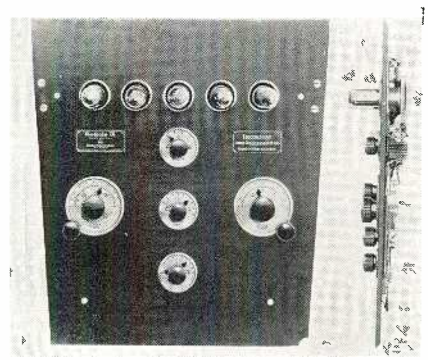
It is well to note that in the beginning of broadcasting, the system set-up as a whole was simple, that it too underwent change toward greater complexity, and that it is still changing in that direction. In the beginning only one wave frequency was used, namely 833 kilocycles. Soon 750 kilocycles was added, then a band, then extensions of the band to the present range of 540 to 1600 kilocycles. But then additional bands were added, in the short-wave region, and now we are seeing the ultra-

Fig. 10. The tuned-radio-frequency receiver.

short-wave region added. Presumably, the micro-wave band will follow that.

The development of receivers is intimately associated with the development of vacuum tubes. The first tubes were simple triodes having high power consumption, low amplification, poor uniformity, high internal capacitance, poor circuit-matching characteristics. Only two or three types were available at all, to serve all purposes. As development progressed, all of these objections were overcome, until today the receiver designer has several hundred tube types from which to choose. Each major step in tube advance made possible a new receiver service expansion. The low-power cathode tube made possible portable sets, the alternating-current tubes changed broadcast listening from a mechanical hobby to a public service, and the screen-grid tube made possible the utilization of complex, high-amplification circuits having greater efficiency and the necessary stability. Today's tubes are so excellent, in fact, that one is tempted to say that they have reached

Left: Fig. 7. An early vacuum-tube receiver.
Below: Fig. 9. The first cabinet receiver.
Right: Fig. 14. Receiver to be installed in lid of old phonographs.



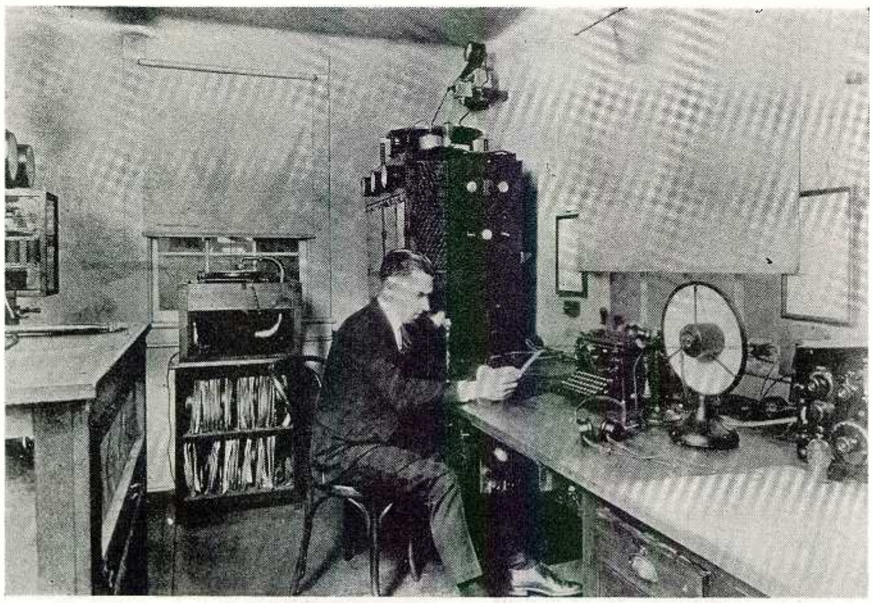


Fig. 4. The first WJZ transmitter. Compare with Fig. 5.

the ultimate, or at least that no great further improvement is needed. However, it will be well to resist the temptation, because there is little doubt that some new development of tomorrow will open up additional receiver and broadcast service possibilities.

After the first simple receivers had done their duty in the initial stages, and after broadcast stations had increased to be very considerable in number, it became apparent that two certain receiver improvements were needed vitally. These were more selectivity and less radiation. It was an unfortunate characteristic of the simple, early receivers that they radiated and caused interference. Two circuits having the needed characteristics were available, both having been invented before the advent of broadcasting. One was the "tuned-radio-frequency" circuit, and the other the "super-heterodyne." The latter was considerably more complex, and although in commercial use, not enough was yet known about it to permit its use in large quantity production. The tuned-radio-frequency circuit was considerably simpler, and considerably easier to reduce to the new practice of large production and layman operation. Therefore it became popular, rapidly displaced the early sets, and for several years met the need for more receiver selectivity, which was growing as the number of broadcast stations increased. But the limit of its capabilities was finally reached, however, and the superheterodyne circuit was introduced. By this time, the complexities of this circuit had been brought under control and it could be built with economy and reliability under mass-production methods. Today, this circuit is used universally, and is still meeting system requirements.

Up to this time, practically no correlation between transmitters and receivers had been effected, or necessary, except with respect to wave frequency range. However, at about this time, another factor entered, that of fidelity of transmission and reception. Up to this time, receivers had been very seriously deficient in this respect. Even the best receivers had a tone frequency range of only about 300 cycles to about 3000 cycles, and the deficiency was due primarily to the loudspeakers used. Introduction of the electro-dynamic speaker brought enormous improvement, and caused more attention to be paid to the matter of fidelity, in transmitters as well as receivers. For example, it was found that improvement of transmitter frequency stability gave improvement in fidelity of reproduction. As a further consequence of the dynamic loudspeaker, and the improved tone frequency range, it became feasible to utilize larger reproduced volume. Receiver output increased from small fractions of one watt to several watts, and the receiver became a qualified musical instrument for the first time. Another result of this improvement in receivers was that they were then capable of revealing transmitter imperfections. Transmitter engineering and operation were then forced to pay full attention to tone frequency range, frequency stability, hum modulation, over-modulation, and all matters affecting fidelity of transmission, and transmission improvement resulted.

Satisfactory basic components of the receiver having been obtained, later development began to turn in the direction of circuit refinements. Such additions as single-knob tuning, higher sensitivity, automatic volume control, hum and noise reduction, tone control, selectivity control were provided. These refinements might be called internal in nature, and as they grew into standard practice, the attention of designers began to be directed externally, that is toward operating characteristics. This resulted in changes such as better knobs and dials, smaller and more convenient cabinets, better antenna design, and has finally culminated in automatic or push-button tuning and remote control. This trend still has considerable momentum, and will be discussed further in connection with future possibilities.

A development having large effect upon both receivers and transmitters, as well as upon broadcasting service as a whole, was that of the extension of

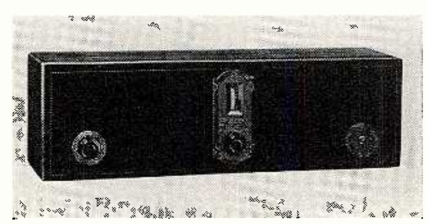


Fig. 13. The first a-c tube receiver.

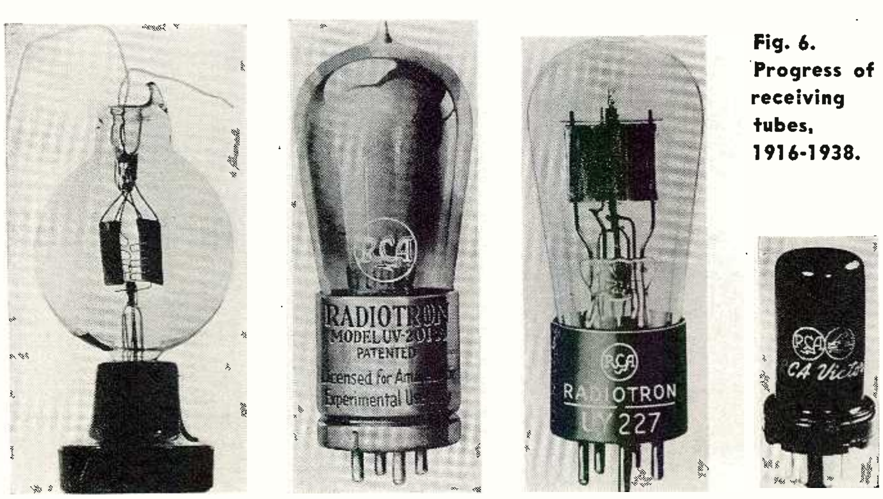


Fig. 6. Progress of receiving tubes, 1916-1938.

broadcasting to short waves. This involved very considerable expansion of broadcasting, but was carried out with little coordination between transmitter and receiver interests. This was due largely to the fact that the receivers were intended for reception from foreign stations, rather than our own, while our transmitters were to supply foreign receivers rather than domestic ones. Even so, the number of receivers built here for sale abroad was large, and it is remarkable that the innovation was accomplished with so little coordination between broadcasters and receiver manufacturers. It seems to prove that the democratic way of operation can be depended upon for good results in the public interest without resort to centralized, planned, and dictatorial methods, even in a matter such as this, where the project is new, untried, and requires an experimental, groping approach.

In the first introduction of short waves, receiver manufacturers supplied receivers to cover practically all the short-wave radio services. It soon developed that public interest in some of these, such as aircraft, amateur and police, was limited, and now the low and medium-priced receivers, and even many of the high-priced ones, are designed to receive only those short-wave bands which are used in foreign broadcasting.

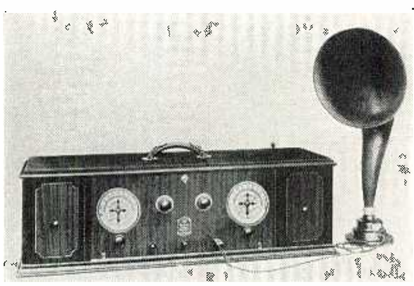


Fig. 11. The first home broadcast superheterodyne.

There are two further factors in receiver development to date which have had large effect upon the system. One is the matter of cost. The prices of receivers have been reduced without any apparent relation to the complexity of their designs, the quality of their appearance and performance, or the service they render. Most of this reduction has been the normal result of large production operation, but some of it has been a competition in reduction of price accompanied by undue lessening of performance and quality of construction. This has resulted in a lessening of prestige of the radio instrument in the estimation of the public, with more or less distortion of their appreciation of proper values in the product. Consequently, and for example, few buyers today have a clear conception of the difference between the $9.95 set and the $49.95 one, even with respect to basic performance matters in which they are interested.

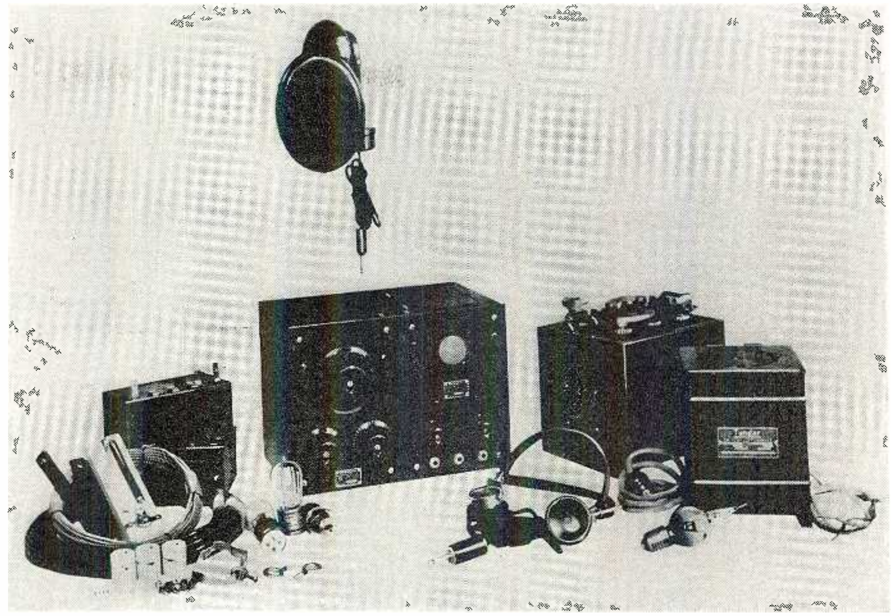


Fig. 8. Some early radio equipment.

However, the enormous reduction in cost has resulted in universal utilization of the service of broadcasting. In this country, a receiver in every home is very nearly completely realized.

A factor of significant magnitude in the development of broadcasting has been its combination with other things, such as the phonograph and the automobile. It has even been united with the refreshment bar to make a combination doubly entertaining to many. The automobile receiver has been especially important from the transmitter viewpoint. It has increased the amount of time devoted to listening, especially during the summer time, which is the low season for listening, and has therefore enlarged the audience, in effect. From the purely technical standpoint, it has offered new aspects of the propagation problem and of the "man-made static" problem.

(To be continued)

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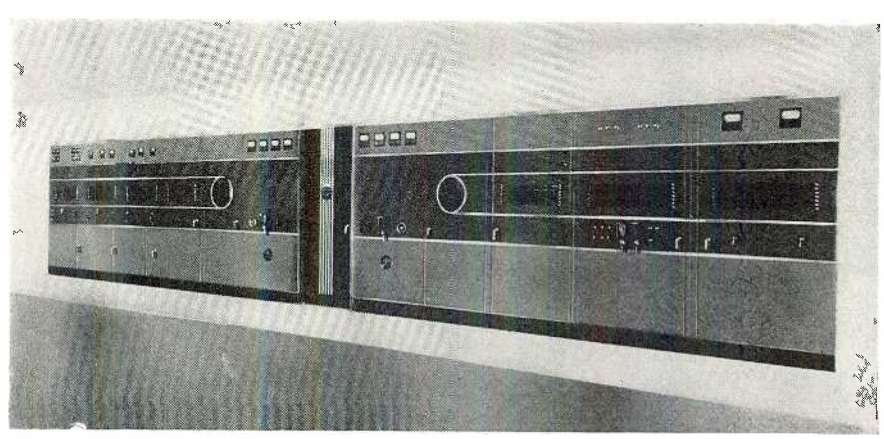
LEAR APPOINTMENT

Lear Developments, Inc., manufacturers of aircraft radio equipment at Roosevelt Field, Mineola, L. I., announce the recent appointment of Mr. Sydney Nesbitt as Sales Manager of the company.

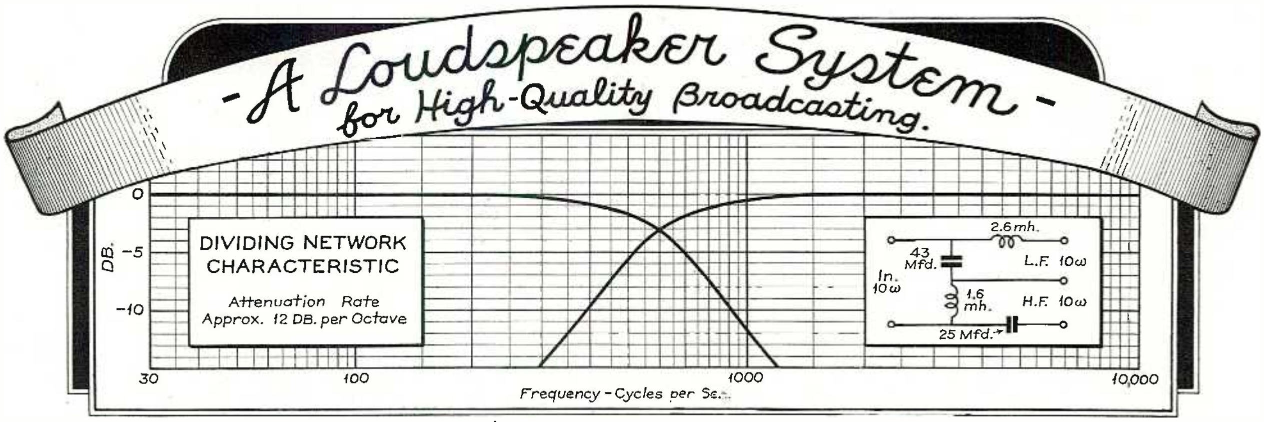
STANDARD ELECTRIC ORDER

Standard Electric Aktieselskab, associated company in Denmark of the International Telephone and Telegraph Corporation, reports that it has received the order from the Danish authorities to supply the complete studio equipment for the new Broadcasting House to be erected in Copenhagen. This is to be one of the largest radio centers in Europe, and will have several features new to studio equipment and studio arrangement.

Fig. 5. A modern broadcast transmitter. Compare with Fig. 4.



A Loudspeaker System for High-Quality Broadcasting

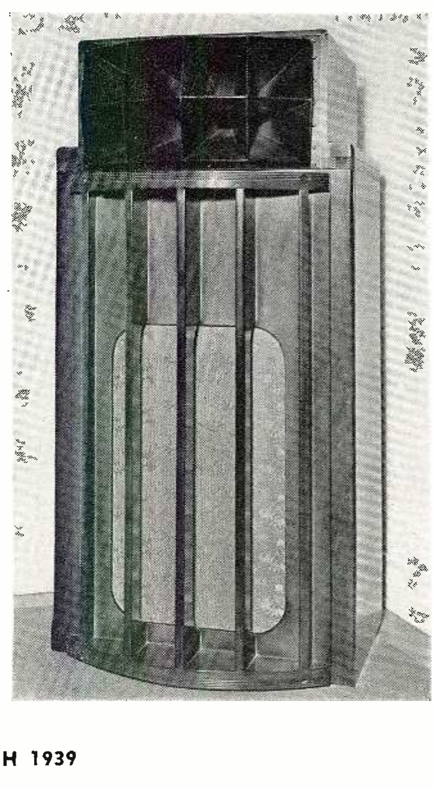


By SAMUEL A. WAITE

AMONG the many components of a modern broadcasting plant, it seems that one in which the rate of improvement has been slow is the matter of monitoring facilities. Audio-frequency amplifiers, for example, have been brought to a point where they leave little to be desired. That they have arrived at this high degree of refinement is due largely to the fact that they are readily and accurately measurable by suitable and repeatable methods, and in the same category fall modulators and radio-frequency amplifiers. The loudspeaker, unfortunately, is not subject to quite such satisfactory performance measurement which probably accounts in large measure for it's less rapid improvement. The situation prevails, that often in the absence of a suitable way to express its degree of naturalness of reproduction, the final test of a loudspeaker is—"What does it sound like?"—and this state of affairs is still further aided and abetted by the character of the room in which the loudspeaker is placed.

Perhaps the reason why a given program or orchestra for instance, sounds entirely different over one station than it does when it broadcasts from another (long distance wire lines and microphones excluded from this consideration), can be explained in terms of monitoring loudspeakers better than in any other way. If one station balances the program by the use of a loudspeaker that is deficient at the high frequencies, the tendency is to place the microphone relatively close to the instruments playing the high frequencies. For another whose loudspeaker is down at the low end, the reverse is true. Likewise a hump at the low end would cause the low-frequency instruments to be placed relatively further away, etc. In each case, however, it is believed that the effort is made to secure what sounds to be the proper balance, as judged by the reproduction obtained in the monitoring loudspeaker. That this balance may be considerably different from the balance existing in the signal fed to the radio transmitter is readily apparent. It is also entirely possible for certain peaks in microphone response (usually at the higher frequencies) to coincide with dips in loudspeaker response and therefore go unnoticed. Indeed it is possible for sounds to be picked up and broadcast that are inaudible on some loudspeakers, such as low-frequency fundamental tones for example. Another and very troublesome effect is caused by the directive characteristic of certain types of loudspeaker, i.e., the higher the frequency, the narrower the beam of sound radiation which causes its position in the room to still further complicate matters. When balancing a show which requires several people in the monitor room, obviously all of them cannot receive the same balance, as their respective positions will differ relative to the high-frequency beam, and conflicting opinions may arise regarding balance.

A front view of the loudspeaker system.

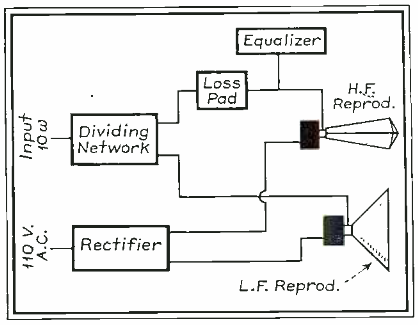


Now it is customary wherever possible, to make every part of a broadcast station stand on its own feet: that means, with respect to frequency characteristics, that every part will be flat if it is possible to make it so, such as amplifiers, etc., resorting to complementary characteristics in other pieces of apparatus only where necessary, such as for wire-line equalization and the like. Therefore, the monitoring loudspeaker should have a flat frequency response, and in addition be as free from all other types of distortion as possible, and also deliver a uniform response to all parts of the monitor room.

A loudspeaker system designed to meet these requirements and believed original with the writer, took practical form in 1936 and has undergone many months of development and critical listening tests. During this time not only were the usual testing and measuring methods applied, but nearly every type of program material was compared for naturalness of reproduction by quickly moving from the room containing the loudspeaker to the room containing the program material and noting the difference. By a long and laborious process the causes of these differences were found, and they were reduced to a point where the reproduced sound is almost indistinguishable from the original with respect to frequency characteristic, phase distortion, and harmonic distortion, when used with a flat channel and a flat microphone. The remaining difference being one which a single loudspeaker cannot reproduce—namely, the spatial characteristic which requires two or more complete channels to give the necessary auditory perspective. The frequency response is very uniform from 30 cycles to 13,000 cycles, gradually falling off to 15,000 cycles. The low frequencies down to 30 cycles are reproduced as true fundamentals, and the harmonic generation at any frequency above 30 cycles is undetectable by a trained ear, even when listening to a pure tone input. A feature of this loudspeaker system is its comparatively small size for its ability to cover so great a range of fundamental tones, requiring but 18½ by 28 inches of floor space without the grille, although standing 57 inches high. A horn for example to reproduce 30 cycles would require a mouth about 9 feet square. This allows its use in monitor rooms even smaller than the optimum which should be about the same size and shape and have about the same reverberation time as the average living room, inasmuch as it is in the living room that radio broadcasting reaches its intended destination.

The complete two-way loudspeaker system consists of a multicellular horn coupled to a high-quality electro-dynamic receiver for the high frequencies, a large cone-type electro-dynamic speaker working against the acoustic load of a vented box for the low frequencies, a dividing network, an equalizer, and a rectifier for supplying the fields of both units, all enclosed in a cabinet-like arrangement.

The high-frequency horn is placed at a suitable height and distributes the high frequencies from 600 cycles to 15,000 cycles over a solid angle of 70 degrees in the horizontal and 35 degrees in the vertical planes, and it is this wide distribution of high frequencies that allows practically all points in a room where an auditor might be located to be covered with direct radiation, as contrasted with the usual narrow beam from a single cone-type speaker. But this is not the only benefit derived from a wide angle of high-frequency radiation—in the case of a single beam,[1] the reflection path is dependent upon the angle it makes with the walls in the room and upon the angular relationship of the walls themselves. Therefore as some of the energy is given up at each reflection it may be attenuated to an inaudible value by the time it gets to certain points in the room, in addition to being late with respect to low frequencies which left the speaker simultaneously, at points where the travel has necessitated several reflections (delay distortion). With the 8-cell horn shown, nearly the entire useful listening portion of the room is not only covered with direct radiation, but the wide distribution angle results in large dispersion of even the first reflection so that the pattern of the reverberant energy is also much more uniform. Now horns do peculiar things at or near their low-frequency cutoff, but in this case the horn cutoff frequency is below the dividing network crossover frequency of 600 cycles hence no distortion occurs from this source.

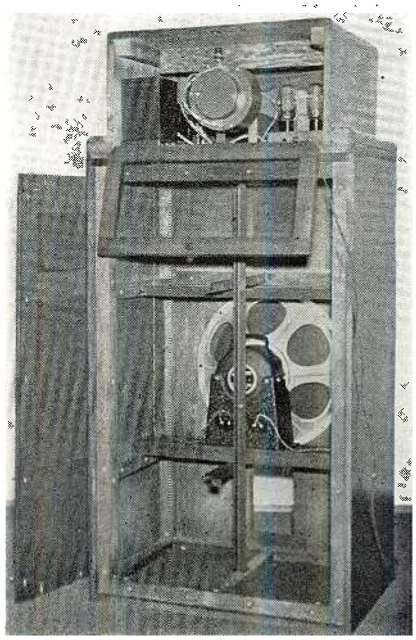


Block diagram of loudspeaker system components.

The high-quality receiver unit is of the metallic diaphragm type, lightness of the moving parts being an attribute in minimizing distortion of transients, and of course sound waves encountered in broadcasting are largely transient in character.

The low-frequency part of the system not being a horn is therefore free from effects produced by a horn working at or below its low-frequency cutoff, works in the range from 600 cycles down to 30 cycles and has a satisfactorily wide angle of radiation up to 600 cycles inherently, due to the fact that the moving diaphragm or cone diameter is small compared to the wavelength. It employs an 18-inch cone-type dynamic speaker especially designed for low-frequency response. The loading on the back of the cone due to the proper use of the semi-confined air in the vented box allows frequencies where the cone diameter is very small compared with the wavelength to be reproduced as true fundamental tones (down to 30 cycles), and with reasonable efficiency. The box is constructed of heavy material and also is very rigidly braced to prevent any spurious resonances.

Speaker system with back cover removed. Note bracing.



The dividing network[2] is of the series type, similar to those used in theatre systems has a characteristic impedance of 10 ohms, crossover frequency at 600 cycles where each radiator receives half of the power, and has a phase shift at 600 cycles of 221 degrees which, by proper positioning and poling of the high-frequency receiver unit, allows the acoustic output of each radiator to be additive at 600 cycles. The dividing network also incorporates the loss pad for adjusting the relative acoustic output of the two radiators to a uniform value because their transducing efficiencies are not equal.

The purpose of the equalizer is to remove some irregularities in the response and thus obtain a very uniform frequency characteristic.

Because no loudspeaker can ever be perfect, and the best practical one must necessarily be a compromise[3] of many factors, the naturalness realized from this design testifies to the success with which these compromises have been attended.

Should really high-fidelity broadcasting become the rule, it would give the receiving set manufacturers an incentive to produce high-fidelity receivers worthy of the name, as they would be assured of satisfactory inputs for their receivers. Of course there will be those who say it cannot be done in view of 10 kc separation of carrier frequencies, monkey chatter, etc., but it can, at least for those who live sufficiently close to one or more broadcast transmitters, and there are a large number of listeners so situated in this country—enough, in fact, to justify production of as wide a band-width receiver as they are willing to pay for. Band narrowing devices would make these receivers as satisfactory as the present day sets with a 4000-cycle average upper limit, for more distant reception. The increase in the degree of naturalness is very rapid[4] in the octave from 4000 cycles to 8000 cycles and while less rapid in the octave above, still much to be desired *provided* the signal is free from microphone peaks and contains a natural balance.

While the underlying incentive to the investigation which resulted in this loudspeaker design was with respect to radio broadcasting, it is finding application in the motion picture industry both in review rooms, and, due to its convenient size, as portable preview equip-

(*Continued on page* 45)

BOOK REVIEWS

STANDARDS ON ELECTRONICS 1938, published by The Institute of Radio Engineers, Inc., 330 West 42 Street, New York City, 1938, 59 pages, paper covers, price 50 cents.

In the past, it was the practice of the IRE to issue a single comprehensive standardization report which covered all phases of radio. This necessitated the issuance of the complete report even though changes in standardization may have occurred in only one field. The present improved practice is to publish separate reports for each branch of radio, of which *Standards on Electronics* 1938 is one.

The first ten pages is devoted to the standardized definitions of tubes and their component parts. This is done for vacuum, gas, cathode-ray, and photoelectric tubes.

Five pages are then devoted to symbols, both letter and graphical.

The remainder of the book concerns itself with methods of testing vacuum tubes and covers such topics as the measurement of vacuum tube characteristics, coefficients, ionization and leakage currents, interelectrode capacitance, power output, detection characteristics, and phototubes.

This book is a valuable addition to every communication engineer's library. R.L.

THE 1939 RADIO AMATEUR'S HANDBOOK, sixteenth edition, by the Headquarters staff of the ARRL, published by The American Radio Relay League, Inc., West Hartford, Conn., 1938, 454 pages text plus 106-page catalog section, paper covers, price $1.00 for continental U. S. A., elsewhere $1.25.

Year after year the ARRL Headquarters Staff produces a "bigger and better" handbook, the new sixteenth edition surpassing all previous editions in excellence. The major defect is the small amount of space devoted to Instruments and Measurements.

The tabular data on vacuum tube characteristics of about 400 types of tubes is one of the most complete compilations to be found anywhere. If for no other reason, this fact alone makes it imperative that the engineer purchase each succeeding edition of this handbook, despite the considerable duplication of text material.

On page 65, the power output watts for the 6A3 is not 1.5 and 1.0 as shown, but is 15. and 10. watts respectively.

New and improved circuits appear in the chapters devoted to receivers and transmitters. The section on antennas has been greatly revised and enlarged, and presents considerable information on this subject.

R. L.

MODERN PLASTICS, Volume 16, No. 2, edited by E. F. Lougee, published by Breskin and Charlton Publishing Corporation, 122 East 42 Street, New York City, 1938, 304 pages, cardboard cover, price, $2.00.

This Catalog-Directory issue of *Modern Plastics* contains a series of articles describing the developments that have occurred in the plastics industry in the past year, not only in the United States but also throughout the rest of the world.

The Plastic Properties Chart, which is inserted opposite page 172, is 11¾ by 31 inches in size and tabulates 45 physical and chemical properties of 27 kinds of plastic materials. This is probably the most complete and accurate chart of plastics ever compiled and should prove invaluable to everybody who has occasion to manufacture or use plastics.

Modern Plastics also contains a selected bibliography of American and foreign publications pertaining to plastics. A short list of words used in plastics and their definitions should be useful to anyone who is unfamiliar with the terminology employed in this field.

At the end of this book will be found several directories: "Directory of Chemicals and Raw Materials," "Directory of Machinery, Equipment and Supplies," "Directory of Custom Molders, Fabricators, Designers," "Directory of Trade Names and Manufacturers of Plastics" and an "Alphabetical Index of All Manufacturers and Addresses."—D. B.

THE RADIO HANDBOOK, fifth edition, by the editors of "Radio," published by Radio, Ltd., 7460 Beverly Blvd., Los Angeles, Calif., 1938, 592 pages, paper covers, price $1.50 in continental U.S.A.; elsewhere $1.65.

The new revised edition of this useful handbook contains a number of short wave and u-h-f circuits of receivers and transmitters which should prove of interest to the radio engineer.

A chapter has been devoted to radio receiver tube characteristics. Data on tubes released during 1938 are not given.

The non-tabular form employed in listing the characteristics of transmitting tubes requires considerable space. The non-alphabetical, non-numerical arrangement decreases the usefulness of these data for reference purposes. On the other hand, the authors are to be highly praised for their practice of marking with an asterisk those tubes which they particularly recommend to amateurs designing new equipment. To anyone considering building a transmitter these recommendations will undoubtedly be valuable.

Also useful in designing a transmitter are the block diagrams showing the comparative outputs of various cw, radiotelephone, and combined cw and radiotelephone transmitters. The audio amplifier block diagrams should prove advantageous not only for transmitter construction but also in designing public-address systems.

The section on decibels is the best elementary treatment that the reviewer has seen. D.B.

MATHEMATICS FOR RADIO AND COMMUNICATION, Book I, Arithmetic, Algebra, Geometry, by G. F. Maedel, published by Prentice-Hall, Inc., New York City, 1938, 314 pages, price, $3.75.

In recent years there has occurred considerable agitation for the drastic shortening of the time to be devoted to the teaching of mathematics of students who did not intend specializing in the sciences. Educators are unanimous in their agreement that a certain amount of mathematics is essential to everyone, but they are in complete disagreement regarding the number of such courses and the amount of time to be spent on them.

Opponents to change of the *status quo* of the mathematical curriculum hark back to the two thousand year old cry that there is no royal road to mathematics. Thus far they seem to have the better of the argument and will continue to do so as long as mathematical textbooks are written from the pedantic point of view without regard to the practical application of such learning.

It is quite possible that the appearance of *Mathematics for Radio and Communication* will mark the turning-point in the "for and against mathematics" controversy. This excellent book distils the essence of what must be known in three branches of elementary mathematics (arithmetic, algebra, and geometry). Unlike other mathematical textbooks which might be considered to be glorified puzzle books, the present book not only retains the rigor so necessary to mathematics, but also is thoroughly practical in nature. For general use in the schools some alterations would be required, such as increasing the scope of the problems and decreasing the emphasis placed upon radio.

It is quite likely that every engineer has at some time or another been asked by a friend, "What book would you recommend that deals with elementary mathematics and which I could study by myself?" The engineer need no longer rack his brains for a suitable answer and then be forced to admit defeat, for *Mathematics for Radio and Communication* can be recommended without hesitation. Not only does this book give numerous problems which pertain to radio, but it also gives answers to all of them, thereby making this book invaluble for self-study.—D. B.

NOMOGRAM FOR THE INDUCTANCE OF A CIRCULAR RING

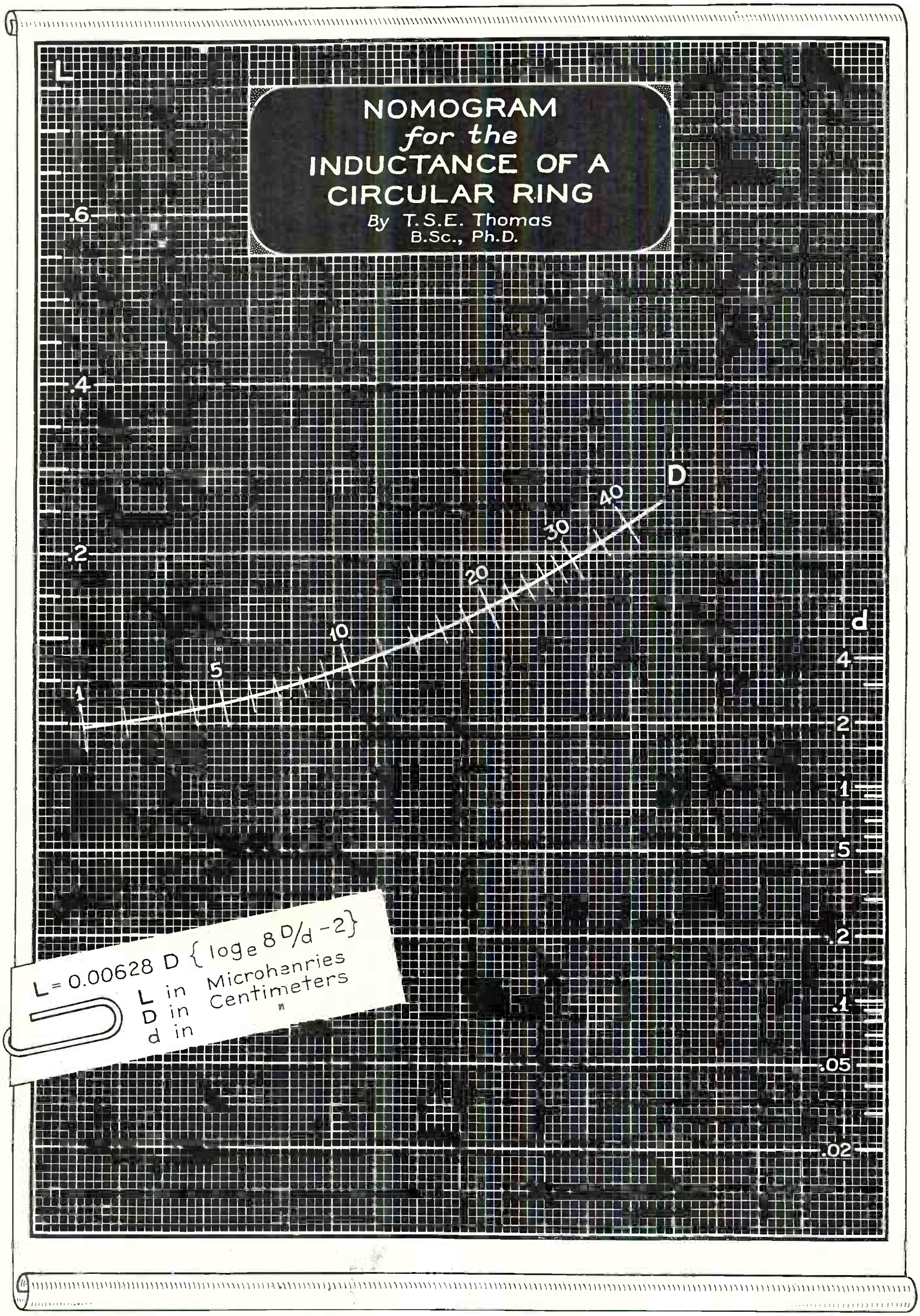
(*See page 15*)

IN EXPERIMENTAL WORK with ultra-short-wave circuits the inductance coils used may consist of a single turn coil in the form of a circular ring. The inductance of a circular ring may be obtained from a formula due to Kirchhoff.

$$L = 0.00628D \left\{ \log_e 8D/d - 2 \right\} \text{ microhenry}$$

where L is the inductance in microhenries, D the diameter of the coil and d the diameter of the wire (circular cross section). Both dimensions are in centimeters.

The accompanying nomogram represents the inter-relation of L, D and d for a certain range of values. Its range may be extended by making use of the rule that the inductances of geometrically similar circuits are directly proportional to their linear dimensions.


NOMOGRAM
for the
INDUCTANCE OF A
CIRCULAR RING
By T.S.E. Thomas
B.Sc., Ph.D.
L
.6
.4
.2
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d
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L = 0.00628 D { log_e 8 D/d − 2 }
L in Microhenries
D in Centimeters
d in "

LIGHT, by V. T. Saunders, published by Chemical Publishing Company of N. Y., Inc., New York City, third edition, 1938, 328 *pages, price,* $2.50.

In the past, a knowledge of light and its manifestations was not an essential part of the intellectual equipment of the communications engineer. The advent of television has changed this state of affairs, for not only does this art require the actual use of optical devices, but also, through the frequent use of optical analogies, light makes its influence felt even in the analysis of electrical circuits.

This book concerns itself mainly with geometrical optics, the other phases of light being treated less thoroughly. Since it requires, except for a very few places, only a knowledge of elementary trigonometry, it should prove of interest to the engineer who wishes to acquire an understanding of the subject with a minimum of effort. In order to expedite the student's grasp of the subject the author adopts the highly commendable practice of furnishing answers to all questions requiring numerical answers.

In the back of the book there is pasted a useful chart which shows the frequencies, the wave lengths in centimeters, and the wave length in Angström units of the whole electromagentic spectrum.—R. L.

COLUMBIAN COLLOIDAL CARBONS, by the Columbian Carbon Company, distributed by Binney and Smith Co.,* 41 *East 42nd Street, New York City,* 1938, 193 *pages.*

Undoubtedly everyone is familiar with the sooty deposit resulting when a plate is held over a kerosene lamp. Although this is, in essence, the principle underlying the manufacture of colloidal carbon ("carbon black" to the uninitiated), the actual complexities of manufacture are so many, for what appears to be so simple a product, as to almost surpass belief.

It is little realized how many and varied are the uses of colloidal carbon. To quote from this book: "It is fairly safe to conclude that every processed material that is black contains colloidal carbon, with the exception of dyed cloth and fabric materials."

*This is a limited edition which is being distributed to those industries employing or contemplating employing colloidal carbon, as well as to consultants and chemistry departments of universities.—*Editor.*

The properties of carbon as ordinarily known and the submicroscopic colloidal carbon (from 60 down to less than 25 millimicrons) differ considerably. Customarily, carbon is considered a conductor. Yet, an increase of 50 percent in insulating power is imparted to the rubber insulation for electric wires if a small amount of colloidal carbon is added to the rubber.

The automobile tire of today is made of equal quantities of rubber and colloidal carbon, this combination accounting for the modern tire's great durability. This is only one of the many uses of colloidal carbon which are described herein.

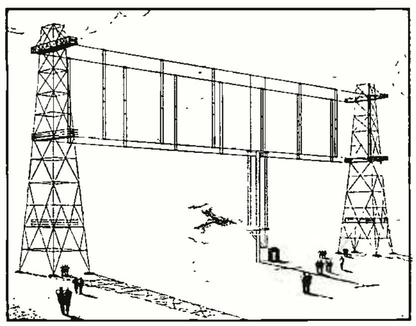
Incidentally, the printing in this book is so jet black that the letters almost jump off the page. Yes, you've guessed it—the ink was made of colloidal carbon.

D. B.

NEW COMPANY

News comes to us that Nathan Schnoll, Chief Engineer of Solar Manufacturing Corporation, has resigned his position to organize Industrial Instruments, Inc., with headquarters at Bayonne, New Jersey.

NBC BEAM ANTENNAS



The antenna of W3XAL.

By GENE GODDESS

THE NATIONAL BROADCASTING COMPANY is building a new directional antenna system which will focus on South American countries, according to Mr. Raymond F. Guy of the Engineering Department of that company. Engineer Guy further stated that the antennas, which were designed by Mr. William Duttera, also of the Radio Facilities Department, would be available for use by the network's two short-wave broadcasting stations W3XL and W3XAL at an early date.

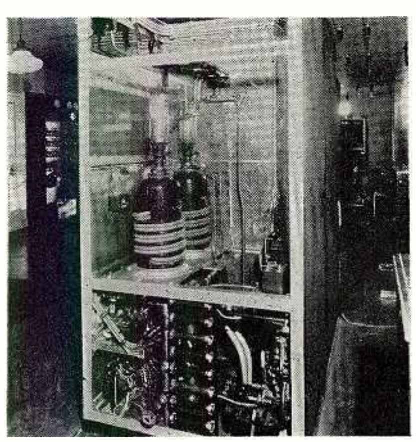
Most interesting is NBC's reason for the development of the new system. South America, at the present time, with its two language groups, Spanish and Portuguese, centered roughly in Argentina and Brazil, respectively, is covered by NBC's single beam. The objective of the engineers is to get more power into these large listening centers by a greater concentration of the power from the new 25-kw transmitters.

One way of accomplishing this was the rather complicated method of building two separate antennas, one of which would be focused on Buenos Aires and the other on Rio de Janeiro—shifting from the first antenna to the second as the program would change from Spanish to Portuguese. There was another possibility—instead of changing antennas, it was decided to build one whose beam could be shifted.

With the possibility of mechanical shifting of the actual geographical location of the antenna eliminated because of its cumbersomeness, an electrical shifting of the beam by a change in the antennas' elements was decided upon.

In contradistinction to the method adopted at the Dutch station PCJ, in which a physically rotatable antenna with fixed beam characteristics was employed, NBC's newest development will be a stationary system whose beam will be changed by changing the electrical elements of the antenna by remote control from the transmitter. While the Dutch method requires several moments for a bodily change of its position, the second splitting American network will accomplish the same electrical effect in three or four seconds.

The W3XL modulator unit.

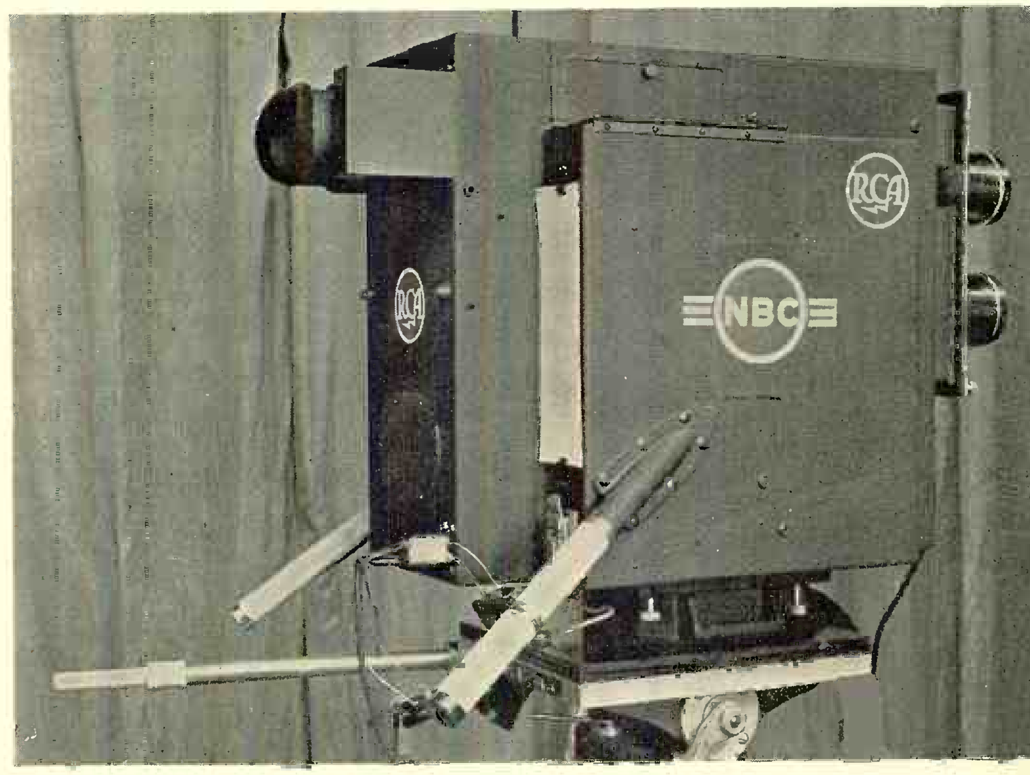


There will be two such beams directed at South America. One of these beams will be operated on a frequency of 21630 kc and the other on a frequency of 9670 kc—the choice of the frequency depending on the program and operating conditions. Additional beam antennas operating on frequencies of 17780 kc and 6100 kc will be directed at will toward either Europe or South America.

The beam emanating from the new antenna system will have a width of 20° at 70% of the maximum signal. There will be a slight overlapping of the two antenna patterns sent out by each of the electrically steerable antennas, but since the patterns will be made at different times, there will be no interference problem.

The antennas, which are being erected at a cost of $15,000 each will be at Boundbrook, New Jersey. The antennas will consist of 250 foot and 170 foot steel towers and wooden poles—ranging up to 170 feet in height.

TELEVISION ENGINEERING



An NBC-RCA television camera ready for action. Interior views of this unit are shown on the following two pages.

By

Dr. ALFRED N. GOLDSMITH

Consulting Industrial Engineer

TELEVISION ECONOMICS

Part II

D. STUDIO-TO-TRANSMITTER LINK

THIS is a relay connection by radio or cable enabling the carrying of the video-audio program from a fixed studio or a mobile pick-up point to the transmitting station.

D-1. Fixed Studio Link

At this time, programs are carried from the studio to the transmitter either by coaxial cable or a radio relay. The radio relay may use the higher-frequency uhf channels or the micro waves. Frequencies between 150 and 200 mc have been found useful, and higher frequencies may prove adequate. In one practical instance 177 mc is used to cover a distance of approximately 1 mile between and over tall steel buildings. Directional transmission and reception were here necessary to avoid the effects of undesired reflection of waves, multiple-path reception, and resulting inacceptable irregularities in the curve showing the strength of the received signal versus the carrier frequency of this signal. At the transmitter, a one-wavelength dipole, central fed, was placed over a metallic reflector. The dipole elements were supported at their centers by metal rods a quarter-wave long. Fading and distortion were practically absent in this circuit, and it showed high diurnal and seasonal steadiness and reliability. Its performance compared favorably with that of a coaxial cable also connecting the studio and the transmitter. The feasibility of such radio relays may enable economies where long or inconvenient coaxial-cable installations would otherwise be involved, for example, through long and circuitous urban routes.

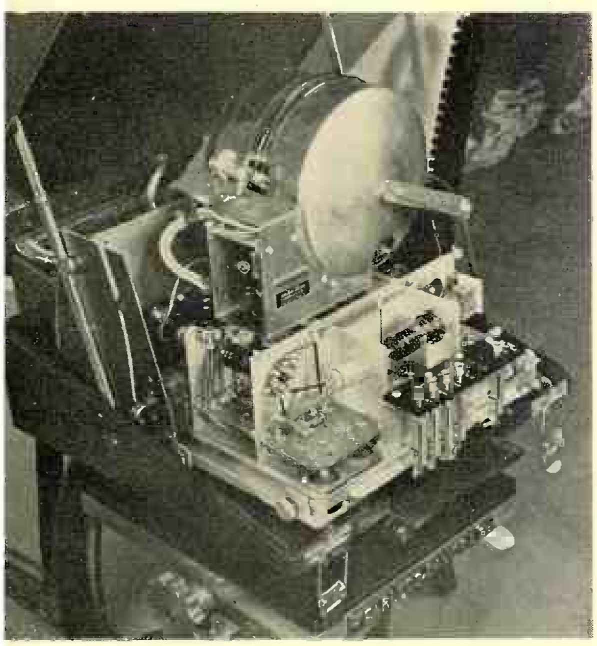
In this connection, the reliability of uhf circuits has been closely studied for various distances of transmission. For example, with transmitting and receiving antenna heights of about 220 and 160 feet, and with a transmitter power of 4 watts at 150 mc, both slow *and* rapid fading, increasing at night, were experienced over a 38-mile overland path (corresponding to an optical path of about 35 miles, neglecting wave refraction). The fading at midnight was greater than 1 db about 70% of the time, and greater than 10 db about 5% of the time; while at one o'clock in the afternoon the fading was greater than 1 db only about 35% of the time, and never greater than 10 db. On such a circuit, in general fading was less than 10 db for 97% of the time even though it sometimes reached 20 db. It was noted that halving the path length reduced the fading in db to one-fifth of the value for the longer path.

No overland fading was found at distances of 6 and 17 miles. Nevertheless, whenever the attenuation over the transmission path in addition to the inverse-distance attenuation reached 30 db, fading occurred. The transmitting conditions were described as corresponding to a satisfactory service so far as overland line-of-sight communication over distances of this order is concerned. However, it should be noted that intervening obstacles in cities and the effects of electrical noise and wave reflections near an urban receiving station (if used) injure picture quality and require fully adequate power at the relay transmitter to overcome their effects. It would be poor commercial planning to use an inexpensive but weak link for this purpose.

D-2. Mobile Pick-Up Units

The pick-up of outside events where no fixed connection to the transmitter is practicable has been carried out in Europe by direct motion-picture photography of the event followed shortly thereafter by radio transmission of the filmed pictures. For this purpose a film camera is placed on the roof of a truck, and developing, washing, and fixing tanks for the film are placed inside the truck together with a television film scanner and uhf transmitter to relay the resulting signal to the main transmitting station. The film is scanned before it is quite dry. It is obviously possible to scan film as a negative by proper choice of the number of video amplifying stages. This method has the advantage of yielding a permanent record of the event, but it has the disadvantages of appreciable cost of the film and processing as well as whatever delay in transmission is involved. By suitable photographic methods this delay can be kept acceptably short for most purposes. The advantages of this method are the possibility of editing and repeating the presentation, as well as the availability of a record of the event.

In America and Europe it has also become common practice to use direct television pick-up by mobile relay units. In one case, 10-ton trucks are used as units. One of these carries the television camera and the video generating and control equipment. Another of these carries a television transmitter on the relay frequency. Both of these may be run on whatever power supply is locally available. In the event that no power lines can be locally tapped, a third truck is required which is provided with a gasoline-engine-driven generator with unusually good voltage regulation, and of the necessary power of about 50 kva. If no other means are available for transmitting the audio program to the main transmitting station from the pick-up point, a fourth truck is necessary to carry an audio transmitter for the sound channel. It will be noted that the mobile equipment is essentially that of a small studio, but even so is relatively inflexible since only a single camera chain is available in most present equipment. Undoubtedly future mobile equipment will require added facilities for the sequential use of several cameras. It has been estimated that it takes from 2 to 5 engineers to man each truck, this corresponding to a possible total field staff on an outside pick-up of about 12 engineers.



An interior view of a television camera showing Iconoscope and preamplifier. NBC photo.

The economics of these arrangements, unless used on a large commercial scale, leaves something to be desired. The equipment is relatively bulky and costly, and while it is mobile and rugged, it can hardly be regarded as being highly flexible and speedy in its transfer from one location to another nor yet capable of meeting rapidly changing adverse local conditions. It is possible that compact, lighter, and more flexible equipment will be developed, as well as means for further minimizing the effect of difficult operating conditions such as wind, rain, and heat. Nevertheless, there is a lower limit to the permissible power for such relay transmitters since electrical noise at the receiving station requires that considerable transmitter power be available if an undistorted and clean picture is to be received. The ideal equipment would approximate, in portability and cost, portable newsreel outfits, but this seems a remote possibility at present.

In England some mobile units of 1 kilowatt at 86 megacycles have been provided with three cameras which have been used at such events as football matches, one being placed in the spectators' stand, and two others stationed opposite the 25-yard lines. Two of these cameras were provided with the equivalent of image iconoscopes. The transmitting antenna is sometimes carried on a square framework at the upper end of an 80-foot extension ladder. Other similar English pick-ups, which are here listed to indicate the scope, likely operating problems, and cost of such methods, include: tennis matches, boat races, horse races, cricket test matches, Trooping of the Colors, the Coronation procession, the Lord Mayor's Show, Cenotaph Services, demonstrations of fire fighting, gardening, golf, horsemanship, model boats, and sheep dog trials.

D-3. Coaxial-Cable Link

Coaxial cables meeting the present requirements for transmitted video band width, minimized differential phase delay, and the like, have not been described, but presumably can be provided. In the absence of installation and maintenance cost data on such cables, their economic feasibility over short and long distances and on a specific scale of operation remains undetermined.

One European television transmitter has been connected to a number of the most likely points of program origination in the same city by a coaxial cable 10 miles long. Another European television studio has been connected by coaxial cable to its transmitter, the video frequencies in this case (between 20 cycles and 2.5 megacycles) being used to modulate a 5.5-megacycle carrier which is sent over the cable; background or average-brightness signals of low frequency being used to modulate a 100-kc carrier which is sent over the same cable. This cable consists of a specially designed flexible outer conductor of copper, sheathed in lead and protected by a serving of impregnated jute over which steel wire is wound spirally. The inner conductor is of solid copper. The maximum attenuation per mile rises from 4.8 db at 1 mc to 6.6 db at 3 mc and 12.6 db at 8 mc, the characteristic impedance being 71 ohms. Unusual care was taken in this case to secure a uniform impedance characteristic. For this reason the outer conductor was held at an extremely constant diameter and, while flexible, was free from distortion on bending. The outer tube was designed to be fully self-supporting.

It may be added that such cables have also been proposed for primary television broadcasting on a toll basis. Cable runs, through densely populated sections having residents at an income level adequate to purchase such television service, might prove both technically and economically feasible but no data nor announced plans for such toll-broadcasting services are available.

E. STUDIO RADIO EQUIPMENT

This group comprises equipment in or near the studio, intended for the picture and sound pick-up, the control and modification of the resulting signals, the injection of synchronizing and allied signals, and the monitoring of all signals, further including film pick-up devices, and testing equipment. It constitutes a substantial fraction of the transmitting-station apparatus cost.

E-1. Video Pick-Up Equipment

The main element of the video equipment is the camera pick-up tube (variously referred to as an iconoscope, image iconoscope, dissector tube, emitron, and so on). The essential element in the storage type of tube is a mosaic plate carrying a multiplicity of photosensitive and secondary-electron-emitting granules on one side of an insulator and a conducting signal plate, from which the video output may be withdrawn, on the other side of the insulating plate. A collector or conducting coating in the tube is usually also provided for absorbing a portion of the secondary emission from the mosaic; and this is also usable as a signal-output terminal. Means are provided for (generally obliquely) scanning electronically the sensitive face of the mosaic plate in accordance with whatever scanning sequence is desired. The production of such tubes is a special art involving many elements of detail and expense. The mosaic plate itself is preferably ruby mica about 50 microns or less in thickness. It is of the most uniform and the highest quality available. Approximately 30 to 40 percent of the surface of the plate is covered by the particles, which are each less than one-tenth of the scanning spot size. One method of coating the mosaic plate involves air-settling a cloud of silver-oxide dust on the plate, the dust particles being later reduced by heating. A special furnace and separate settling-chamber equipment are required. One of the principal defects in the otherwise uniform deposits are particles of lint in the air; and accordingly special precautions are necessary to prevent lint settling on the plate during its formation. Another method of producing the granular structure on the plate is by agglomeration of either an evaporated, a sputtered, or a chemically-reduced silver film. The silver particles may be caesium coated with subsequent oxidation, there being a fairly wide variety of methods of treatment.

Halation effects (luminous image spreading) have been reduced in the iconoscope by sand-blasting the mica surface of the mosaic plate delicately to avoid specular refractions therefrom.

Recent improvements in these devices include scanning-beam guns producing an electron stream of constant current during the focussing process, and by such designs that secondary electrons from the gun apertures are not permitted to enter the primary beam. The "dark spot" in the iconoscopes (to be later discussed) has been reduced by the use of a cylindrical bulb for the iconoscope in place of the earlier spherical bulb. Another improvement has consisted in making the walls of the bulb photo-sensitive, and then steadily illuminating them and thus increasing the sensitivity of the device. Further, sensitiveness, spectral response, and saturated signal output have all been improved by evaporating an additional silver layer over the sensitized mosaic and rebaking.

In place of the insulating signal plate of the standard iconoscope, semi-conducting plates of appropriately selected glass have been tested in Europe. The resulting storage pickup tube is claimed to have considerably higher sensitivity and efficiency than the standard iconoscope, which sensitivity can again be increased by the use of a transparent photo-cathode and the focussing of the resulting electron-density image beam on the signal plate. Successful operation of semi-conducting-signal-plate pick-up tubes depends on suitable choice, in association, of the capacity between the picture element and the conductor at the back of the mosaic plate, the secondary emission factor of the mosaic, the time constant of the picture element as based on the capacity and resistance between the picture element and the back conductor, the collector potential, and the intensity of the incident light. In general, the best overall operation of this type of tube (with avoidance of picture persistence or "hang-over" through successive scannings) occurs when there is a certain residual space charge over the mosaic which tends to limit the electron emission therefrom, although this mode of operation naturally somewhat reduces the available sensitivity (by about 30%).

Iconoscopes are run with a second anode potential of about 1,000 volts. The iconoscope itself is preferably shielded electrostatically, for example, by an external and surrounding wire grid which is itself connected to an appropriate point in the first stage of the preamplifier. The output from the iconoscope is about 1 mv across 10,000 ohms, but in general the iconoscope should work into 30,000-300,000 ohms. Magnetic beam deflection is commonly used (the deflection yoke carrying both the vertical and horizontal deflection windings). The video-frequency amplifier connected to the iconoscope output is also electrically shielded and is designed to have a sufficiently low output impedance to enable satisfactorily sending the picture signals over a required length of special cable to the video control room.

The iconoscope preamplifier generally has an input of a few tenths of a microampere and an output of 0.5 volts or more for the peak-to-peak video signal. The first stage of the preamplifier is connected to the collector and signal plate of the iconoscope. It is principally designed to deliver the best available signal-to-noise ratio and need not necessarily have a flat frequency or phase characteristic. The correction of frequency or phase limitations of the first preamplifier stage may satisfactorily be carried out in later stages. In the first preamplifier stage, high transconductance low-plate-current tubes are most useful. Conventional older tubes have an input capacity of about 10 micro-microfarads, which is excessive for this purpose. New tubes of the specified type are available, and improve the signal-to-noise ratio several times in addition to having an extremely low shunt-input capacity.

The iconoscope produces certain spurious irregularities or shadings in the image field. These spurious signals may be as high as 3 or 4 times the picture signals. These are generally canceled out by the injection of reverse and locally generated and controlled shading voltages. This shading input can be introduced across a small resistance in the grid circuit of the first preamplifier stage. Typical preamplifiers have 4 or more tubes, and approximately 50 or more component parts.

More recently the "image iconoscope" has attracted attention and come

(*Continued on page 27*)

Another view of an open television camera. Note that Iconoscope shield has been removed. NBC photo.

Practical Aspects of Wideband

TELEVISION AMPLIFIER DESIGN

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Instructor in Electrical Engineering—
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MOST of the literature covering video amplifiers deals only with the theoretical factors limiting the high and low-frequency steady-state and transient response of resistance-capacitance coupled amplifiers and methods of extending the useful response region. The purpose of this paper is to present information of a practical nature which will be helpful to the designer of a wide-band, high-gain amplifier whether it is used for television or for other purposes such as biological research, or the study of transient waveforms.

BALANCED VS. UNBALANCED AMPLIFIERS

From a theoretical standpoint the balanced resistance-capacitance coupled amplifier offers some attractive advantages. As the grids of two tubes operated in "push-pull" are excited with identical signals displaced 180 degrees from each other, the current changes in the plate circuits of the tubes will also be identical, but displaced 180 degrees from the respective grid signals. As both tubes are connected to the same power supply, the instantaneous sum of the space currents drawn will be a constant amount provided the tubes, circuit elements, and signals of both sides are exactly balanced and that the signals are exactly 180 degrees out of phase. Because the bleeder of the power supply is an impedance common to all the stages operated from that power supply, any signal set up across this bleeder impedance will, in turn, be transferred to the other stages. As this common impedance is very low at the higher frequencies due to its being shunted with the output capacitance of the power-supply filter, feedback at these frequencies is unlikely. However, at frequencies of only a few cycles per second the reactance of these condensers becomes large, resulting in a large signal being transferred to preceding stages. The tendency is then toward a low-frequency relaxation oscillation commonly called "motor-boating." The balanced connection aids in decreasing the amount of voltage appearing across the power-supply bleeder and hence being applied to preceding stages by tending to keep the current drawn from the power supply by any given pair of tubes in a stage at a constant value, thus reducing the tendency to motorboat.

The decoupling networks $R_1 C_1$ and $R_2 C_2$ of Fig. 1 aid in keeping the signal voltage from appearing across the bleeder resistor. The decoupling network $R_1 C_1$ connected in this manner does not increase the effective plate load of the tubes at the low frequencies at which the shunting action of C_1 becomes negligible. In the unbalanced amplifier the amplification may rise to abnormal heights at very low frequencies because of the increase in plate load impedance of such a decoupling network. The extent of this difficulty in unbalanced amplifiers may be shown by an example encountered in one typical wide-band amplifier. The plate resistance was 1000 ohms and the decoupling resistance was 5000 ohms shunted by an 8-microfarad condenser. The normal stage gain was 9 from a few cycles to 1.5 megacycles. Owing to the increasing reactance of the condenser bypassing the 5000-ohm resistor at low frequencies, the effective load impedance of the tube increases eventually to 6000 ohms and the gain in the region of 1 cycle per second to about 54. With a large grid coupling condenser and grid resistor, this could make the stage abnormally sensitive to low-frequency surges and would undoubtedly result in relaxation oscillations. It will be noticed that an intelligent use of this same effect can be used to correct for poor low-frequency response and excessive phase shift. The $R_1 C_1$ network of the balanced circuit of Fig. 1 does not result in this desired or undesired increase in amplification at low frequencies to any appreciable extent. If low-frequency correction is desired in the balanced amplifier, it must be inserted at the points marked "x."

The bias for the tubes in a balanced stage may be obtained without degeneration by means of the unbypassed resistor R_b of Fig. 1. The cathode currents of both tubes flow through this resistance to ground, and the fact that the signal current of one tube is in phase opposition to that of the other results in a con-

*Presented at the second Pacific Coast Convention of the Institute of Radio Engineers, Portland, Oregon, August 11, 1938.

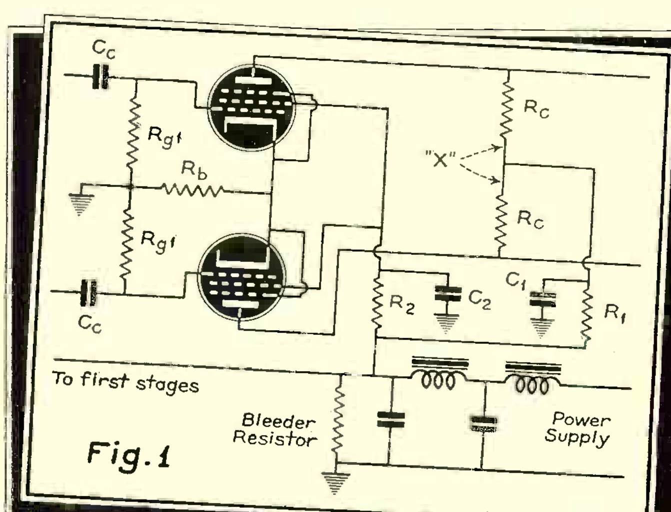


Fig. 1

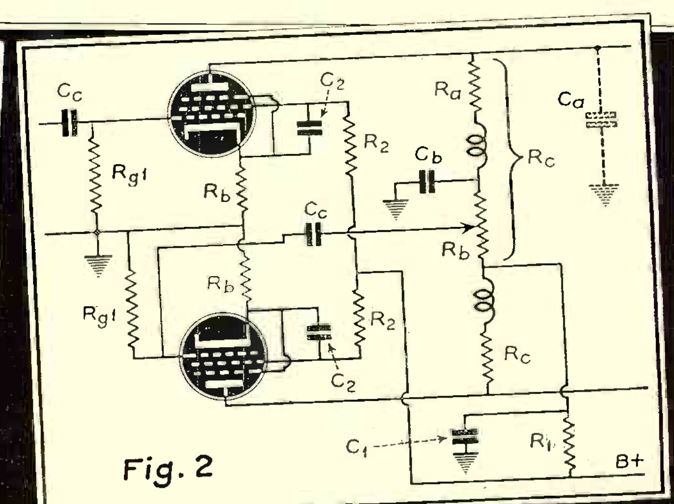
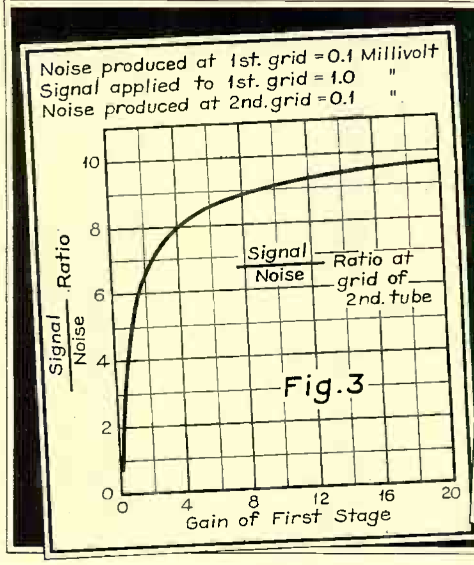
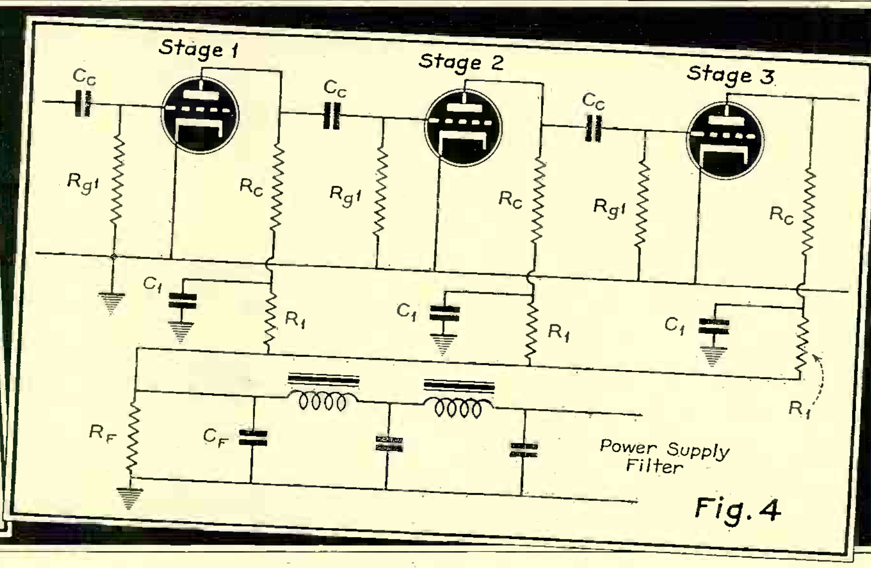


Fig. 2





stant current through R_b if the two halves of the stage are exactly balanced in all respects.

In a perfectly functioning balanced resistance-capacitance coupled amplifier, there should be no transfer of the signal from one side to the other. That is, if a signal is applied between ground and the grid of the tube on one side, no signal should appear in the plate or grid circuits of any of the following tubes of the opposite side. In other words, a balanced resistance-capacitance coupled amplifier is in reality two independent amplifiers put together. In practice it will be found that the combination of a wide frequency band and high overall gain will often result in trouble with the balanced amplifier which otherwise exhibits so many theoretical advantages. One common trouble is an oscillation of two tubes in one stage in parallel, with any mid-branch impedance acting as part of the load resistance[1]. Once this oscillation is set up, feedback can take place to preceding stages by virtue of the voltage across the mid-branch impedance of the power supply common to several stages. If the two halves of the stages are unbalanced in any way (such as one tube being more sensitive than the other) the stronger side sets up a signal across the mid-branch impedance in phase opposition to the signal of the weaker side, exaggerating the unbalance. It will be found very difficult to balance both sides because this unbalancing tendency is cumulative. Extremely good decoupling, perhaps even to the extent of decoupling the two tubes of a single balanced stage from each other, is one answer to these difficulties, but effective decoupling calls for either very large condensers or very large resistors or both. Satisfactory condensers larger than about 16 microfarads are not generally available and the large resistors necessitate high supply voltages to make up for the decoupling resistor drop.

Because of these troubles encountered in the balanced amplifier, it loses much of the theoretical glamor which might be attributed to it after a casual survey. With the older type of low transconductance tubes, many of these oscillation troubles may have been non-existent but with modern tubes (to be discussed later) having transconductances as much as seven and one-half times as high as the Type 57, these oscillation possibilities are enhanced.

Because the input to a balanced amplifier is often in single-end form, some sort of phase inverter must be used because transformers, which simplify the problem for audio frequencies, cannot be used over the wide range of frequencies used in television. Resistance-capacitance networks must be used and the inverter of Fig. 2 may be used with fair success provided the extremely high transconductance tubes are not used. By a judicious selection of grid circuit time constants, the low-frequency amplitude response and phase shift may be balanced for the two sides of the amplifier. The inverter is excited in phase opposition to the input tube by taking its excitation voltage from the plate circuit of the input tube. This involves a voltage divider which will divide uniformly to the upper frequency limit of the amplifier. In television amplifiers this frequency may be several megacycles, and special precautions must be exercised to insure equal voltage division for all frequency components. Equal voltage division at all frequencies will be realized only when the capacitance across each portion of the resistor is inversely proportional to that portion of the resistance. If the resistor is divided into two parts, R_a and R_b, then to make E_a (the voltage across R_a) proportional to R_a and E_b (the voltage across R_b) proportional to E_b at all frequencies, the relationship

$$R_a C_a = R_b C_b$$

must exist[2], where C_a is the capacitance, distributed or otherwise, across R_a, and C_b the capacitance across R_b. The ratio $\frac{E_a}{E_b}$ may have either a rising or falling characteristic with frequency, depending upon whether the factor $\frac{R_a C_a}{R_b C_b}$ is greater or smaller than unity. An estimate of the distributed capacitance to ground per stage makes possible the calculation of the approximate value of C_b needed.

Based on the preceding discussion of balanced and unbalanced amplifiers, and on the facts generally known regarding these amplifiers, the advantages of the unbalanced amplifier over the balanced type are as follows:

(1) No phase inverter trouble and adjustment.

(2) Half the parts needed for the amplifier proper.

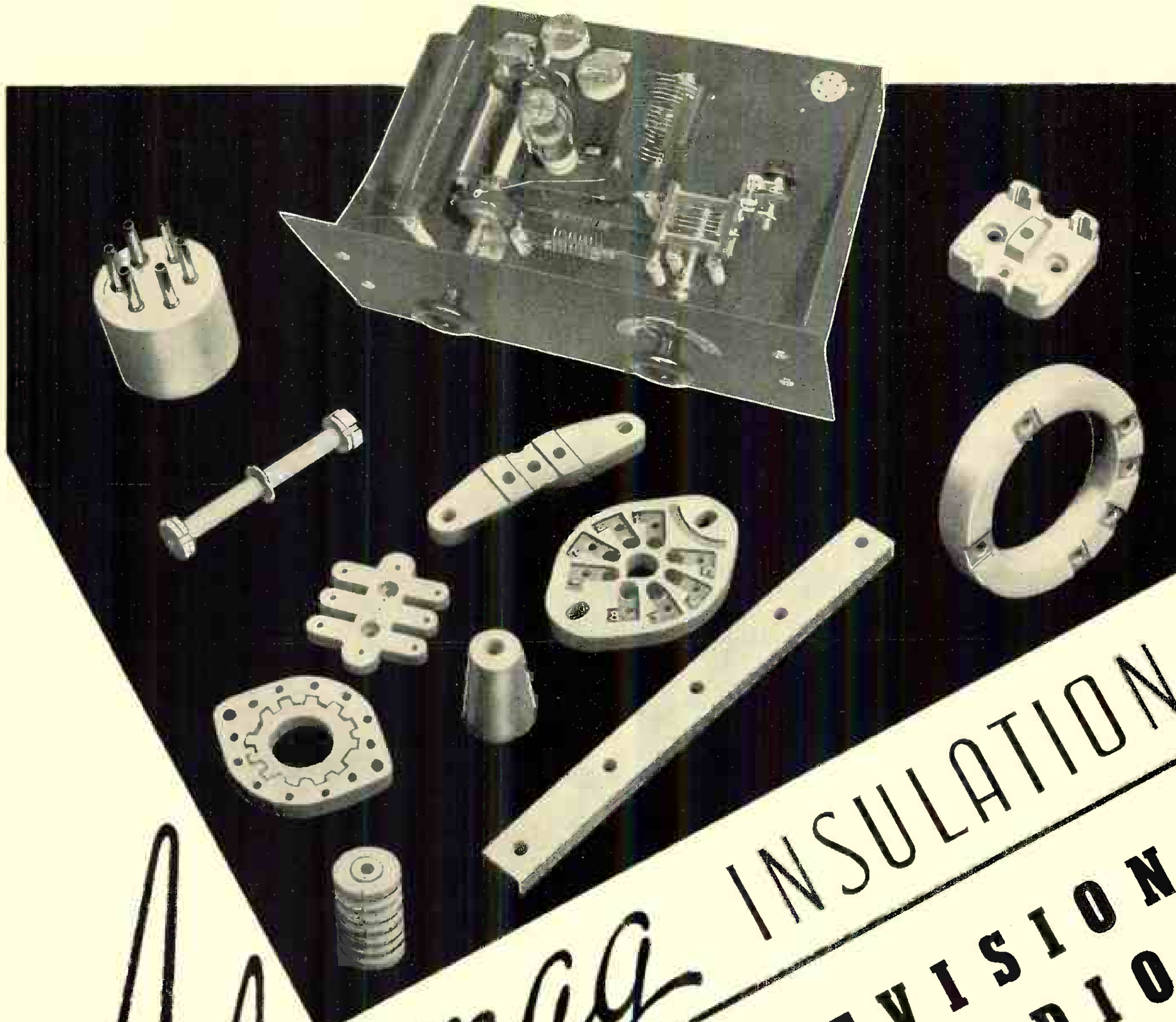
(3) Same gain as the balanced amplifier except that if balanced output is used the output voltage is double that of the single ended output—a gain of only 6 db.

(4) Only half the low- and high-frequency compensation networks to be inserted for the same frequency response.

(5) Only half the heat dissipated in the housing—a possible important factor with high gain necessitating many stages and tight shielding.

1"General Purpose Audio Amplifier"—Preisman, COMMUNICATIONS, p. 11, May, 1938.

2"Theory of Voltage Dividers and their Use with Cathode-Ray Oscillographs"—Peters, Blackburn, and Hannen. Bureau of Standards Research Paper No. 460.



SELECTION OF TUBES

The recent release of several high transconductance tubes has helped the designer of wide-band amplifiers greatly. The RCA Type 1851 and 1852, and the Sylvania 1231 are typical tubes now available which have transconductances of 9000 and 5500 micromhos respectively when connected as pentodes. A reasonable gain can be realized with these tubes even though it is necessary to use low plate load resistances to minimize the shunting effect of stray capacitances. For instance, an amplifier uncorrected for high-frequency response having a stray capacitance to ground as high as 100 micromicrofarads and a plate load resistor of 1000 ohms can realize a gain of 19 db per stage using a Type 1851 and still have a high-frequency response such as the 6F6 or 802 having relatively low inter-electrode capacitances and capacitances to ground are suitable.

For the low-level, voltage-amplification stages of a wide-band amplifier, these tubes are very useful. As their bias point is only about minus 2 volts, and the gain per stage is limited by the selection of that plate load resistor which is compatible with high-frequency response, a power stage is usually necessary to achieve enough output. Any of the ordinary pentode output tubes such as the 6F6 or 802 having relatively low inter-electrode capacitances and capacitances to ground are suitable.

The high transconductance type of tube has a great tendency toward instability unless the grid circuit resistance, consisting of the grid resistor and the plate load resistor effectively in parallel, is quite low. For the ordinary stage of the wide-band amplifier, the low plate load resistor dictated by high-frequency response considerations takes care of this, for it is usually only a few thousand ohms at the most. However, the input resistance of the first stage must be dictated by the type of equipment to be coupled to it. If this signal source is of the high-impedance type such as a phototube or electron multiplier, the high transconductance tube will be apt to cause instability in the form of oscillations which may degenerate into a blocking disturbance resembling the relaxation oscillation. For such applications a tube such as the Type 1603 is recommended, not only for its low noise properties, but also because it has a normal transconductance.

The shielding of the metal type of high transconductance tube unfortunately is often poor, at least in the earlier tubes. In several instances it was found necessary to scrape the enamel off the metal shell and install a band which was grounded at the nearest possible point. Connecting the shield pin to ground was often found to be insufficient.

NOISE

Microphonic characteristics of ordinary tubes necessitate the use of rubber mounted sockets or spring suspensions for the first one or two stages of high-gain amplifiers. Special tubes are available such as the Type 1603 in which the trouble from this source is minimized by extra bracing of the electrode structure. For gains of less than 80 db, microphonic noises will present no undue problems. In addition to special suspensions, installation of felt of other sound absorbing material may be necessary for protection of the electrodes of the initial stages against vibrations caused by extraneous sound waves for the higher gain amplifiers.

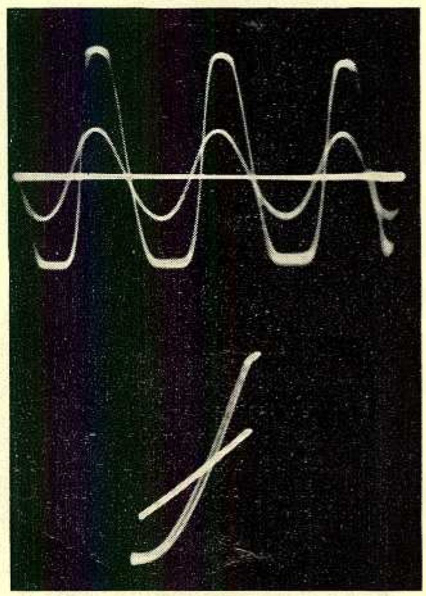


Fig. 5. Illustrating how cathode feedback straightens dynamic characteristic of an 1851.

Of the other sources of noise, thermal agitation and hum are most probable sources of trouble. The thermal agitation noise will be determined almost entirely by the resistance in the first grid circuit. The magnitude of the noise from this source may be calculated from the relationship:[3]

$$E^2 = (1.65 \times 10^{-20})\ R\ (f_2 - f_1)$$

assuming normal room temperatures to be the operating temperature of the input grid resistor, where

R = resistance causing themal agitation noises
$f_2 - f_1$ = frequency response band of amplifier
E = effective value of thermal agitation noise.

For example, the thermal noise that could be expected with an input grid resistance of 100,000 ohms with an amplifier whose response band is 2 megacycles wide would be about 53 microvolts effective. This would be about the theoretical minimum input noise voltage that could be hoped for without elaborate precautions and it may easily be the factor which limits the usable gain of a wide-band amplifier.

Hum from the power source is ordinarily greater than the thermal agitation noise if plate and heater power is derived from the a-c mains. Good filtering of the plate power supply for the initial stages is usually sufficient to minimize hum from this source. However, the heaters fed from a-c introduce hum by virtue of the alternating electrostatic and electromagnetic fields caused by the heater current. Suitable heater bias, as described by McNally[4], and careful shielding of the heater wires will help the situation. For extremely high-gain amplifiers, it is essential to heat the early tubes by means of batteries.

To keep the signal-to-noise ratio at the highest value, a relatively large gain should be used in the input stage. Let us assume that the total noise produced at the input grid is 0.1 millivolts and that an equal noise voltage is produced in the second grid circuit. It is obvious that noise produced in any stages after the second will have negligible effect. To preserve a signal-to-noise ratio of 10 to 1 the input signal must be at least 1 millivolt. Based upon these assumptions, Fig. 3 has been drawn. If there is a 10-to-1 signal-to-noise ratio on the input grid, the ratio at the second grid depends upon the gain of the first stage. Under these particular conditions, a first stage gain of less than 5 would be unwise unless ample signal were available. It might be said that, in general, the noise problem is not severe unless the amplifier has an overall gain of more than 80 or 90 db.

THE USE OF FEEDBACK

Negative feedback may be applied to wide-band amplifiers resulting in an improvement in frequency response, and a reduction in amplitude distortion and noise. In order to keep the feedback effect uniform throughout the entire frequency band in wide-band amplifiers, the blocking condenser used with the feedback resistor in the common two-stage type of feedback must be large enough to keep the reactance of the condenser small compared to the resistor in series with it. This feedback resistor is part of a voltage divider and any appreciable reactance of the blocking condenser upsets the division of voltage. The necessity of a large and bulky condenser

(Continued on page 38)

[3] Radio Engineering, Terman, 2nd Edition, p. 229.

[4] *Proc. IRE*, Vol. 20, p. 1263, August, 1932.

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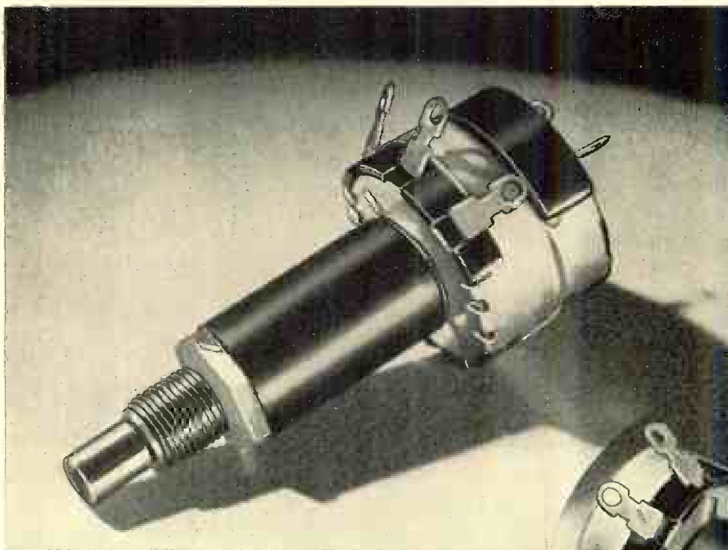
YOUR RESISTANCE PROBLEM



Television type CLAROSTAT composition-element control. Insulating bushing provides 2000-volt insulation to ground. ⅜ x 32 mounting bushing. (Shown slightly larger than actual size.)

Clarostat composition - element control for television, with 5000-volt insulating sleeve and ⅜ x 32 mounting bushing. Unit with power switch if desired. Any length shaft can be provided. (Shown actual size.)

CONTROLS

for Television

● HIGH voltages required in television reception call for exceptional insulation precaution in controls. The critical needs of video reproduction demand positive conduction throughout each control to avoid blotching of screen images. To maintain proper balance of delicate circuits, controls must maintain their resistance values within close limits.

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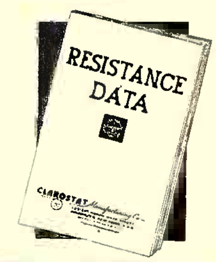
● *In addition to controls especially intended for television needs, CLAROSTAT offers wire-wound power resistors now found in television transmitters and studio equipment. Also glass-insulated flexible resistors, metal-clad resistors, precision resistors, plug-in resistors and ballasts, etc., etc. We either have what you need or can develop and produce that special resistor or control. So submit your problems and our engineers will collaborate with suggestions, specifications, samples, quotations.*



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Safety in Television Receivers

By Alfred W. Barber
Consulting Engineer

THE safety of tele-viewers, or whatever people who look in on television programs in their homes may be called, rests squarely in the hands of present and future television engineers. Since many who now consider themselves to be radio engineers will soon be concerned with television, this subject should interest them too. It is my purpose to present a picture of electrical shock, in general, and to show where television fits in this picture. At some future date a number of suggestions will be made for improving television safety factors.

While television literature is quite extensive, few references have been made to the matter of safety. Television receivers, only, will be considered at present since transmitters offer problems of a different order of magnitude.

ELECTRIC SHOCK

Electric shock may be divided into two broad classes: those due to current from a continuously operating source, and those due to current from a sudden discharge. First, the current from a continuously operating source will be considered. These sources include power lines, whether alternating or direct current, transformers, rectified power supplies after the initial contact, etc.

CAUSES OF DEATH

The most comonly accepted causes of death from electric current may be divided into three classes. First, the current may cause the heart or brain to lose its power to react to a stimulus. Second, metabolism in the body may be so accelerated that the blood is deprived of its supply of oxygen and asphyxiation results. Third, sudden violent muscular contractions may cause fatal hemorrhages in various parts of the body especially in the brain. Artificial respiration* may be effective in restoring life in the first two instances and especially in the second. The first two causes result usually from more or less prolonged passage of current while the third is usually the result of a sudden heavy current. The path which the current takes determines to a large extent the effect on the body. A path through the heart is usually much more dangerous than other paths.

SAFE CURRENT

The current which may safely be passed through the body depends on the frequency. Frequencies of 50 to 150 cycles are the most dangerous. Direct current is considered to be equivalent to alternating current at 350 cycles. The human body readily tolerates the following for considerable periods of time: 8 ma at 60 cycles, 30 ma at 11,000 cycles, 800 ma at 100,000 cycles, and 3,000 ma at 1,000,000 cycles.

While there is no close agreement by various investigators in the field, some sort of weighing of the available information would lead to the conclusion that 75 ma of 60-cycle current and 150 ma of direct current should be considered as a dividing point between safe and dangerous currents. The resistance which the human body presents to an electric circuit depends largely on the skin resistance and hence on the type and area of contact. In general it varies between 5,000 and 100,000 ohms in actual cases with something of the order of 30,000 ohms being average. Direct current usually kicks the subject away from the circuit while alternating current, especially at frequencies around 60 cycles, causes the subject to cling tighter to the circuit. Prolonged contact with the circuit usually causes more and more current to pass due to the breaking down of skin resistance. Above 50,000 cycles the muscular contractions disappear.

In 1934 the census of the United States showed that 442 people were killed by lightning and 723 by electric currents in that year. Insurance companies state that 50 percent of electric accidents are fatal.

CONDENSER CHARGE

Danger from condenser charge has not been very well investigated. An early investigator found 400 joules fatal to a 1-pound guinea-pig and concluded that the number of joules in the charge were more important than the voltage or initial current.[3]

GENERATED VOLTAGE

An automobile ignition system has considerable similarity to a television

Table I

Capacity	Joules at 1000 V.	Joules at 2000 V.	Joules at 5000 V.	Joules at 10,000 V.
0.01 mfd.	0.005	0.020	0.125	0.50
0.03 "	0.015	0.060	0.375	1.50
0.05 "	0.025	0.100	0.625	2.50
0.10 "	0.050	0.200	1.250	5.00
0.25 "	0.125	0.500	3.125	12.50
0.50 "	0.250	1.00	6.25	25.00
1.00 "	0.500	2.00	12.50	50.00
2.00 "	1.00	4.00	25.00	100.00
4.00 "	2.00	8.00	50.00	200.00
8.00 "	4.00	16.00	100.00	400.00

Table II

Capacity yielding 1 joule at various voltages

1000 volts	2000 volts	5000 volts	10,000 volts
2 mfd.	0.5 mfd.	0.08 mfd.	0.02 mfd.

[1] "Electrical Injuries," by Charles A. Tauffer.

*For the proper procedure to follow in case of a severe shock, readers are referred to "Resuscitation from Electrical Shock," by C. B. Desoto, p. 16. Feb., 1939. *QST*.—Editor.

[2] A. E. Kennelly and E. F. W. Alexander in *Electrical World*, July 21, 1910.

[3] Dr. R. N. Cunningham in *New York Medical Journal*.

receiver. The voltage generated is of the order of 10,000 to 15,000 volts. The waveform is very sharp being roughly equivalent to an impulse lasting for 0.0005 second. The system will pass impulses having peak currents of 100 to 200 ma through the human body. The system will pass about 1 joule per discharge through the human body. Such a system is not considered to be dangerous but will deliver an unpleasant shock. Perhaps "kick" is more descriptive of the feeling of the subject as it seems more mechanical than electrical.

Recommendations

High voltage transformer secondary current into 5000 ohms regardless of capacity in series or parallel should be less than 75 ma. for safety, less than 10 ma. to avoid possible uncomfortable shock.

Rectified current into a 5000 ohm load should be limited to a peak value of 150 ma. for safety, and 20 ma. to avoid uncomfortable shock.

Individual filter or by-pass condensers to avoid uncomfortable shock should be limited to: 2 mfd. at 1000 volts, 0.5 mfd. at 2000 volts, 0.08 mfd. at 5000 volts, and 0.02 mfd. at 10,000 volts.

High frequency or highly peaked waveforms should be used in high voltage supply whenever possible.

IMPORTANT FACTORS

Three characteristics are important in the television receiver: first, the short-circuit power transformer current; second, the short-circuit direct current from the power supply; and third, the joules in the filter condensers. Since the cathode-ray tube and its bleeder system may be operated on a current of the order of 1 ma the first two characteristics may be made perfectly safe by proper design. Table I has been prepared showing voltage, capacity and joules for various combinations. Table II shows the capacities which will store 1 joule when charged to various voltages. It is believed that Table II shows not only a safe limit but a limit which will insure a not too severe shock.

INTERLOCKING SWITCHES

Interlocking switches have been used extensively in television systems but are not considered infallible or a direct solution of the safety problem. A perusal of published circuits indicates an apparent lack of appreciation of the problem in many cases. A request sent to ten leading transformer manufacturers resulted in no useful information regarding current characteristics of their transformers. Measurements, however, showed that a transformer rated at 5 ma would deliver 140 ma into a low resistance, a dangerous current from a transformer with a very low rating.

RECOMMENDATIONS

It is appreciated that exact figures or figures applicable under all circumstances are impossible. Herewith are shown some recommendations for design of television receiver high-voltage systems. They are believed to be easily attainable from a technical standpoint and to represent safety from severe shock to the tele-viewer. A frank discussion of the subject is invited especially from those who have first-hand experiences to submit. As stated above, practical suggestions as to how the reccommended specifications may be met will be considered at some future time.

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C. L. Kasson in Electric Light and Power, March, 1930.

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TELEVISION COURSE

The Radio Electronic Television Schools 4709 Woodward Ave., Detroit, Mich., have announced a new training plan for both radiomen and those who have had no previous experience or training in television, electronics and radio. Heretofore the school has offered both home-study and residential training courses. The new plan contemplates an interchangeable arrangement for all students whereby a home-study student may transfer to the residential school, or vice versa, at any time during the training program.

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TELEVISION ECONOMICS

(*Continued from page* 19)

into partial use. In this device, the optical image is formed on a semi-transparent photo-cathode.

The light image reproduces itself in the form of an electron beam of corresponding electron density in its transverse cross section, which is then enlarged and magnetically focussed on the mosaic. The mosaic material has high secondary emission, and accordingly there is formed on the mosaic an amplified "charge image." This is scanned electronically to produce the picture signal.

The translucent photo-cathode consists of consecutive layers of silver oxide, caesium, and silver. The cathode coating may be made by spraying a metal on the glass surface: covering this with a layer of silver, oxidizing the silver layers, coating this with caesium, and baking the layers. It must be produced under precisely controlled conditions; and, in particular, means are necessary within the tube for evaporating silver on the cathode without having the evaporating device in the path of any portions of the beams necessary for the iconoscope operation. However, numerous improvements and variations are possible. Careful reduction of the electro-optical aberrations in beam focussing also is necessary.

The cathode may have a sensitivity of up to 50 microamperes per lumen. It is to be noted that caesium on caesium oxide on silver in the conventional iconoscope has given as high a sensitiveness as 40 microamperes per lumen, though it is usually considerably less.

The advantages of the image iconoscope include the following:

(a) The semi-transparent photocathode. has a sensitivity of 20-50 microamperes per lumen versus less than 15 microamperes per lumen for the usual mosaic in the "standard" iconoscope.

(*Continued on page* 49)

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ANDREA TELECEPTOR

THE VITAL IMPORTANCE of a correct antenna is appreciated by every manufacturer of television equipment and must be impressed upon every purchaser of such equipment. Man-made inter-

(*Continued on page* 47)

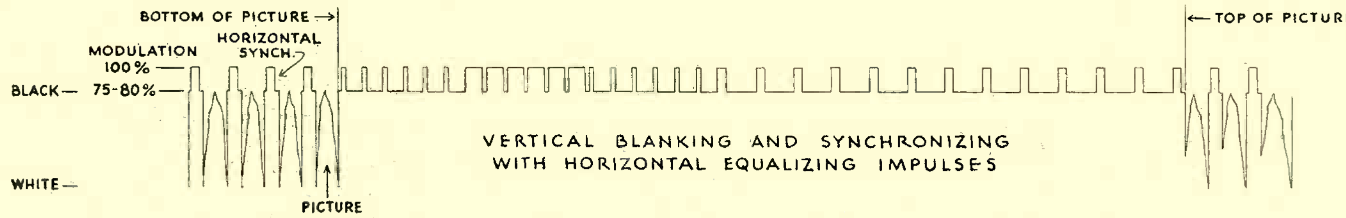


Fig. 1. Picture, synchronizing and blanking signals near bottom of one field.

RADIO TRANSMISSION CONSIDERATIONS

Sound vs. Picture

By T. A. SMITH
RCA MANUFACTURING CO., INC.
Camden

HOW does a television picture transmitter differ from a broadcast transmitter? Which of the performance characteristics are important in television? What system of modulation is employed? These and similar questions are frequently asked by the radio engineer whose experience lies with the more conventional systems. This article attempts to outline some of the differences in performance of radio transmission apparatus for sound and for pictures.

In the first place, a television transmitter bears resemblances to both telegraph and radio-phone apparatus. In addition to carrying the impulses of variable amplitude and frequency which make up the picture signal, it must also transmit regular impules which have certain similarities to a telegraph dot. These latter impulses are, of course, the synchronizing and blanking signals which appear at the end of each line and at the end of each half frame. Fig. 1 illustrates a highly hypothetical signal and shows the approximate degrees of modulation which are required by the various components. For negative modulation, a white portion of the picture will produce a decrease in carrier and hence low carrier amplitudes are due to bright sections of the transmitted image. The modulation of the television transmitter is very asymmetrical—quite unlike audio—a fact of considerable importance in circuit design.

The illustration shows the last few lines at the bottom of the picture before the scanning spot is returned to the top by the vertical synchronizing and difference in the width of the two types of synchronizing and blanking signals which corresponds to a considerable difference in frequency of the fundamental component. Note also the relative straightness of the sides of the impulses which must be reasonably well preserved. Note the slots in the vertical pulse for keeping the horizontal oscillator going during the return-line time. These factors refer to the important business of synchronizing. There is also the equally important requirement of sending the picture signal in proper form.

Fig. 4. The RCA 1000-watt picture transmitter. It is believed that the power of this transmitter, with a suitable antenna, is sufficient to render a satisfactory service over a reasonable area. It conforms with the RMA standards.

VIDEO REQUIREMENTS

First, let us consider the picture signal. For a 441-line picture scanned at the rate of 30 frames per second and having a relative width-to-height ratio of 4 to 3, the maximum frequency band required for transmission of equal horizontal and vertical detail would be in the order of from 30 cycles to 4 megacycles. If this frequency band is established as the response of the transmitter, it will be found that the synchronizing and blanking pulses can also be reproduced with a reasonable degree of accuracy. In fact the shape of these impulses was selected to fit within the picture requirements.

The synchronizing and blanking pulses are waveforms having relatively steep slopes. It is desirable to provide sharp slopes on these waveforms so that noise impulses will have little effect on the time of triggering off the oscillators in the receiver. The reproduction of these waveforms involves transmission of a frequency band of the same general order as the picture which does not introduce any additional requirements and enables the accuracy of synchronizing to be maintained within rigid limits.

D-C COMPONENT

So much for the higher limit of the band needed. But what about the low-frequency limit? This has been specified as the frame frequency of 30 cycles. However, the complete picture signal contains frequencies down to zero frequency or direct current because the symmetry of the signal changes during various sorts of picture transmission, since not all pictures to be transmitted contain the same total amount of light, thus resulting in a shifting of the a-c axis. Hence it should be remembered that television video signals are not, in general, regular and that the a-c axis (or line drawn so that the signals subtend equal areas above and below it) shifts during transmission. In sound transmission this is not an important consideration since the audio signal is reasonably symmetrical. This shifting of the a-c axis for two different sorts of pictures is shown in Fig. 2. For such a shifting signal, a difference in direct-current component is required for reproduction. This is necessary, but d-c amplifiers are difficult to handle and somewhat expensive. A much easier way, so far as merely conveying the intelligence for the picture background is concerned, is to transmit only the a-c component but to insert the proper varying d-c bias at the Kinescope end of the system, in the receiver. This is done readily by allowing the pedestal height to adjust the d-c bias of the Kinescope and so to bring the impulses back to their original positioning.

The d-c component is introduced at another point in the system; namely, in the transmitter. As indicated in Fig. 2, the signal going through the a-c system occupies a greater range of voltage than that required for a d-c system. A larger voltage excursion requires a greater field of modulation. For the sake of improving the transmitter efficiency, it is desirable to insert the d-c component in the transmitter and so to reduce the dynamic modulation range. This is done during the interval when the picture signals are transmitted, not during the time when the blanking signals are transmitted. The result is that the average carrier is varied to compensate for the shift in the a-c axis, in accordance with the over-all illumination of the picture, in a somewhat similar fashion to controlled carrier transmission, with resultant improvement in signal-to-noise ratio and higher transmitter efficiency. The receivers pick up only the a-c component so that it is necessary to reinsert the d-c bias again at the Kinescope. The d-c insertion at the transmitter is for purposes of increased efficiency and better signal-to-noise ratio, not for reestablishing the black level of the signal for reproduction.

Thus the frequency band required for an a-c system can be specified as covering the range of from 30 to 4,000,000 cycles—some 400 times wider than for a conventional broadcast transmitter.

What will happen if the transmitted frequency band is less than the required gamut? If the high-frequency response starts to fall off gradually, the effect will be a loss of detail along the lines, small details disappearing and vertical lines of demarcation between white and black areas becoming less distinct. Phase shift at the point of cutoff of the frequency-response characteristics should be avoided as this will tend to cause transients of alternate light and dark fringes to appear in the picture. Attenuation of low frequencies will affect the reproduction of large, horizontal shaded bands in the picture.

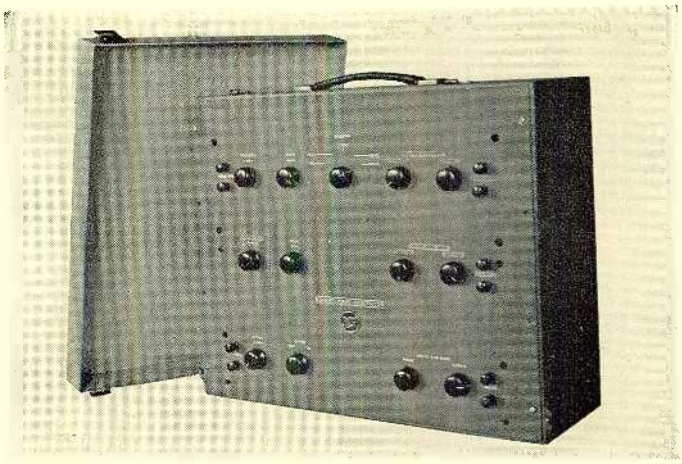
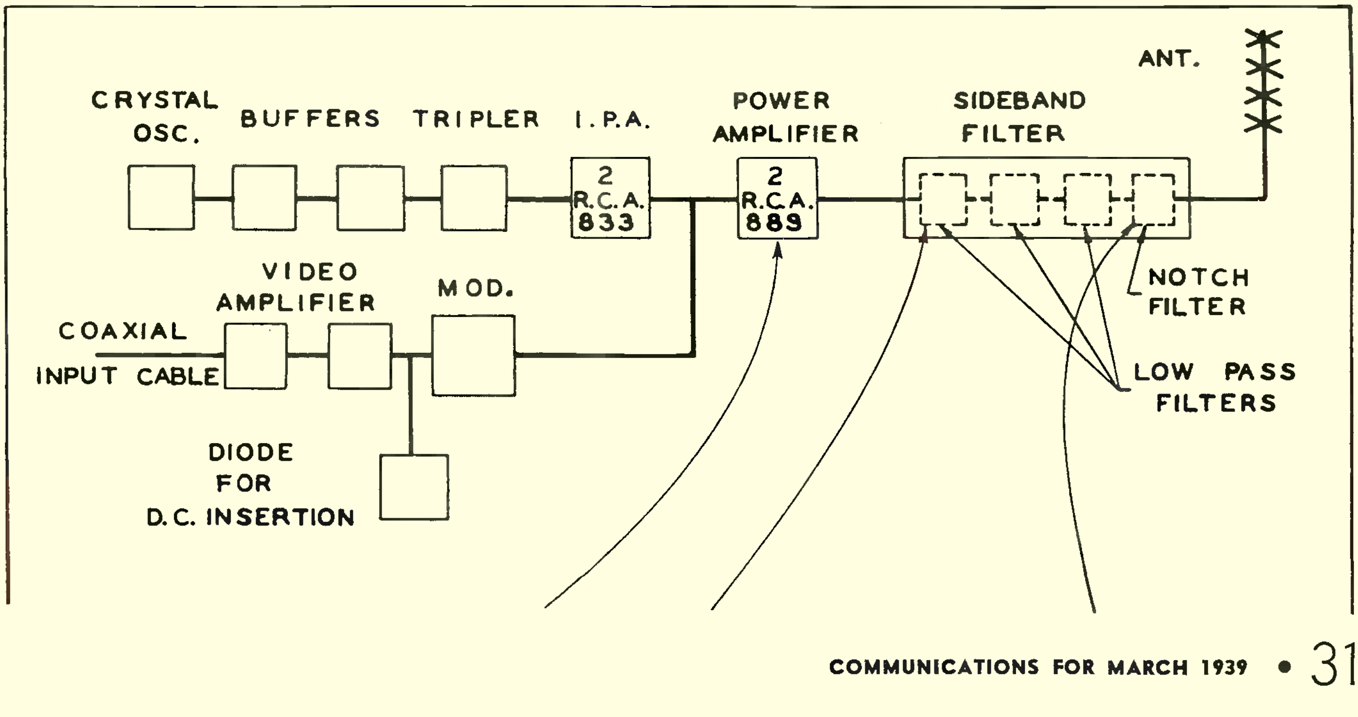


Fig. 5. Square-wave generator employed for checking phase displacement of circuits. The use of square waves for testing amplifiers was described on page 22 of the February issue.

NOISE LEVEL AND DISTORTION

Hum level must be low in a television system or the received picture will have broad gray and white bands. High-frequency noise produces an ever changing granular structure and other types of interference result in other annoying effects in the picture. Noise in the transmitter or amplifier circuits tends

Fig. 3. Block diagram of the 1-kw picture transmitter.



to limit the contrast range, tending to lighten the blacks or darken the whites. A hum level of the order demanded for broadcasting is usually satisfactory for television.

Harmonic distortion caused by non-linearity is not as serious as might be expected in comparison with the effects produced by harmonic distortion in audio systems. If, for example, modulation is effected in the grid circuit of the power amplifier, non-linearity of the modulator or power amplifier, resulting in harmonic distortion, is noticed principally as a change in contrast, usually preventing good halftone reproduction. This may wash out details in some areas of the picture and is undesirable but does not cause a sudden change of quality as does the appearance of harmonic distortion in an audio system.

TRANSIENTS AND PHASE ANGLE

The television transmitter, however, has other requirements which are not, at present, considered as important parameters in audio transmitters. The most important are the transient response and phase displacement.

In the television equipment, sudden impulses must not produce an oscillation or this will be seen in the picture. Filter systems are sometimes resonant in the video band and produce strange effects in the picture. Testing by means of square waves of various frequencies is apt to show up such conditions.

Phase shift of an objectionable sort will produce a light or dark fringe near a vertical line in the picture. The cause of this displacement and fringing will be apparent if it is considered that the edge of a vertical line corresponds to a high frequency whereas the width of the line corresponds to a lower frequency. If the higher frequencies are shifted in phase, the width of the line will be physically separated from the sharp edge, i.e., the line will have an indefinite, shaded edge with a sharply defined line a short distance away and parallel to it. It is desirable to obtain apparatus which will produce a phase angle proportional to frequency (constant phase shift expressed in microseconds). Square waveforms also provide an indication of phase shift taking place in the circuits.

TRANSMISSION SYSTEMS

Previous material has summarized the various factors which affect the performance of a television-picture transmitter. The actual design of the transmitter may be carried forward in a number of different ways. For example, it is possible to provide for low-level modulation with a series of linear-amplifier stages or the transmitter may be modulated in the final stage. Another variant is to provide for an r-f transmission system in which the video amplifiers are replaced by radio-frequency amplifiers in the studio. This may be compared to a system used for sound broadcasting in which a crystal oscillator of perhaps 100 kc was to be located in the studios and an r-f amplifier operated at the same frequency was to be driven by the crystal oscillator and modulated by the output of a microphone amplifier. Instead of employing audio-frequency amplification therefor, linear radio-frequency amplifiers would be employed and the modulated 100-kc signal would be sent to the transmitter. At the transmitter the signal would be heterodyned against another carrier and amplified in order to obtain the desired output frequency and power output. Television-transmission systems have

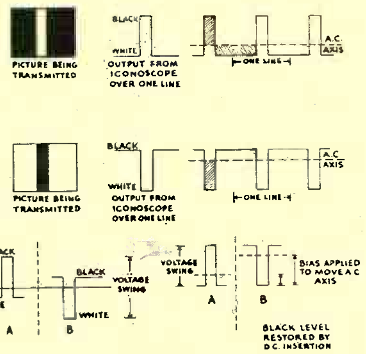


Fig. 2. Showing shift in a-c axis produced by change in symmetry of two video signals.

been constructed employing a parallel method of procedure.

In the RCA 1-kw television transmitter a more conventional system is employed. A crystal-oscillator circuit is followed by a series of frequency multipliers and buffers which drive the output amplifier. The final stage is grid modulated by a d-c coupled video amplifier of low plate impedance. The d-c component is inserted in the grid of the power amplifier by changing its d-c bias in accordance with the voltage produced from a small tube on which the pedestal voltages are applied. With this type of construction, it is not necessary to employ a series of wideband linear r-f amplifiers. Grid modulation has been used rather than plate modulation because it is difficult at present to produce large amounts of video power with wide frequency pass band characteristics. If plate modulation is used, thus requiring more modulating power, it will be found that due to the distributed capacity of the tubes, it is necessary to use low plate-coupling impedances and hence the power gain may become unity or less. Grid modulation has proved satisfactory for picture transmission, particularly since it appears that video harmonic distortion can be tolerated to a somewhat greater extent than in audio systems.

PARTIALLY-SUPPRESSED SIDEBAND

Because the television channels are only 6 mc in width, a portion of the lower sideband must be filtered out in order to retain the video sidebands within the prescribed limits. The RCA picture transmitters employ a filter between the output of the transmitter and the line to the antenna. This filter is composed of sections of concentric lines forming a high-pass filter with one or more notching sections for removing the sideband more completely outside of the channel. While a high-level filter requires the dissipation of the power contained in the section of the sideband which is removed, it assures complete filtering.

Test apparatus for lining up picture transmitters is of special design. A square-wave generator is desirable for checking transient response and phase displacement. This apparatus also provides an indication of frequency response, but a video sweep oscillator is convenient for checking frequency characteristics. A cathode-ray oscillograph, responsive to a wide video band is needed for testing as well as for setting levels. An r-f sweep oscillator may be desirable for checking the pass characteristics of the line, filter and antenna.

From this brief review, it will appear that the picture and sound transmitters differ considerably in respect to requirements from the standpoint of frequency response, distortion, noise level, phase displacement, etc. A consideration of these requirements has determined the design of picture transmitters and it is hoped that this will help to explain the divergencies in design between the newer equipment and the more conventional apparatus.

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CATHODE-RAY TUBE CHART

An elaborate lithographed two-color 2½ x 3½ foot wall chart just issued enables even the layman to understand the principles of cathode-ray tube operation. Compiled and published by DuMont this chart is finding uses in classroom, lecture halls, sales rooms, stores, servicemen's gatherings, and even in windows as an attractive display. The chart depicts a large cross-section view of a cathode-ray tube with lettered components and corresponding explanations. Copies of the wall chart may be obtained at the cost price of 50 cents each, direct from the Allen B. DuMont Labs.

INTENSIFIER TYPE CATHODE-RAY TUBE

PRIMARILY for larger and brighter television images at given cost, but likewise of importance in other applications, the DuMont intensifier element is said to mark a fundamental improvement affecting sensitivity of cathode-ray tubes. Covered by patent applications, this is a development of the Allen B. DuMont Labs., Inc.

The intensifier electrode takes the form of one or two metallic deposit rings near the screen end of the cathode-ray tube, and serves to accelerate the electrons *after* deflection. So equipped, a tube is said to have greatly increased brilliance without corresponding loss in deflection sensitivity. Heretofore, attempts at increasing deflection sensitivity while operating at given anode voltage, have been along lines of increasing deflection plate size and decreasing the space between.

The DuMont 54-9-T five-inch tube is provided with the intensifier feature, as well as several refinements in its gun structure to obtain better focus and modulating characteristics. In operation, the electron gun is operated at the same potentials and in the same manner as other DuMont tubes of corresponding screen diameter. The intensifier electrode may be connected to the final anode and the tube operated in the conventional manner. If, however, an additional voltage equal approximately to the accelerating electrode potential be applied between intensifier and second anode, the effect of the former is to brighten the pattern equivalent to doubling the accelerating voltage, yet not causing so great sensitivity decrease as would normally result. In terms of screen pattern size, this means that, instead of a 50% reduction which doubled accelerating voltage would normally produce, the voltage with use of accelerating element reduces pattern size by only 18%. Thus the design of deflection amplifiers is simplified considerably.

The positive potential required between second anode and intensifier electrode may be taken from existing cathode-ray tube power supply by addition of a single half-wave rectifier operating from the same transformer winding and connected in reverse polarity. Filter requirements may be satisfied by the use of a light filter condenser and a high-resistance bleeder.

INDUCTIVE TUNING

Design and Application

Fig. 1.

By O. J. MORELOCK

Radio Engineer

WESTON ELECTRICAL INSTRUMENT CORP.

THE method of tuning resonant circuits over broad frequency ranges by continuous variation of the circuit inductance, has been outlined in an article published in the February issue of COMMUNICATIONS. In this article it was shown by diagrams and curves that greatly expanded tuning ranges were available with increased uniformity of operation, using this system. Higher resonant circuit voltages were shown to be obtainable at the vacuum-tube grid, thus providing greater radio-frequency amplification in high-frequency, as well as u-h-f receivers. Circuits with Q increasing with frequency can be designed making use of the end-inductance feature. Furthermore, in multiple units these coils can be made to track accurately over the whole band once they are properly adjusted.

In adapting the continuously-variable-inductance (CVI) system to practical designs, considerable study was applied from the maufacturing angle. This involved simplification as much as possible, the minimum number of moving parts, a standard design for easy assembly in multiple units and a study of dial or indexing requirements.

U-H-F REQUIREMENTS

From the electrical standpoint it appeared that the severest and most pressing requirements for tuning devices of this type, were present in high-frequency and u-h-f fields. Equipments with a high order of stability and broad coverage are definitely needed for experimental and *actual service work* in the higher frequency section of the spectrum. Testing devices as well as higher gain receivers are required for all the mobile services including television, aircraft, police, amateur and military as well as other services. Accordingly, high-frequency and u-h-f design problems were attacked first in the CVI design, as these devices will undoubtedly be most urgently required.

This is the second article of a series on this interesting subject. The first article appeared on page 12 of our February issue.—Editor.

Tests showed that a ¾-in. diameter coil would cover most requirements up to approximately 175 megacycles. The coil forms are of high-grade bakelite tubing and are accurately grooved for the wire. Several end-ring arrangements were tested and it was found that screw-machine brass rings knurled to fit the inside diameter of the coil tube would provide the best design. The ground end ring is solid fitting into the ground end of the coil and equipped with a hole and set screw for fastening and positioning on the shaft. The grid end ring has an enlarged hole for shaft clearance and low shunt capacity. One assembled coil with end rings is shown in Fig. 1. The coil is wound with special wire which is, in turn, connected to the two end rings and forms the assembly as shown.

To provide a greater working range and a lower minimum coil inductance, a single-wheel carriage design was worked out. The original design of this device included a double-wheel carriage, but this new arrangement allows the contactor to approach much closer to the grid end of the coil and makes use of the last fraction of coil turn right up to the grid-ring connection. This single-wheel design may be observed in Fig. 2. The contactor cannot be seen, but actually rides on the wire above the wheel and in under the frame and antler spring. The contacting nib does nothing but its own job of making contact, the rotation of the coil, in conjunction with the carriage motion through the wheel, keeping the contactor in position on the wire. By observation it will be seen that the contactor leads the wheel in approaching the high-frequency end of the coil as the coil is rotated.

A group of wheels as used in the carriage assembly to follow the turns of wire on the coil are shown on the front cover.

Having designed the carriage to allow close approach of the contactor to the coil end, it was necessary to provide an accurate stop mechanism. Such a mechanism would require the following features:

(1) Free movement of the coil and carriage should be allowed through all required turns.

(2) The rotation of the coil should be stopped accurately before the contactor reached the end of the last turn.

(3) If possible, means should be provided for indicating the turn number at any point in the coil rotation.

Various worm-gear arrangements were tried, but it was found that too much stress was set up in the high ratio gears and too much torsion or frame weave occurred for accurate stopping. It is quite possible that with very heavy parts a worm-gear drive and a stop might be worked out, but the design would be bulky and expensive.

Accordingly, a novel and practical combination stop mechanism and turn counter was evolved by the writer. The design provides an accurate stop mechanism with low gear ratio and provides means for stopping the coil rotation within two or three degrees at any predetermined number of turns. A partial side view of this

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mechanism may be observed in Fig. 3. The stop gear is moved over one position each time that the coil is rotated through 360 degrees, and an index plate carrying the turn numbers is fastened to this gear. This index plate works in conjunction with a uniformly divided dial, the turn number being read on the index, and the decimal fractions of the turn indicated on the dial.

As mentioned previously, the end inductance and tuning capacitor mount between the grid coil contactor and ground. A complete tuner with these two components in place is shown in Fig. 2. The photograph was taken from an angle to illustrate this mounting and to show the carriage.

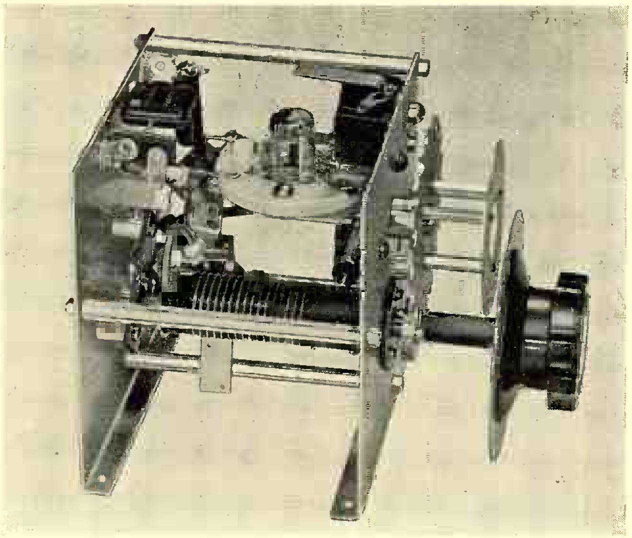


Fig. 3. An inductive tuned oscillator unit from which a partial side view of the combination stop mechanism and turn counter can be obtained.

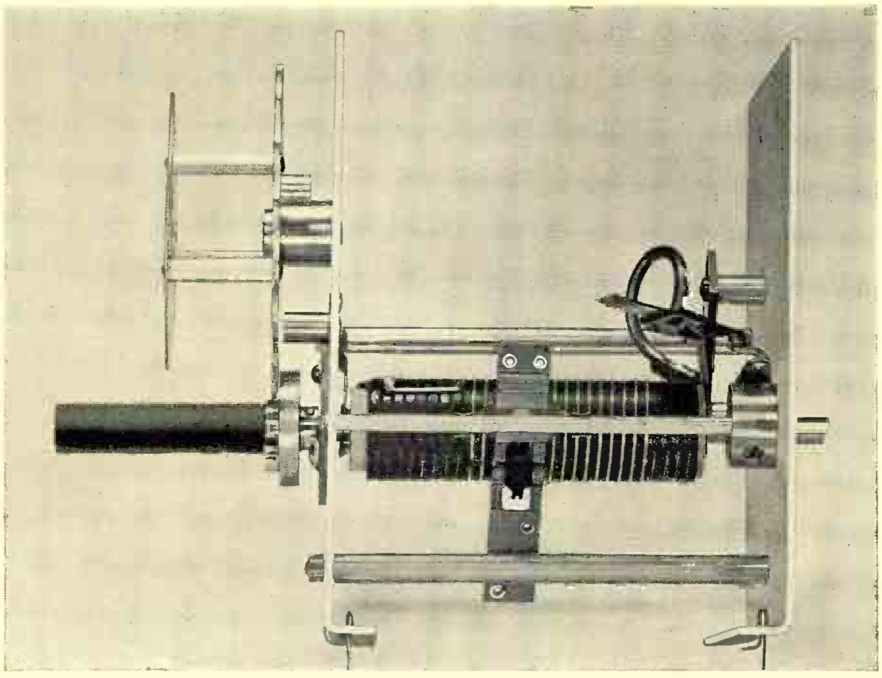
U-H-F OSCILLATOR

There has been much demand for a portable high-frequency oscillator in the television, aircraft, government, and police fields. The first production application of the CVI system will appear shortly on the market in the form of a compact u-h-f oscillator Fig. 4, weighing only 16 pounds and covering a frequency range of 22 to 150 megacycles. This continuous band is available on fundamentals with 16 complete revolutions of the dial affording over 5700 degrees of dial tuning. The coil is driven directly by the dial, thus affording accurate resetability at all points, by eliminating any gear mechanism. Fig. 4 shows the complete oscillator as it will be sold, equipped for various types of service in mobile work.

The r-f section of the high-frequency oscillator is completely assembled between the two end plates of the inductance tuning unit. This makes use of a standard acorn type 955 tube with associated filters for operation over the wide frequency range. Fig. 3 shows the r-f section with the tube and component parts in position. Note the compact arrangement of the parts and the very short grid and plate leads to the oscillator tube. The end inductance, tuning capacitor and grid coupling condensers can be easily seen connected in the grid circuit of the acorn tube. The circuit used is a modified Colpitts with a capacitive center tap connecting into the cathode circuit. Plate and cathode r-f chokes are shown in the upper left and center right-hand sections of the photograph. At the top center of the picture may be seen the connecting spring which makes contact to the antenna rod when this is fastened in position on the top of the oscillator case. Only three battery connections to this unit, as shown, are required to provide a continuously-variable-frequency oscillator from 22 to 150 megacycles. The circuits are adequately filtered so that no particular precautions need be taken in the leads from the supply circuits to the oscillator section.

Referring to Fig. 4 many interesting features have been included in this device to provide accurate and dependable signals in the high-frequency and u-h-f bands for mobile service work. CW or modulated signals are available from either the antenna rod or the attenuator jacks as required. A 400-cycle modulator is included which may be switched on providing approximate 30% modulation over the whole frequency band.

Fig. 2. A tuner. Note the end inductance and tuning capacitor.



A beat-note detection jack is available for plugging in phones and making zero-beat adjustments for crystal operation, or for zero beating with local transmitters. The oscillator is equipped for picture modulation on all television bands. A picture modulator will shortly be available, designed with output circuits for correctly modulating the u-h-f oscillator. This merely plugs into the jack in the upper center section of the panel. With this combination, television signals are emitted from the antenna rod or attenuator jacks. The internal circuits of the oscillator are designed for flat modulation characteristics and these circuits will cause no appreciable sideband attenuation even on television-modulation signals. Likewise. all types of audio-response curves can be taken on receivers by supplying uniform modulation from audio oscillators to the external modulation jack.

The 2½-in. instrument noted on the panel operates in six different ways through the rotary selector switch. This

NOW .. ULTRA HIGH FREQUENCY SIGNALS

WHERE YOU WANT THEM

22 TO 150 MEGACYCLES

24 hours a day!

WITH THE NEW

WESTON Television ULTRA HIGH FREQUENCY OSCILLATOR

- Frequency—continuous range 22 to 150 megacycles—no band switching.
- All frequencies fundamental.
- High order of stability and resetability over entire range.
- Equipped for television modulation.
- Employs continuously variable inductive tuning.*
- Equipped for use with crystals.
- Battery operated (self contained).
- Equipped with 400 cycle modulator.
- Used with portable antenna (included) or with standard output leads.
- Jack provided for external power to increase radiation.
- Over 5700 degrees of continuous dial rotation.
- Meter equipped, for six control measurements.
- Small size, light weight, extreme portability.

* Patents Pending

Essential for all branches of television, for police radio, aircraft, maintenance trucks, etc.

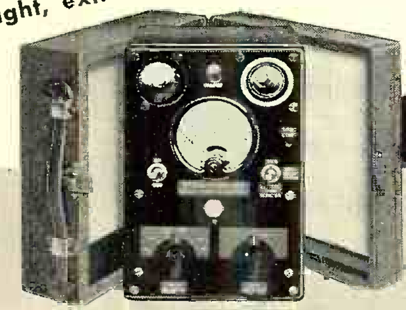
Model 772

5000 VOLT

TELEVISION AND RADIO ANALYZER

Sensitivity 20,000 ohms-per-volt.
Input impedance 100 megohms on top range.
Specially designed low-leakage jacks.
Breakdown voltage in accordance with AIEE safety standards . . . 11,000 volts.
Current readings down to ½ microampere.

NOTE—present owners of 20,000 ohms-per-volt analyzers can bring them up-to-date with the compact WESTON 5,000 volt Televerter . . . an inexpensive multiplying unit which fits the carrying case.



Model 669

VACUUM TUBE VOLTMETER—measures gain in video and sound amplifying channels—peak voltages in thyraton (sawtooth) generators in oscillator circuits—grid potentials on cathode ray tubes—as well as other essential measurements in all sound receivers.

SEND COUPON FOR COMPLETE INFORMATION

Weston Electrical Instrument Corporation
612 Frelinghuysen Ave., Newark, N. J.

Send bulletin describing the Model 787 Ultra High Frequency Oscillator and other WESTON Instruments.

Name____________________

Address____________________

City__________ State__________

is used for various purposes including measurements on both of the internal batteries so that immediate checks on these batteries can be made by the operator. Equipment is included for crystal operation and this involves metering and tuning equipment as well as an internal socket for quartz crystals. When used in this way, the signal emitted from the rod is modulated by the crystal oscillator, and the beat note between the crystal and u-h-f oscillators may be picked up with a receiver. Thus the unit forms a miniature crystal-controlled transmitter for high-frequency work, which can be set up at a moment's notice anywhere in the field, on the wing of an airplane or near a car, etc. No connections are required with the rod, and the efficiency and operation of the antenna system on the mobile unit can be tested rapidly. This is an important advantage, as the characteristics of any car or plane antenna are altered when connections from a signal generator are made directly to the antenna input.

One important feature of this service oscillator is its phenomenal stability over this very broad band of frequencies. The inductively-tuned oscillator circuit has many advantages along these lines, in that vibration effects causing variation in frequency in condenser tuned oscillators are not present. Furthermore, variation in tube capacitance has very little effect on the oscillator *at any point in the range* as the tuning capacitance is fixed and also constant at all times. The tube capacity is actually a small percentage of the total and this is true regardless of the frequency setting of the oscillator. Due to the large number of revolutions and direct-drive features, the resetability of the oscillator to a predetermined frequency, is quite accurate and this along with the high-stability features of the device make it a valuable piece of equipment for all types of measurement in the high-frequency spectrum.

Fig. 4. An ultra-high-frequency oscillator which uses the CVI system. This unit weighs 16 pounds and covers a frequency range from 22 to 150 megacycles.

ISEC TAKES FINCH LICENSE

W. G. H. Finch, President of the Finch Telecommunications Laboratories, Inc. has announced that the International Standard Electric Corporation, a subsidiary of the International Telephone and Telegraph Company, has taken out a license under the Finch facsimile patents.

CUTLER-HAMMER APPOINTMENTS

The promotions of Mr. E. W. Seeger to Chief Engineer and Mr. P. B. Harwood to Assistant Chief Engineer are announced by Mr. W. C. Stevens, Vice-President in Charge of Engineering, Cutler-Hammer, Inc., Milwaukee manufacturers of electric apparatus. Prior to their advancements, Mr. Seeger was Assistant Chief Engineer and Mr. Harwood General Engineering Supervisor.

WESTINGHOUSE APPOINTMENTS

C. J. Burnside, formerly Manager of Radio Engineering for the Westinghouse Electric & Manufacturing Company, Baltimore, Md., has been appointed Manager of Radio Sales, Walter Evans, Radio Division Manager, announced recently. Succeeding Mr. Burnside is Donald G. Little, former Chief Engineer of the radio engineering department. John W. McNair, formerly works manager of the Westinghouse Merchandising Division at Mansfield, Ohio, has been named Assistant Manager of the radio division.

TELEVISION AMPLIFIERS

(*Continued from page* 24)

is readily seen. Phase shift of this feedback voltage and the possibility of oscillations existing in all multi-tube feedback circuits cause many to avoid their use for wide-band purposes.[5]

Single tube feedback, however, of the type obtained by employing an unbypassed cathode resistor, is extremely simple and foolproof in its operation and offers some worthwhile advantages. Cathode bias in wide-band amplifiers calls for a very large capacitance to shunt the bias resistor so that no degeneration will occur at the very low frequencies causing abnormal loss of amplification in that region. As the reactance of a 100-microfarad condenser is about 80 ohms at 20 cycles per second, it is obvious that the loss in gain in this region would be appreciable with 100 microfarads across a 150-ohm cathode resistor. Good low voltage electrolytic condensers are available, but for avoiding a drop in low-frequency response, several hundred microfarads would have to be used, a bulky and relatively expensive arrangement.

The use of an unbypassed cathode resistor does cause degeneration and hence results in a loss in gain, but the response will be independent of frequency as far as the cathode resistor is concerned. The loss in gain can be made up by increasing the load resistance. This resistance can be adjusted so that the same gain is realized using degenerative feedback that was obtained with the bypassed cathode resistor. The only sacrifice will be a slight reduction in high-frequency response. By using the new high transconductance tubes this increase in gain can be realized by using a plate load resistance that, although larger than before, is still relatively small. For example, consider a stage employing a type 1851 tube operated with a bypassed 150-ohm cathode resistor and with a plate load resistance of 1000 ohms. The voltage gain of the stage under these conditions is 9. By removing the cathode bypassing condenser the distortion arising in that tube is greatly decreased and the stage is freed from low-frequency loss in amplification, but the overall gain falls to 4.25. By employing a plate load resistance of 2350 ohms, the gain is again 9 for the stage. The slight loss in high-frequency response can be easily cor-

[5]An excellent summary of the use of common types of feedback is given in an article by Terman in January, 1937, *Electronics*.

rected by one of the standard ways[6]. It must be borne in mind that no improvement in frequency response is realized by single-tube feedback except that the discrimination against the low frequencies by the bias condenser-resistor combination is eliminated. It might be said that the use of this type of feedback is made possible in wide-band amplifiers by the introduction of the new tubes.

The straightening of the dynamic characteristic by means of cathode feedback in a single stage utilizing a type 1851 tube, and the resulting decrease of tube distortion is shown in the cathode-ray oscillogram of Fig. 5. Without cathode feedback the larger distorted wave and the severely bent dynamic characteristic is attained. The introduction of cathode feedback by the removal of the cathode bypass condenser results in the straight characteristic and the nearly perfect sine wave in the output.

The necessary calculations for the design of single tube feedback circuits are easily made. The feedback factor, β, is found from

$$\beta = \frac{R_b}{R_c},$$

where R_b is the cathode bias resistor and R_c is the plate load resistance. This holds as long as R_c is small compared to the plate resistance of the tube and the grid leak resistance of the following tube. The amplification, A, which would be realized if the cathode resistor were bypassed can be found from the expression,

$$A = G_m R_c,$$

where G_m is the transconductance of the tube. This amplification is reduced by cathode bias degeneration. The actual gain realized is given by the following expression.

$$\text{Actual gain} = \frac{A}{1 + \beta A}.$$

In using unbypassed cathode resistors, the screen grid should be bypassed directly to the cathode.

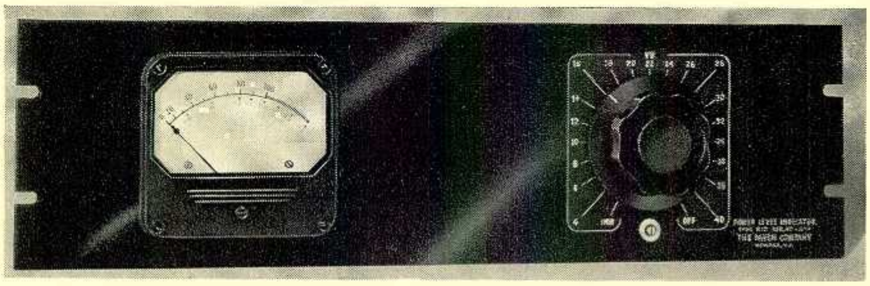
POWER SUPPLIES

As far as plate and screen electrode potentials are concerned, well designed power supplies of the conventional rectifier-filter type are very satisfactory for wide-band, high-gain amplifiers. The only exception may possibly be the

(*Continued on page* 48)

[6]See "High-Frequency Correction in Resistance-Coupled Amplifiers," by E. W. Herold, COMMUNICATIONS, August, 1938; "Wide-Band Television Amplifiers," by F. Alton Everest, *Electronics*, January, 1938; "Amplification Problems of Television," by F. Alton Everest, COMMUNICATIONS, January, 1938. Each of these articles contains several references to the literature on this subject.

the New DAVEN Type No. 910
POWER LEVEL INDICATOR



It is designed to indicate audio levels in broadcasting, sound recording and allied fields where precise monitoring is important. The type 910 unit is completely self-contained, requiring no batteries or external power supply. The indicator is sensitive to low power levels, rugged and dependable.

The new WESTON Type 30 meter used with this unit is a copper-oxide type instrument possessing nearly ideal characteristics for monitoring purposes. The adjustment is such that the pointer will indicate 99% normal deflection at zero Db. in approximately 0.3 seconds. Overswing is not more than 1 to 1½%. The meter scale is calibrated in decibels and percent. It is large, clearly marked and carefully designed to minimize eye fatigue.

Two meter controls are provided, one a small decade with screw-driver adjustment for zero level setting of the meter pointer; the other a constant impedance "T" type network for extending the range of the instrument in steps of 2 Db.

Because of the length of the meter scale, small differences in pointer indications are easily noticed. For this reason the screw-driver type vernier is provided. All V.I. meters can thus be adjusted to the same scale reading. This is particularly convenient in complex installations where several V.I. meters must be read by one operator, or in coordinating the various meters at different points in a network.

SPECIFICATIONS

★ INPUT IMPEDANCE: 7500 ohms constant on all steps of meter range switch except on the 1 mw. calibration step.

★ POWER LEVEL-RANGES: Standard 1 mw. at 600 ohms reference. See table below.

★ FREQUENCY RANGE: Less than 0.2 Db. variation up to 10,000 cycles.

★ SCALE READING: Meter calibrated —20 to +3 Db. and 0 to 100%. Type "A" Scale, for sound level work is marked in Db. on the upper scale; Type "B" scale for broadcasting work is marked in percent on the upper scale.

★ INDICATING METER: Copper-oxide-type adjusted for deliberate pointer action. Large clearly marked scale.

★ METER RANGE CONTROL: Heavy duty "T" network. Input impedance 7500 ohms; Output impedance 3900 ohms. Attenuation variable in steps of 2 Db.

★ METER ADJUSTMENT CONTROL: Miniature step-by-step decade type unit. Designed for fine adjustment of the zero level reading over a range of ± 0.5 Db.

★ TERMINALS: Screw type lugs.

★ MOUNTING: Standard relay rack mounting Panel 5¼ x 19".

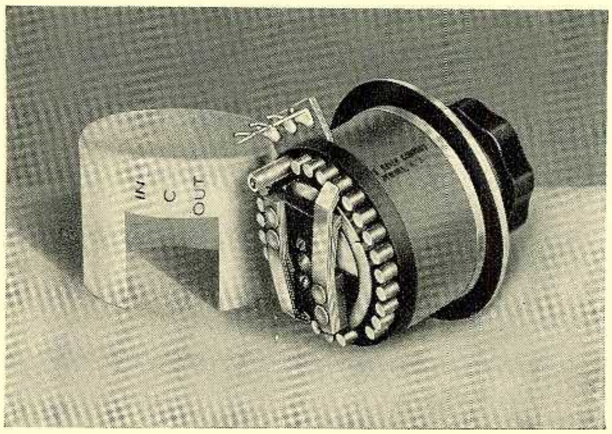
★ FINISH: Black alumilite, dull satin finish; R.C.A. or W.E gray.

★ NET WEIGHT: 3½ lbs.

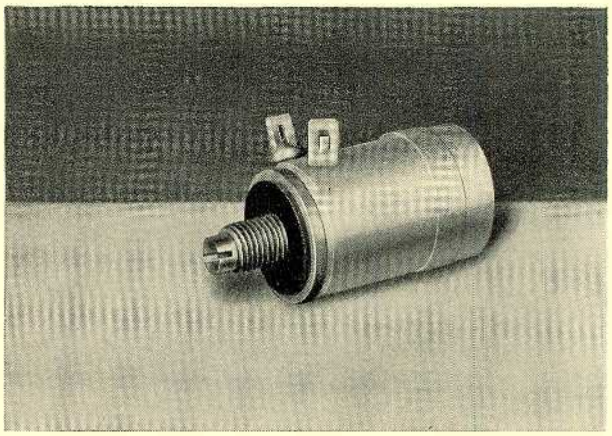
Type No.	Range	Zero Level	Scale	Price
910-A	1 mw. 4 to 40 Db. off	1 mw. 600 Ohms	A	$65.00
910-B	1 mw. 4 to 40 Db. off	1 mw. 600 Ohms	B	65.00
910-C	1 mw. 4 to 24 Db. off	1 mw. 600 Ohms	A	60.00
910-D	1 mw 4 to 24 Db. off	1 mw. 600 Ohms	B	60.00

Units calibrated 6 mw. across 500 ohms available upon request.

NOTE: Unless otherwise specified, meter range controls will be supplied turning counter-clockwise for decreasing attenuation.



The new attenuator illustrated above is a 12 step unit. Both the 12 and 20 step attenuators are in stock for immediate delivery.



Special screw-driver type rheostat for calibrating meter.

Type T-994	12 step attenuator	Price $12.50
Type TA-1000	20 step attenuator	Price 17.50
Type 991	Rheostat for calibrating meter	Price 2.50

THE DAVEN COMPANY

MANUFACTURERS OF SINGLE & DUAL POTENTIOMETERS, SPECIAL ROTARY SWITCHES, FILAMENT RHEOSTATS, MIXER PANELS, VARIABLE & FIXED ATTENUATORS, FADERS, RF SWITCHES, VOLUME INDICATORS, OUTPUT METERS, LINE EQUALIZERS, ATTENUATION BOXES, MULTIPLIERS, SUPER DAVOHMS, LABORATORY EQUIPMENT, SPEECH INPUT CONTROL APPARATUS, DECADE RESISTANCES, RESISTANCES, DAVOHMS, GAIN SETS, AND OUTPUT POWER METERS.

158 SUMMIT STREET **NEWARK, NEW JERSEY**

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

W. J. McGONIGLE, President | **RCA Building, 30 Rockefeller Plaza, New York, N. Y.** | **H. H. PARKER, Secretary**

ACHIEVEMENT AWARD

THE FIRST Marconi Memorial Medal of Achievement awarded by our Association was presented to David Sarnoff for his outstanding achievements in the radio art. Mr. Sarnoff was unable to receive the medal in person at our Fourteenth Annual Dinner-Cruise at the Hotel Astor on February 11th, 1939, as he was a guest at the home of Ambassador Joseph P. Kennedy, at Palm Beach, Florida, at the time. The presentation of the medal by our President, William J. McGonigle, and its acceptance by Mr. Sarnoff, were made by long distance telephone connection. A loudspeaker was used at the banquet to carry Mr. Sarnoff's voice to all parts of the hall.

In presenting the medal to Mr. Sarnoff by long distance telephone our President said:

"Fellow members of the Veteran Wireless Operators Association: Thirty-two years ago a young lad gained the proud title of Junior Operator with the American Marconi Company. A year later, he was assigned to his first station, at Siasconsett, Massachusetts. For four years he remained an operator, being assigned to more and more important stations until he was appointed Radio Inspector for the company. Those four years at the key rendered this young man eligible for membership in our Association and he has been a member since our incorporation and has the distinction of being our Number 1 Life Member.

"In 1914, he became Contract Manager for the Marconi Company. Then he gave up his active membership in the telegraphic fraternity, and started up the ladder of executive operation. He then became Commercial Manager, General Manager, and finally in 1930, President of what had in the meantime become one of the largest communication companies in the world, the Radio Corporation of America. I need not say to you that I have been referring to former wireless operator, David Sarnoff.

"We are proud of his success for many reasons, but chiefly because his is the success of 'one of us.' And to give tangible proof of our high regard and esteem we present to him this evening our first Marconi Memorial Gold Medal of Achievement in tribute to a wireless operator who has risen to a position of eminent prominence in the communications industry.

"Veteran Sarnoff cannot be with us this evening, on account of conditions not under his control, but we will now listen to his acceptance of this award. Mr. Sarnoff is talking by long distance telephone from Palm Beach, Florida. Mr. Sarnoff."

Mr. Sarnoff replied: "Mr. President and fellow members of the Veteran Wireless Operators Association: I am deeply touched by the honor you have shown me this evening, because it comes from men associated with me from the early days of radio communications and men who have played a great part in its development. You have chosen a novel method to bestow honors. By doing it in 'absentia' the recipient is spared the embarrassment of listening to an obituary of himself, and the audience is spared the agony of listening to a long speech. In thus blazing a new trail, you may some day again be known as Veterans.

"I have been a member of your organization since its beginning, and have always been in sympathy with its aims, which

David Sarnoff.

are: to foster an esprit de corps among wireless operators, to recognize meritorious service by them, and to acquaint the public with their work, traditions and ideals. In these troubled days, it is of great value to have the steady hand and the experienced mind of the builders of an industry still on call.

"Two years ago, on the occasion of the thirtieth year of my service with RCA, my fellow-workers gave me a party. At that time your Association presented me with a scroll, referring in generous terms to my years of service in this art and industry. This scroll hangs in a prominent place in my study at home. There, too, I shall place the medal which you are presenting to me this evening. I regret that you cannot forward it to me where I am now at the speed of light, by teletransportation.

"In accepting this great award from you, I should like to point out that there have been and there are others who also started from a lowly beginning, and reached the same goal as I have. Time prevents my calling of the roll, but I may mention an old friend, the late George S. Davis, who began life as a coal passer on a ship in the United States Navy, and passed through the position of wireless operator, to the presidency of Tropical Radio. Edward J. Nally began life as a messenger boy and reached the presidency of the RCA. Another I may mention is Thomas Morgan, whom I first knew when he was one of Uncle Sam's wireless boys and now known as the able president of the Sperry Gyroscope Corporation. Apparently, it seems to be easy for wireless men to become presidents. In fact, your own president, Mr. McGonigle, also handled the key on shipboard in his earlier days and handled it very well, indeed.

"In accepting your first Marconi Medal of Achievement tonight, I consider it not merely a personal honor, but rather a tribute to America; for it is a tangible expression of the fact that this land of ours is the land of opportunity. A young man beginning life, in our country, is not forced to have his life moulded by others than himself; he is not the victim of a caste system that compels him to remain always within the narrow boundaries into which he was born. He is free to follow his own destiny, and to make of himself whatever life's complicated system of native talent, study, force of character, persistence and opportunity may afford.

"In a rapidly changing world, there is always some new horizon beckoning, some new field towards which the newcomers may look forward. In my day, wireless was the magic key to a future. Aviation next captured the imagination of youth. Today, one of the outgrowths of radio—television—holds possible future opportunities which no one can fully evaluate as yet. Twenty years from now, it may be that some veteran of the Iconoscope may be awarded by you a token of your feelings, and if he receives it in the spirit I feel tonight, he will indeed be a grateful man. Good night, boys, and my fondest 73."

Among the messages received at the banquet was one from Mr. Alfred J. McCosker, President of WOR and Chairman of the Board of the Mutual Broadcasting System. Mr. McCosker wired as follows: "William J. McConigle, President, Veteran Wireless Operators Association, Hotel Astor, New York City. Unfortunately I cannot be with you tonight, but may I take this opportunity to extend my heartiest congratulations to the Veteran Wireless Operators Association to Dave Sarnoff, one of your most distinguished members, and to all of my friends. The Veteran Wireless Operators Association is a grand organization whose history and tradition has contributed immeasurably to the broadcasting and communication industries. WOR has always been privileged to cooperate with you and it is our sincere wish that this fine spirit may ever predominate." (Signed) Alfred J. McCosker, President of WOR and Chairman of the Board of Mutual Broadcasting Service.

An inspiring letter from our beloved

(Continued on page 54)

FREQUENCY-MODULATED STATION

THE FIRST high-powered frequency-modulated radio station, W2XMN, will be put into operation this Spring, it is announced by Major Edwin H. Armstrong, professor of electrical engineering in Columbia University, who designed and built the broadcasting equipment.

Arrangements have been made with station WQXR for the new station to receive and transmit the programs now broadcast from New York's "High Fidelity" station. Mr. John V. Hogan, radio engineer and owner of WQXR, has filed a petition with the Federal Communications Commission for permission to build a frequency-modulated station in New York City. The studios and programs of WQXR will be used by W2XMN until such a time as Mr. Hogan's own station is erected.

Construction of frequency modulated receiving sets of the new type has already been started on a commercial basis by General Electric. The new sets, when produced on a quantity basis, will cost no more than the ordinary good set of today and will be able to receive both the old and the new kinds of broadcasting much the same as sets now receive both the short and long-wave programs. Arrangements are being made for manufacture and sales of transmitter by the Radio Engineering Laboratories of Long Island City. Patents on the system have been granted to Major Armstrong in the important countries of the world.

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FARNSWORTH JOINS RMA

A new member of RMA is the Farnsworth Radio and Television Corporation, whose application for membership in the Association was approved by the RMA Board of Directors at New York on February 2. Membership of RMA now includes virtually all of the leading companies interested in the development of television, and non-member companies, as well as all broadcasting interests, have participated in RMA engineering work in connection with television. The Association also is considering a special engineering service to determine signal strength and market areas of future television broadcasting service.

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ELECTROMAGNETIC HORNS

HOW HORNS are useful in directing radio waves, just as they are for sound waves, was demonstrated recently before the Institute of Radio Engineers by Dr. George C. Southworth, Bell Telephone Laboratories. Using a wave only 3½ inches long, sent down a metal tube into a horn ten feet long and two and a half feet square at its mouth, Dr. Southworth showed that practically all the energy was shot out in a narrow beam. Giving the waves this kind of send-off, Dr. Southworth said, is as good as a 500-fold increase in power for an antenna of the ordinary type. One of his transmitters was about the size of a big flashlight and when he pointed it toward the open throat of the big horn, the beam of waves immediately set a loudspeaker into action. Evidently the horn's directivity was as useful on the receiver as the transmitter, both for the purpose of increasing signal pick-up and discriminating against unwanted signals, as the speaker demonstrated by shooting a beam at the side of the horn.

Reviewing briefly some experiments which he performed before the same audience last year, Dr. Southworth explained how very short radio waves could be sent down a metal tube, or guided by a cylinder of insulating rubber. At the end of such a tube a film of graphite on paper would act as a resistance to absorb the waves. Or they could be radiated into space; Dr. Southworth showed how varying amounts of energy could be drawn from the tube, depending on the way its flared out into the horn.

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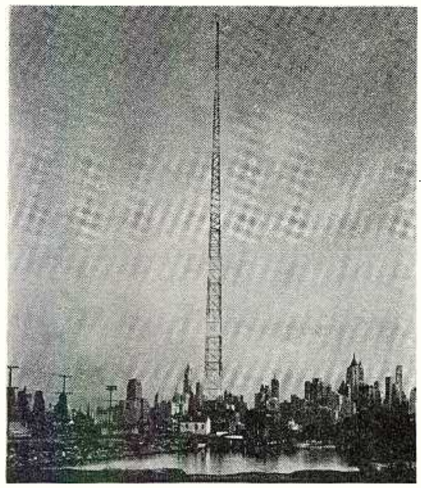
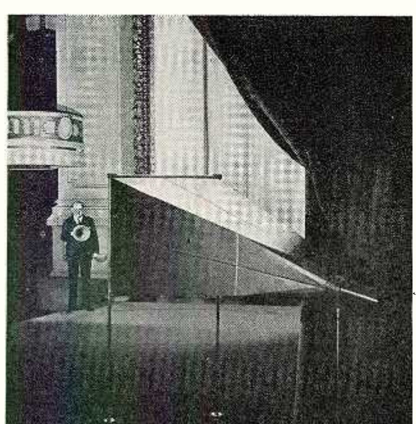


An interesting view of the 387-foot Lehigh antenna of WHOM, Jersey City, N. J.

G. C. Southworth receiving a radio beam by means of a wave collector.



FEEDBACK AMPLIFIERS

(Continued from page 7)

This undoubtedly accounts for reports received from broadcast engineers stating that when a large amount of feedback is used a peculiar form of quality distortion is observed that appears to be associated with transients.

MATHEMATICAL APPENDIX

The vector amplification of a single-stage amplifier having adequate screen and cathode bypass condensers can be expressed as follows[2]:

$$\left.\begin{matrix}\text{Amplification at}\\ \text{low freqeuncies}\end{matrix}\right\} = \frac{A'}{1 - j\dfrac{X_c}{R}} \qquad (1a)$$

$$\left.\begin{matrix}\text{Amplification at}\\ \text{high frequencies}\end{matrix}\right\} = \frac{A'}{1 + j\dfrac{R_{eq}}{X_s}} \qquad (1b)$$

where

A' = amplification in mid-frequency range.

X_c = reactance of coupling condenser C_c.

X_s = reactance of equivalent shunting capacitance C_s.

R = resistance formed by grid leak in series with combination of plate and coupling resistances in parallel.

R_{eq} = resistance formed by plate, coupling and grid-leak resistances all in parallel.

If now f_1 and f_2 are taken as the frequencies that make $X_c = R$ and $X_s = R_{eq}$, respectively, then Eqs. (1a) and (1b) can be written

$$\left.\begin{matrix}\text{Amplification at}\\ \text{low frequencies}\end{matrix}\right\} = \frac{A}{1 - j\dfrac{f_1}{f}} \qquad (2a)$$

$$\left.\begin{matrix}\text{Amplification at}\\ \text{high frequencies}\end{matrix}\right\} = \frac{A}{1 + j\dfrac{f}{f_2}}, \qquad (2b)$$

where f is the actual frequency. It will be noted that when $f = f_1$ and also when $f = f_2$, that the voltage amplification has fallen to 70.7 percent of the mid-range value A, and that the phase shift is 45°.

The amplification when feedback is used is given by the well-known equation

$$\left.\begin{matrix}\text{Amplification of}\\ \text{feedback amplifier}\end{matrix}\right\} = \frac{A_1}{1 - A_1\beta} = -\frac{1}{\beta\left(1 - \dfrac{1}{A_1\beta}\right)} \qquad (3)$$

[2]See F. E. Terman, "Radio Engineering," Second Edition, p. 177-180.

where

A_1 = actual vector amplification
β = fraction of output voltage fed back.

It is to be noted that *in actual feedback amplifiers* β *is always negative because the feedback is negative.*

If the value of amplification given by Eq. (2) is now substituted in Eq. (3), the result becomes, after some algebraic manipulation

$$\left.\begin{matrix}\text{Amplification of}\\ \text{one stage at low}\\ \text{frequencies with}\\ \text{feedback}\end{matrix}\right\} = \frac{\dfrac{A}{1-A\beta}}{\left(1-j\dfrac{f_1/f}{1-A\beta}\right)} \quad (4a)$$

$$\left.\begin{matrix}\text{Amplification of}\\ \text{one stage at high}\\ \text{frequencies with}\\ \text{feedback}\end{matrix}\right\} = \frac{\dfrac{A}{1-A\beta}}{\left(1+j\dfrac{(f/f_2)}{1-A\beta}\right)} \quad (4b)$$

Comparison of Eqs. (2) and (4) indicates that they are of the same form but that the amplification is now reduced by the factor $1/(1-A\beta)$ because of feedback, while the points of 70.7 percent response at high and low frequencies now occur at frequencies of $f_1/(1-A\beta)$ and $f_2(1-A\beta)$, respectively, instead of f_1 and f_2. This is equivalent to a flattening of the response curve without changing its form, as shown in Fig. 1, which is calculated from Eqs. (4).

In the case of a two-stage amplifier, the actual amplification without feedback is obtained at once from Eqs. (2a) and (2b), as

$$\left.\begin{matrix}\text{Actual amplifi-}\\ \text{cation at low}\\ \text{frequencies}\end{matrix}\right\} = \frac{AA'}{\left(1-j\dfrac{f'}{f}\right)\left(1-j\dfrac{f_1'}{f}\right)} \quad (5a)$$

$$\left.\begin{matrix}\text{Actual amplifi-}\\ \text{cation at high}\\ \text{frequencies}\end{matrix}\right\} = \frac{AA'}{\left(1+j\dfrac{f}{f_2}\right)\left(1+j\dfrac{f}{f_2'}\right)} \quad (5b)$$

where the prime indicates the second stage. When these equations are substituted into Eq. (3) the results are:

$$\left.\begin{matrix}\text{Amplifi-}\\ \text{cation of}\\ \text{two stages}\\ \text{at low fre-}\\ \text{quencies}\\ \text{with feed-}\\ \text{back}\end{matrix}\right\} = \frac{AA'}{AA'\beta-\left(1-j\dfrac{f_1}{f}\right)\left(1-j\dfrac{f_1'}{f}\right)} \quad (6a)$$

Amplification of two stages at high frequencies with feedback

$$= \frac{AA'}{AA'\beta - \left(1 + j\frac{f}{f_2}\right)\left(1 + j\frac{f}{f_2'}\right)} \quad (6b)$$

The results given in Fig. 2 are plotted from these equations for $f_1' = f_1$, and $f_2' = f_2$, while Fig. 3 is obtained for the case $f_1' = f_1/a$, and $f_2' = af_2$. A check between the amplification calculated by Eqs. (6) and values measured for an actual two-stage feedback amplifier is shown in Fig. 5.

Formulas for the three-stage case analogous to Eqs. (5) and (6) can readily be obtained by the same process, and lead to

Amplification of three stages at low frequencies with feedback

$$= \frac{AA'A''}{AA'A''\beta - \left(1 - j\frac{f_1}{f}\right)\left(1 - j\frac{f_{12}}{f}\right)\left(1 - j\frac{f_1''}{f}\right)} \quad (7a)$$

Amplification of three stages at high frequencies with feedback

$$= \frac{AA'A''}{AA'A''\beta - \left(1 + j\frac{f}{f_2}\right)\left(1 + j\frac{f}{f_2'}\right)\left(1 + j\frac{f}{f_2''}\right)} \quad (7b)$$

where the double primes refer to the third stage. The curves of Fig. 4 are obtained by plotting these equations for $f_1 = f_1' = nf_1''$ and $f_2 = f_2' = f_2''/n$.

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LOUDSPEAKER SYSTEM

(*Continued from page* 13)

ment for use in theatres not yet equipped with modern high-fidelity horn systems.

REFERENCES

(1) "Sound Measurements and Loudspeaker Characteristics," Irving Wolff, *Proc. I.R.E.*, Vol. 16, Dec., 1928, p. 1729.

(2) "Motion Picture Sound Engineering," Research Council of the Academy of Motion Picture Arts and Sciences, D. Van Nostrand Co., Inc., New York, 1st ed., 1938, p. 327.

(3) "Loudspeakers and Microphones," E. C. Wente and A. L. Thuras, *Bell Sys. Tech. Jour.*, Vol. XIII, Apr., 1934, p. 263.

(4) "Audible Frequency Ranges of Music, Speech and Noise," W. B. Snow, *Jour. Acous. Soc. Am.*, Vol. 3, July, 1931, p. 155.

KUNZ JOINS SUPREME

Walden H. Kunz, head of the Radio Engineering Department of Indiana Technical College, has joined the engineering staff of Supreme Instruments Corporation, Greenwood, Mississippi. He will do research and development work for Supreme in the high-frequency field, culminating in new high-frequency test equipment. Mr. Kunz has had a background of both theoretical and practical experience.

SERVICE INSTRUMENTS BOOKLET

Service Instruments have prepared an 80-page booklet which gives detailed information about the Rider Chanalyst and true dynamic testing. It explains the use of the Rider Chanalyst for the location of the defects in receivers of all kinds and types. Copies may be had by mailing 25c in stamps or coins to Service Instruments, Inc., 404 Fourth Ave., New York City.

MASS & WALDSTEIN REPRESENTATIVE

Maas & Waldstein Company, makers of industrial finishes, Newark, New Jersey, announce the appointment of Harlan M. Gale as a sales representative for the New England territory. Mr. Gale, who was formerly connected with the Cleveland Varnish Company and the Glidden Company, is well known in New England.

WARD LEONARD REPRESENTATIVE

Ward Leonard Electric Co. have announced a change in address of their agent, Mark G. Mueller, whose new address is 1644 Blake Street, Denver, Colorado. Mr. Mueller is their representative in the states of Colorado, Western Nebraska, Northern New Mexico and nearly all of Wyoming.

TRANSFORMER CATALOG

The Spring-Summer edition of their transformer catalog, No. 400-CX, is announced by the Electric Mfg. Co., 500 W. Huron St., Chicago, Ill. Several new transformers are included. Copies may be obtained free of charge from any Thordarson distributor or direct from the factory.

GUTHMAN BULLETIN

Edwin I. Guthman & Co., Inc., 400 S. Peoria St., Chicago, Ill., have recently made available their catalog supplement A. This bulletin covers the Type U17 communication receiver, U21 audio tone control tuner, U23 modulator-driver and universal p-a amplifier. Also described are a frequency deviation meter, a diversity coupler and a frequency meter-monitor.

WHEN YOU CHANGE YOUR ADDRESS

Be sure to notify the Subscription Department of COMMUNICATIONS at 19 E. Forty-seventh St., New York City, giving the old as well as the new address, and do this at least four weeks in advance. The Post Office Department does not forward magazines unless you pay additional postage, and we cannot duplicate copies mailed to the old address. We ask your cooperation.

NASH RADIO REPRESENTATIVE

Saul Shapiro, Los Angeles factory representative, is now California representative for Nash Radio Products, Inc., of St. Louis, manufacturers of recording lubricants and cleaners.

ATR CATALOG

American Radio & Television Co., 300 E. 4th St., St. Paul, Minn., have made available Catalog No. 139. It covers their complete line of vibrator-operated and rectifier power supplies including shaver-packs, low-power inverters, radio inverters, industrial inverters, vibrapacks, polarity changers, "A" battery eliminators, battery chargers, rectifier packs, etc.

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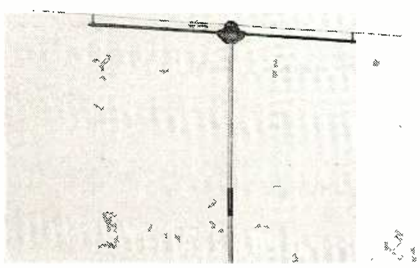
ANDREA TELECEPTOR

(*Continued from page 27*)

ference and poor antenna construction will greatly lower the performance of even the most expensive television receiver.

Andrea Radio and Television Corp. in collaboration with the L. S. Brach



Mfg. Corp. now offer a complete antenna system for home television receivers. The Andrea Teleceptor features a climate sealed teleceptor coupler into which are attached the antenna rods which form the legs of a one-quarter-wave doublet and 75 feet of low-loss rubber-jacketed transmission line having its impedance matched to the doublet and the antenna circuit of the television receiver. The rods and teleceptor are supported by a mast with crossarms of treated Washington cedar, which combines lightness of weight and required strength. The entire unit comes complete, ready for assembly, and when assembled stands 8½ feet high with a spread of 10 feet, all arranged to be attached directly to any portion of the roof. The vertical pole comes in 4-ft sections with a telescoping shell for extending the pole. There are some instances where additional height may be desirable, in which case the construction permits the attaching of an additional section of pole that would extend the height to 12½ feet. The length of the doublet rods may be chosen for maximum efficiency on the particular television channels desired, and the entire doublet may be rotated in a horizontal plane to any desired position, taking advantage of the directional characteristics of the doublet to exclude interference.

NON-GLARE TREATMENT FOR GLASS

GLARE from reflected light, which has made it difficult to see pictures framed under glass at certain angles, has been removed by a new process developed in General Electric's research laboratory by Dr. Katharine B. Blodgett. By applying thin chemical films to the surface of glass, Dr. Blodgett has been able to nullify or neutralize rebounding light rays with the result that pictures framed with glass so treated appear as though there was no glass at all, regardless of the angle viewed from.

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THE VODER

AN ELECTRICAL DEVICE which, under control of an operator at a keyboard, actually talks was demonstrated on January 5 at the Franklin Institute, Philadelphia. Known as the Voder, it is a development of Bell Telephone Laboratories as a scientific novelty to make an interesting educational exhibit for the Bell System's displays at the San Francisco Exposition and at the World's Fair in New York.

The Voder creates speech. It is the first machine in the world to do that. Individual vowels and consonants have been made by a variety of instruments, but they have never been linked into connected speech. Seated at a keyboard something like that of the old-fashioned parlor organ, an operator can carry on a conversation simply by pressing keys, singly or in combination. It takes a good deal of practice and some time to learn—not as much time as it takes the human to learn the mechanisms he is born with, but still quite a while.

Designers of the Voder provided it with electrical equipment corresponding to the two kinds of speech sounds. One kind of sound is made by forcing the breath through the mouth, past tongue, teeth and lips. Turbulence in the air-stream sets up a hissing sound which contains a great many vibration-frequencies. Some of these are reinforced by resonances in the mouth cavity; that is the way in which are made all the sounds of speech when one whispers, and such sounds as s, th and f. In the Voder there is an electrical hiss, and with some of the keys the operator can control its quality so as to make those sounds. Other keys make the "stop consonants" like d, k, and p.

Another kind of sound enters into human speech, most importantly in the vowels, like a, e, and o. It comes from the vocal cords, and is very complex and somewhat musical. In the Voder, therefore, there is an electrical source of sound corresponding to the vocal cords; and there is a pedal for changing its pitch and for giving to speech a rising or falling inflection as desired. When the operator wants the sounds made by the vocal cords, instead of whispered sounds or consonants, an arm rest switch is depressed. Then the particular parts of this vocalized sound which are wanted are selected by playing the proper keys.

The voder in operation.

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TELEVISION AMPLIFIERS

(*Continued from page 39*)

power source for the first stage or two of amplifiers having a gain of 80 or 90 db or above, whose output noise level must be very low. Even in this case it will probably be found that most of the hum arises from the heater wiring or the heater itself. In one typical amplifier of 85 db gain, the hum was reduced to extremely low level by heating the first tubes from a storage battery, but still deriving the other electrode voltages from a well-filtered power supply.

The main difficulty surrounding the use of rectifier-filter power sources lies in the fact that at the low frequencies, their internal impedance is appreciable. As shown in the simplified diagram of Fig. 4, several stages may be receiving power from the same power supply. The impedance formed by R_f and C_f in parallel (to a first approximation at least) is common to the plate circuits of all three of the stages deriving power from the one supply. Each plate circuit is coupled directly to the grid circuit of the following tube by means of the condenser C_c and resistance R_{g1}. Any impulse arising across the R_f-C_f combination due to a disturbance in stage 3, for instance, will be applied, with some attenuation, to the grids of stages 2 and 3. As a signal suffers a phase shift of 180 degrees in going through one amplifier stage, the passage of this impulse arising in the plate circuit of stage 3 back to the grid of stage 2 would cause it to be amplified by stages 2 and 3, arriving at the plate of stage 3 in proper phase to aid the original impulse. This causes an instability which is stopped only by the driving of grids positive causing a current to flow through the grid leak resistance which causes a large negative voltage to be applied to the grid. This allows the tube again to become inoperative, probably repeating the cycle in a sustained relaxation oscillation. For proper phase relationships, it is obvious that it takes at least two stages to oscillate in this manner and a third stage must be connected to the same power supply in order that the grid of stage 2 be coupled into the circuit. It follows, then, that it will be impossible for this mode of oscillation to exist with only two stages from the same power supply.

The tendency toward these relaxation oscillations will depend largely upon the magnitude of the impedance of the parallel combination, R_f-C_f. At low frequencies, this impedance increases due to the finite reactance of C_f at these frequencies. For this reason the feedback will be negligible except at these low frequencies, and hence the frequency of oscillation will be low. The inherent low-frequency response of the amplifier, determined entirely by the grid circuit components, C_c and R_{g1}, will also determine the tendency to oscillate because if the amplifier does not amplify at the frequencies at which the impedance of R_f and C_f is appreciable, no oscillation can take place. Unfortunately, wide-band television amplifiers usually demand uniform low-frequency response to 30 cycles per second or lower, making them particularly susceptible to relaxation oscillations.

The safest way to avoid this trouble is to operate no more than two stages from a single power supply. By increasing the value of C_f greatly, more than two stages of moderate gain possibly could be operated from one supply. The decoupling networks, R_1-C_1, (and similar ones in the screen-grid circuit) can be used to great advantage provided the supply voltage is high enough that large values of R_1 can be used so that obtainable values of C_1 will be really effective. It must be remembered that the $R_1 C_1$ network is ordinary low frequency compensation, the point of action being determined by the size of C_1. If only decoupling is desired, this correction point must be at such a low frequency that the amplifier, due to C_c and R_{g1}, is ineffective. Little can be expected of the $R_1 C_1$ network from a decoupling standpoint, however, if it is designed for effective low-frequency compensation.

Separate screen-grid decoupling circuits are often of great value in controlling the relaxation oscillations. In one particularly troublesome case, a screen decoupling circuit of 8 microfarads capacitance and 100,000 ohms resistance in parallel for the first tube of a group of three operated from one power supply was effective when 100 microfarads added to the 48 microfarads already shunting the power supply bleeder did not reduce the oscillation. It can be seen that the method selected for avoiding relaxation oscillations is determined largely by economic factors.

CONCLUSION

In the design of wide-band amplifiers, practical considerations often demand the use of certain methods or circuits while the same amplifier viewed from theoretical considerations appeared satisfactory. This paper has attempted to call attention to several of these, perhaps unrelated, practical problems.

ACKNOWLEDGMENT

The writer wishes to express appreciation for the helpful work rendered by Mr. Herbert R. Johnston, graduate student at Oregon State College, in the laboratory work leading up to this paper.

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DX BULLETIN

DX Radio Products Co., 1571-1579 Milwaukee Ave., Chicago, Ill., have issued a 22-page bulletin covering their line of coils, chokes, transformers, inductances and trimmer condensers. Of special interest is a 6-page section devoted to circuits. The bulletin is available from the above organization.

LEAR BULLETIN

Lear Developments, Inc., Bldg. 31, Roosevelt Field, Mineola, L. I., have just issued a bulletin covering their ARC-6 automatic aircraft direction finder, as well as the T-30-AB, R-3-AB. transmitter-receiver. The bulletin is available from the above organization.

ALLIED BULLETIN

An interesting and attractive 8-page bulletin is now available from Allied Recording Products Co., 126 W. 46 St., New York City. This bulletin deals in considerable detail with their wide-frequency-response recorders.

NEW NEELEY LINE

Norman B. Neely, technical sales agent with main offices in Hollywood, announces appointment as Western distributor for an acetate shaving collector, designed and manufactured by the Lakeside Supply Company of Chicago. Through Mr. Neely units are now available for demonstration on any type of recording equipment.

G-M PUBLICATION

The 10th issue of the G-M house publication entitled "G-M Comments" has been released. Two new G-M instruments and a new series of self-generating photoelectric cells are announced. Information included in the issue covers galvanometers, phototubes, power-supply units, and rheostats. Copies may be secured by writing to G-M Laboratories, Inc., 1733 Belmont Ave., Chicago, Ill.

WESTINGHOUSE BULLETINS

The Westinghouse Lamp Division, Westinghouse Electric & Manufacturing Co., Bloomfield, N. J., have made available two interesting bulletins. One bulletin gives the ratings for various Westinghouse electronic tubes. The second bulletin, No. 17, discusses Ignitron tubes. To secure copies, write to the above organization.

SMPE ATLANTIC COAST OFFICERS

At a meeting of the Atlantic Coast Section of the Society of Motion Picture Engineers at the Hotel Pennsylvania on January 11, the following officers for 1939 were announced: D. E. Hyndman (Eastman Kodak Company), Chairman; George Friedl, Jr. (International Projector Corp.), Past Chairman; P. J. Larson (Consulting Engineer), Secretary-Treasurer; H. Griffin (International Projector Corp.), Governor-2 years; R. O Strock (Eastern Service Studios), Governor-1 year.

The Centenary of Arago's communication to the French Academy of Sciences disclosing the new findings of Daguerre on what was then known as light-writing was celebrated at the meeting.

TELEVISION ECONOMICS

(*Continued from page 27*)

(b) The strong field at the photocathode is capable of saturating the electron emission and thus increasing efficiency of operation.

(c) Although the final mosaic in the image iconoscope necessarily operates at the usual reduced efficiency when scanned, its high emission ratio, with measured values of from 3 to 11 times, produces a further improvement in operation.

The performance of the image iconoscope has experimentally been found to be highly satisfactory, and particularly in its capability of producing high-quality pictures at relatively low levels of illumination. Thus, with 1,000-volt supply for the electron beam (with a beam current of 0.1-0.2 microampere), 400-line picture resolution is available; while raising the voltage to 3,000 improves picture resolution to the 800-line point.

The mosaic in these tubes may be made in several ways including, typically: (a) small silver elements are deposited on a 1.5-mil sheet of mica, and are then oxidized and caesiated; (b) a mica surface is heated to incandescence in an oxygen atmosphere, and thereafter exposed to caesium vapor; (c) a metallic signal plate is covered by a deposit of a finely-divided insulating powder (e.g., cryolite). The preceding type (b) has higher sensitiveness than type (a) but is less readily produced uniformly; while type (c) with suitable processing provides a uniform and highly sensitive mosaic.

Available data on the useful sensitivity of the standard iconoscope are not completely consistent, the tubes presumably having been somewhat variable, i.e., giving a performance which depends upon their mode of use, and having been subject to steady manufacturing improvement. In general, the following data may serve as a guide. Assuming a lens of focal length of 6-7 inches and of speed of f:3.5-4.5, excellent results on outdoor pick-up are obtainable when the surface brightness of the illuminated area is about 100 candles per square foot (corresponding to a bright Fall day). A brightness of 20 candles per square foot still gives satisfactory transmission (corresponding to about 3 millilumens per square centimeter on the mosaic). Entertainment value is seriously reduced or absent when the surface brightness drops notably below 5 candles per square foot. From the preceding, it will be seen that with the usual low reflection coefficient of surfaces in studio and outdoor pick-up (0.10-0.30 approximately), illumination of the surface for excellent pick-up with the standard iconoscope should be of the order of 1000 foot candles or more, even though usable results are obtainable with a fraction of this illumination, fixing lighting level and its cost.

It should be stressed that any reduction of lighting for satisfactory pick-up constitutes a major economic improvement in television. It reduces power consumption, cost of lighting equipment, replacement costs for lamps or carbons, inconvenience or annoyance to the actor with resulting deterioration of quality of performance or injury to make-up, air-conditioning requirements, and personnel required to handle the lighting system. This should be kept in mind in connection with the present considerable cost of uniform and highly sensitive iconoscopic tubes.

The image iconoscope is therefore of particular interest since it has an intrinsic sensitivity 6 to 10 times greater than that of the standard iconoscope. Further, spurious signals requiring shading correction are stated to be less with the image iconoscope. Whereas the standard iconoscope uses a lens of focal length of 6.5 inches and speed of f:2.7-4.5 for the longer shots (with a view angle of 37 degrees), the magnetically-focussed type of image iconoscope typically uses lenses of focal length of 2.5-3 inches and speed of f:1.7, and the electrostatically-focussed image iconoscope typically uses a lens of 3.25-inch focal length operating at f:2.1. For close-ups, a narrow-angle lens of focal length of 14-18 inches is used with the standard iconoscope, and one of correspondingly less focal length for the image iconoscope. The full tenfold increase in sensitivity of the image iconoscope as compared with the standard iconoscope is not used in studio operations, the lens being stopped down to secure greater depth of focus, and a twofold or threefold increase in sensitivity is thus obtained.

The trend in iconoscope design is toward higher sensitivity, greater resolution, increased uniformity of product, and reduced cost (the last factor is somewhat contradictory to foregoing).

Depth of focus is of major importance in satisfactory television presentations where, of course, retakes are impossible, as contrasted with motion-picture operations where any reasonable number of retakes may be made. It has been pointed out that where greater depth of focus is required in photography, the focal length of the lens may be reduced while maintaining its relative aperture constant, thus avoiding loss of sensitivity. It is true there are marked limitations to this method if a natural perspective of the resulting picture is required. Nevertheless, minor increases in usable depth of focus in photography are thus obtainable. The signal output of the iconoscope, by contrast, depends on both the intensity of the illumination of the mosaic and also on the scanning-spot velocity across the mosaic, wherefore the video output signal is related to light flux rather than, as in photography, to light intensity. In an iconoscope, reduction of the area of the mosaic and corresponding reduction of the focal length of the lens gives an overall reduction of sensitivity. It has been stated that the video output is approximately inversely proportional to the square of the depth of focus obtained in the object field—a limitation which requires that efforts be made to increase the sensitivity of the iconoscope. Such increases in sensitivity result from the addition of a secondary-emission multiplier to the iconoscope for signal amplification, from increasing the photo-sensitivity of the mosaic and improving its general operation, or from using secondary-emission amplification of an optical image. The last-mentioned expedient requires that an electron image rather than a luminous image be focussed on the mosaic, this arrangement constituting the image-iconoscope.

Depth of focus is a primary financial

factor in television, provided it is not obtained at the cost of unduly increased illumination of the set. It enables the successful and natural pick-up of complicated action, gives freedom of expression and mobility to the actors by reducing artificial restraints on them and permitting them to devote themselves concentratedly to their parts, it reduces the choppy effect of excessive cutting from one viewpoint to another, it avoids blurred and meaningless backgrounds, and it greatly increases the satisfaction of the home audience since it provides a picture which is sharp and clear in all parts. Thus it greatly enhances the appeal and value of the television service. It must be remembered that the television picture at this time has quality limitations imposed by its line structure. Television is a costly and luxurious form of communication and any reduction in image sharpness at the receiving station in effect discards a part of the image detail which has been painfully sought by expensive technical methods. Thus, a 441-line picture in the focussed foreground may be nothing more than a 30-line picture, in effect, in an out-of-focus background. The limited depth of focus now available can be judged from the following typical data which apply to the standard iconoscope if a 14-inch lens be used at f:3.5, with a maximum permissible diameter of the circle of confusion of 0.008 inch. If the lens is used to photograph the head and shoulders of an individual at a distance of 15 feet from the lens, the depth of focus is only a few inches. For a 6.5-inch lens operating at f:3.5, with the same permissible maximum circle of confusion, a full-length picture of an individual made at say 15 feet from the lens shows a back depth of only a couple of feet—and in practice even less than this may be usefully employed.

Studio camera operations have been simplified by providing reflex finders on the camera to follow the action continuously. The cameras themselves are mounted on perambulators, on which the cameramen may or may not be carried. Motors for driving the cameras up and down, with simple controls, are available, as are also convenient handles for focussing, panning, or tilting. Maximum flexibility, mobility, and ease of operation are economically justified under the trying conditions of a television presentation. The camera is provided with high-voltage protection against shock to the operators and is connected by a special cable to the control room. This cable carries the necessary deflection and amplifier voltages to the camera, and carries the amplified signal output back to the control room.

(To be continued)

THE MARKET PLACE

NEW PRODUCTS FOR THE COMMUNICATIONS FIELD

N. U. TELE TUBE

A new "stubby" 5-inch cathode-ray television tube incorporating several new features has been announced by National Union. The latest addition to the Videotron family is a streamlined, compact affair measuring 13-inches in length—3½ inches less than earlier designed units with the same size screen. The 5-inch "stubby" offers advantages for adaptation to small cabinets. Electrostatic deflection is utilized and images are reproduced in black and white. The new tube has been assigned the type number 1805-P4. *National Union Radio Corporation*, 57 State Street, Newark, N. J.—COMMUNICATIONS.

GRID-CONTROL RECTIFIER

United Electronics have just announced a new grid-control rectifier No. 967. The tube corresponds to the 866 A with the exception that it is of the Thyratron na-

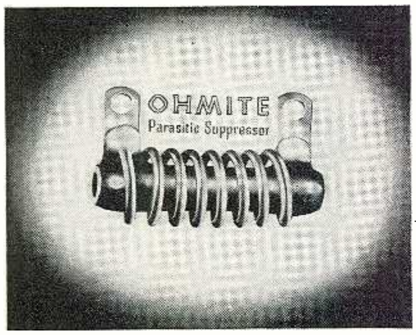
ture and may be used for voltage regulation, voltage control and keying circuits. Characteristics are available from *United Electronics Corp.*, 42 Spring St., Newark, N. J.—COMMUNICATIONS.

A B C RADIO BULLETIN

The A B C Radio Laboratories, 3334 N. New Jersey St., Indianapolis, Ind., have issued a bulletin covering their short-wave converters and antennas for police and other uses.

OHMITE PARASITIC SUPPRESSOR

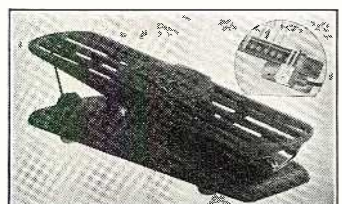
The Ohmite type P300 parasitic sup-



pressor is a non-inductive vitreous enamel resistor combined with a choke into one integral unit. For full details, write to *Ohmite Mfg. Co.*, 4835 Flournoy St., Chicago.—COMMUNICATIONS.

KONTAK MIKE VOLUME CONTROL

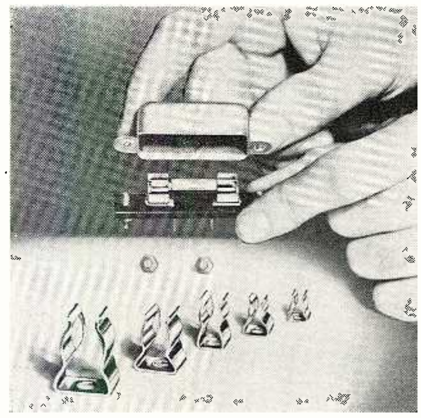
Smooth and easily controlled crescendos can be obtained with the new Amperite footpedal control. It can be used with any of the Amperite high-impedance Kontak



microphones for musical instruments. The volume can also be set to any point and the foot removed. Since the control is wired as a "T" pad, any number up to five can be used in parallel and fed into one input. When used in parallel any of the controls can be varied without affecting the other, it is said. *Amperite Co.*, 561 Broadway, New York City.—COMMUNICATIONS.

FUSE CLIPS

Littelfuse announces fuse clips for cap sizes ¼ in to 13/16 in of Beryllium Copper. They are designed to fill the need for a clip having high-resistance to fatigue, heat and vibration in aircraft, portable tools, etc. Beryllium Copper, the alloy of beryllium and copper, which is used in these fuse clips, will, when treated, withstand a vibration pressure of 35,000 to 40,000 lbs. per square inch almost indefinitely. It is said to have a gripping strength about three times that of phosphor bronze, and a wear resistance of five times that of phosphor bronze when used in fuse clips. *Littelfuse, Inc.*, 4238 Lincoln Ave., Chicago, Ill.—COMMUNICATIONS.



EISLER BULLETIN

The Eisler Engineering Co. have recently issued a bulletin describing and giving data on the Eisler spot welders. To secure a copy of the bulletin write to the above organization at 740-770 South 13th Street, Newark, N. J.

WIRE-WOUND RESISTORS

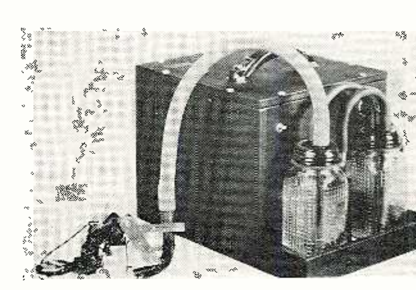
Ceramic-jacketed, fully-sealed precision non-inductive wide-wound resistors in a wide range of resistance values up to 3 megohms, and in ½, 1, 1½, and 2-watt ratings, are now offered by Clarostat.

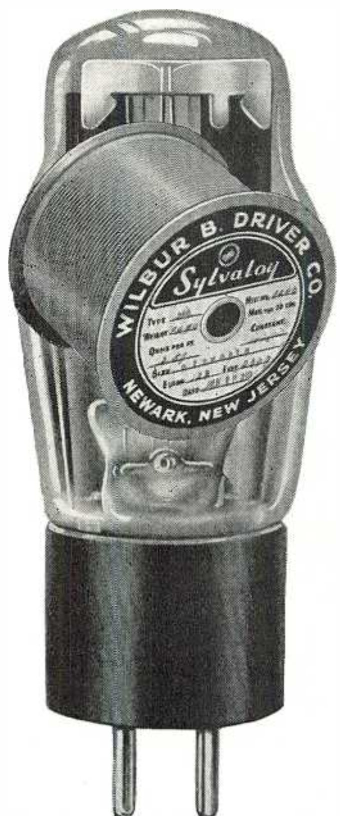
Each unit comprises a ceramic spool with a plurality of sections so that the winding can be in reverse direction "pies" for adjacent sections. The selected enameled resistance wire is impregnated and protected by a ceramic sleeve that slips over the spool. Standard tolerance of 1% on all stock items. On special order, units can be supplied with tolerances as low as 1/10th of 1% at slight increase in cost.

Wide assortment of terminal styles, including wire leads, lugs, lugs at one end, and caps for 6/32 screws, binding posts and nut terminals. Resistance values plainly marked on the units. *Clarostat Mfg. Co., Inc.*, 285-7 North Sixth St., Brooklyn, N. Y.—COMMUNICATIONS.

ACETATE SHAVING COLLECTOR

An acetate shaving collector is shown in the accompanying illustration. This unit measures approximately 11 by 17 by 11 inches and weighs 20 pounds. A high-speed universal motor pulls the thread or shaving away from the stylus, through a nozzle and deposits it in a jar partly filled with water. A second jar is provided as a safety measure to prevent moisture from going into the motor. Nozzles are made to fit the various types of recorders. *Lakeside Supply Co.*, 416 South Dearborn Street, Chicago, Illinois.—COMMUNICATIONS.





The heart of the 280 tube

WILBUR B. DRIVER CO.
NEWARK, NEW JERSEY

Approved by F. C. C.

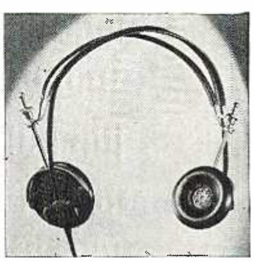
BLILEY CRYSTALS

Bliley Broadcast Crystals, Holders and Ovens are specially designed for General Communication Frequencies from 20 Kc. to 25 Mc. Bliley Broadcast Crystals and Ovens are approved by F.C.C. For full information and prices, write for Bulletin G-9.

BLILEY ELECTRIC COMPANY
UNION STATION BUILDING ERIE, PA.

BE SURE.. OF CUSTOMER SATISFACTION
with Brush headphones!

BRUSH PIEZO ELECTRIC DEVICES



● Model BJ—A communications type headset which will fill the bill for commercial applications. Lightweight aluminum case, with crystal element hermetically sealed within. Phones encased in molded rubber jackets assuring comfort and good earseal. As an added feature the conventional card yoke has been replaced, on this model, by a single cord, giving the operator greater freedom. List price . . . $12.00

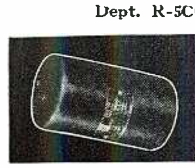
● Model A-1—This exceptional Brush headset will meet with approval among your most demanding customers, in fields of broadcasting, recording, speech correction and sound research work. They carry positive assurance of faithful, high fidelity, wide range response and light weight. Response of the Model A-1 is 50 to 12,000 c.p.s. You'll find it easy meeting the strictest specifications with these fine Brush headphones. List price $27.50

THE BRUSH DEVELOPMENT CO.
3317 Perkins Avenue Cleveland, Ohio

SMOOTH . . . QUIET . . . DEPENDABLE

"PINCOR" offers the only complete line of "B" power supply equipment for police units, aircraft and radio broadcast service and sound systems. Frames, sizes and capacities to fit any requirement.
"PINCOR" dynamotors are the last word in efficiency and regulation. Deliver high voltage current for proper operation of your apparatus with a minimum of A.C. ripple. Compact, light weight. With or without filter. Send for catalog.

PIONEER GEN-E-MOTOR CORPORATION
Dept. R-5CC, 466 West Superior St., Chicago, Illinois



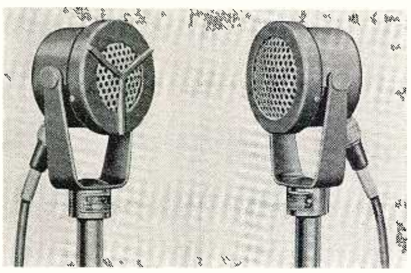
Without obligation kindly send me "PINCOR" Silver Band Dynamotor catalog and data sheets.
Name ....
Address ....
City .... State ....
☐ Also send me Converter Catalog.

CRYSTAL & DYNAMIC MICROPHONES

Webster-Chicago has just announced two new model microphones which are said to feature improvements in both performance and appearance.

Model 1236 is a diaphragm type crystal microphone, especially adapted to p-a work. The high-capacity torsion-drive crystal is moisture-sealed.

The new dynamic microphone utilizes a moving coil mounted on a Dural diaphragm. The frequency response is rated at from 50 to 9,000 cycles. The output level is —56 db. Assembly includes a bal-



anced guadropi type winding transformer to eliminate stray electro-magnetic pickup.

Full information on request from *Webster-Chicago,* 5622 Bloomingdale Ave., Chicago, Ill.—COMMUNICATIONS.

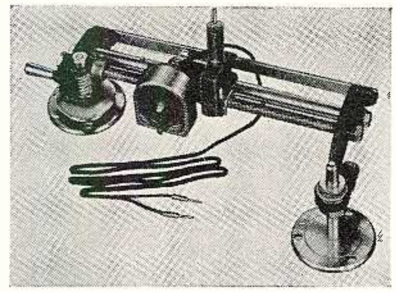
MOLDING MATERIALS

Two newly formulated, asbestos-filled Durez molding materials have just been made commercially available. These compounds are known as Durez 38-443 and Durez 38-646. Several advancements over others of their type previously offered have been incorporated into these new materials.

Durez 38-443 was formulated specifically to meet Underwriters' specifications of withstanding 200° C. for 72 hours. It also has an impact strength of .23 (ASTM) and a compressive strength of 28,000 (ASTM). Heat resistance is recorded at 490° F. Specific gravity is 1.80.

Durez 38-646 has a low specific gravity for asbestos-filled molding compounds—1.59. It has a slightly higher heat resistance, 500° F., but a lower impact strength—.19 (ASTM). However, its flexural strength of 9000 (ASTM) is greater than for any previously available. Compressive strength is also 28,000 (ASTM).

Further information is available from *General Plastics, Inc.,* North Tonawanda, New York.—COMMUNICATIONS.



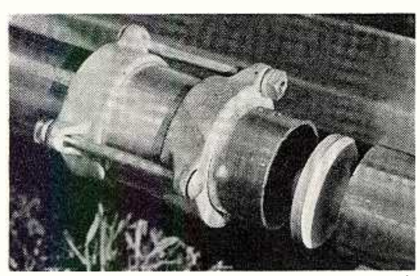
RECORDING ASSEMBLY

Rek-O-Kut Corporation announces a new recording assembly which records on acetate. It consists of a spindle and worm gear driven at the center of the turntable, feed screw, cutting head mounting and cutting head. This entire mechanism can be simply aligned with turntable. It operates with as little as 2 watts driving power from amplifier. Cutter impedance 8 ohms. *Rek-O-Kut Corporation,* 254 Canal Street, New York, N. Y.—COMMUNICATIONS.

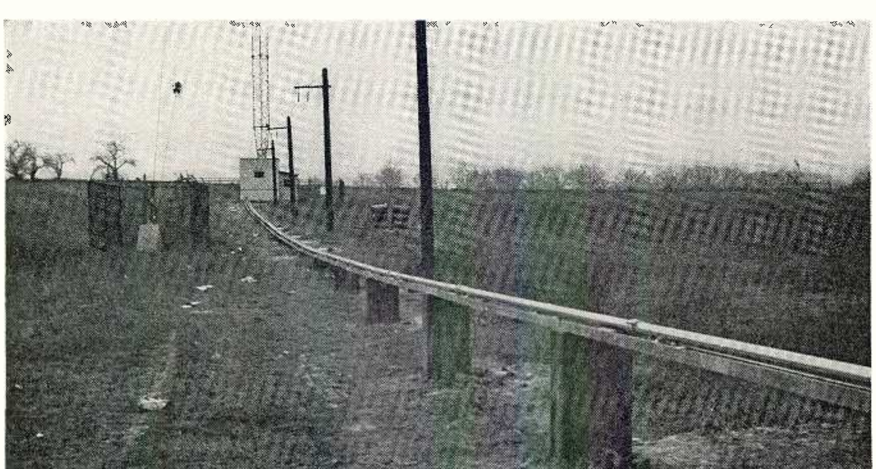
LOKTAL SOCKETS AND ADAPTERS

A complete line of molded sockets and adapters for the new loktal tubes are avail-

able in black bakelite. Supplied with molded-in-plate, retainer ring mounting or an adapter plate for replacement work. Contacts have a long wiping action and grip the entire length of tube prong securely. Adapters for tube testers and analyzers are available both wired and unwired. Prices on request from *American Phenolic Corp.,* 1250 Van Buren St., Chicago.—COMMUNICATIONS.

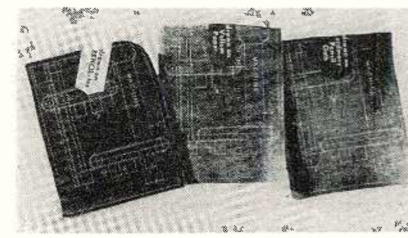


Above is a close up of a coupling joint of a gas-filled aluminum co-axial cable installed at WTAM (below). This transmission line was developed by Isolantite, Inc., in conjunction with NBC and the Aluminum Co. of America.



PENCIL-TEX

Under the name Pencil-tex, the Frederick Post Company recently introduced a new pencil drafting cloth. Of similar appearance to fine tracing cloth, Pencil-tex has a new and patented velvety surface



which is said to have a remarkable affinity for pencils of all degrees of hardness. Post claims that even the hardest of hard pencils will leave a sharp, uniform, ink-dense line in its wake. This line intensification, together with a glass-like transparency is said to permit the production of a blueprint with the sharp contrast of "prints" made from fine ink tracings. The accompanying illustration shows identical drawings made with a 5H pencil on ordinary pencil cloth, on vellum paper, and on Pencil-tex.

A novel try-it-yourself kit is now being distributed to interested drafting supply users by the *Frederick Post Company,* P. O. Box 803, Chicago, Illinois.—COMMUNICATIONS.

ROLLER-SMITH CONSOLIDATION

The Roller-Smith Company announces the consolidation, as of February 1st, 1939, of its Executive Offices (located prior to February 1st in New York City) with its works at Bethlehem, Pa. After February 1st all activities of the company were concentrated at the new headquarters.

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VWOA NEWS

(*Continued from page* 41)

Honorary Member, Mr. Edward J. Nally, from his home in Connecticut. Mr. Nally (First President of the Radio Corporation of America) in his own handwriting wrote:

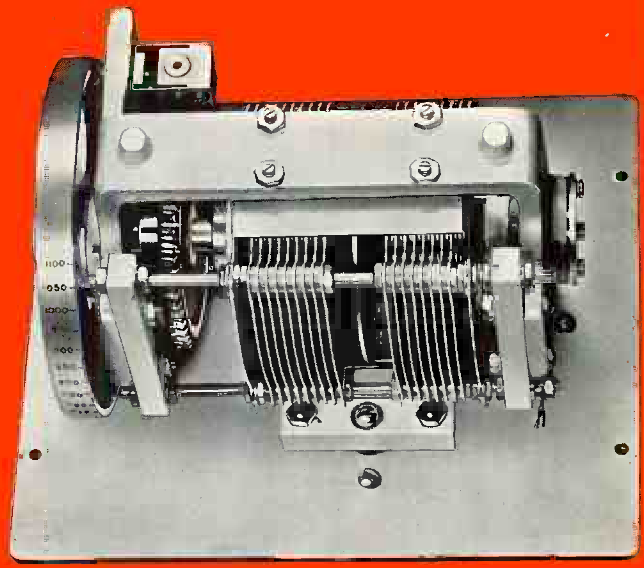
"My Dear Mr. McGonigle: I am sorry that the notice of the interesting meeting of the VWOA did not reach me in time to enable me to send you a letter or telegram of felicitation. We are away from telegraph and telephone and when I received late last evening Mr. Clark's kind reminder in the shape of your most interesting program I regretted I could not have sent you an expression of my interest and admiration at the wonderful way in which the association does and has done so many worthwhile things.

"All of those listed are fully deserving of the high honor your Association has accorded them. It is most fortunate and fortuitous that there exists an organization of such high purposes and one so well fitted to carry out its fine intentions. More power to it and to you. Sincerely, (Signed) E. J. Nally."

Advertising Index

HIGH-FREQUENCY LABORATORY STANDARDS

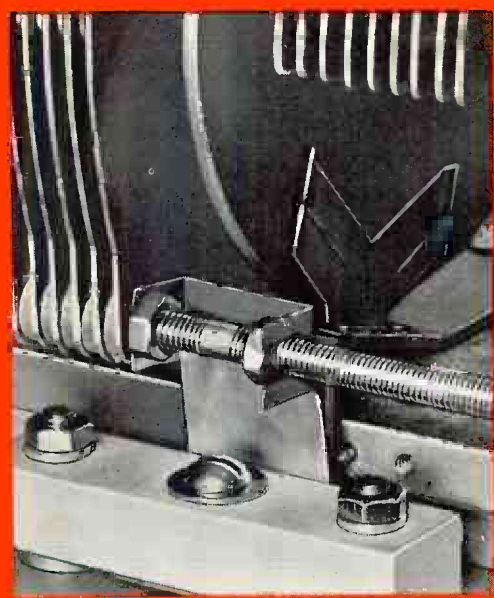
THREE recently developed General Radio instruments now make possible accurate measurements of capacitance, resistance, voltage and current up to the ultra high radio-frequency range. Each of these instruments is the outcome of considerable research involving not only new design methods, but also new calibration technique. These instruments are invaluable in all laboratories where precision measurements are being made.



Standard Type 722 Precision Condenser Mechanical Construction

CAPACITANCE

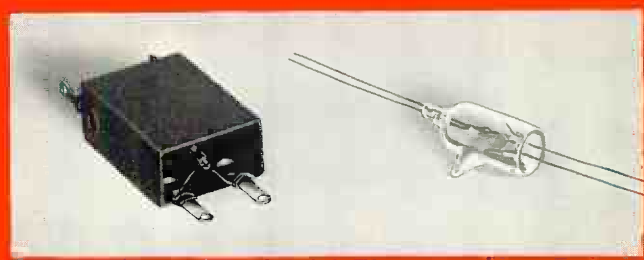
The Type 722-N Precision Condenser is a modification of the standard Type 722 Condenser noted for many years for its ruggedness, stability and accuracy. In the new condenser connection is made at the center of both rotor and stator plate stacks. The rotor stack is fed by a brass disc with wide multiple-finger brush contactors. The stator stack is fed through a heavy strip connector. This construction reduces the metallic resistance and residual inductance by a factor of approximately three. The residual inductance is constant and equal to 0.024 μh. The capacitance range is 100 to 1100 μμf, direct reading with linear calibration, and with a calibration accuracy of ± 1 μμf. The Type 722-N Precision Condenser is priced at $150.00.



In the 722-N Condenser connections to both plate stacks are made at the center

CURRENT and VOLTAGE

The Type 493 Vacuum Thermocouples are heater-type couples designed for accurate measurements of r.m.s. values of voltage and current irrespective of waveform. These units can be used with good accuracy for current measurements to frequencies up to about 300 Mc. Many new and unique features are incorporated in these couples. Four unmounted models (preferred for ultra-high-frequency use) with rated currents from 3 ma to 100 ma and with corresponding heater resistances from 600 ohms to 2 ohms are priced at $10.00 each. The corresponding mounted models are priced at $12.50 each.



Type 493 Vacuum Thermocouple in unmounted shipping case (at left). Heater and couple leads brought out at opposite ends of bulb

RESISTANCE

The Type 633 Resistor is a new standard designed for use where units of low resistance with small residual reactance, moderate power-handling capacity and accurately known values are required. The design of these resistors overcomes many disadvantages of former straight-wire units. The wire is clamped upon flat metal fins to decrease the inductance and to increase the power dissipation. These units are stocked in seven resistance values adjusted to within 1%. The frequency error of resistance is less than 5% for all frequencies below 50 Mc. The temperature coefficient at normal room temperature is less than ± 0.002% per degree C. With values of 1, 2, 5, 10, 20, 50 and 100 ohms, the Type 663 Resistors are priced at $5.00 each.

In the Type 663 Resistors the wire is clamped on flat metal fins to decrease inductance and increase power dissipation

Write for Bulletin 394 for Complete Information

GENERAL RADIO COMPANY, Cambridge, Mass.
NEW YORK LOS ANGELES