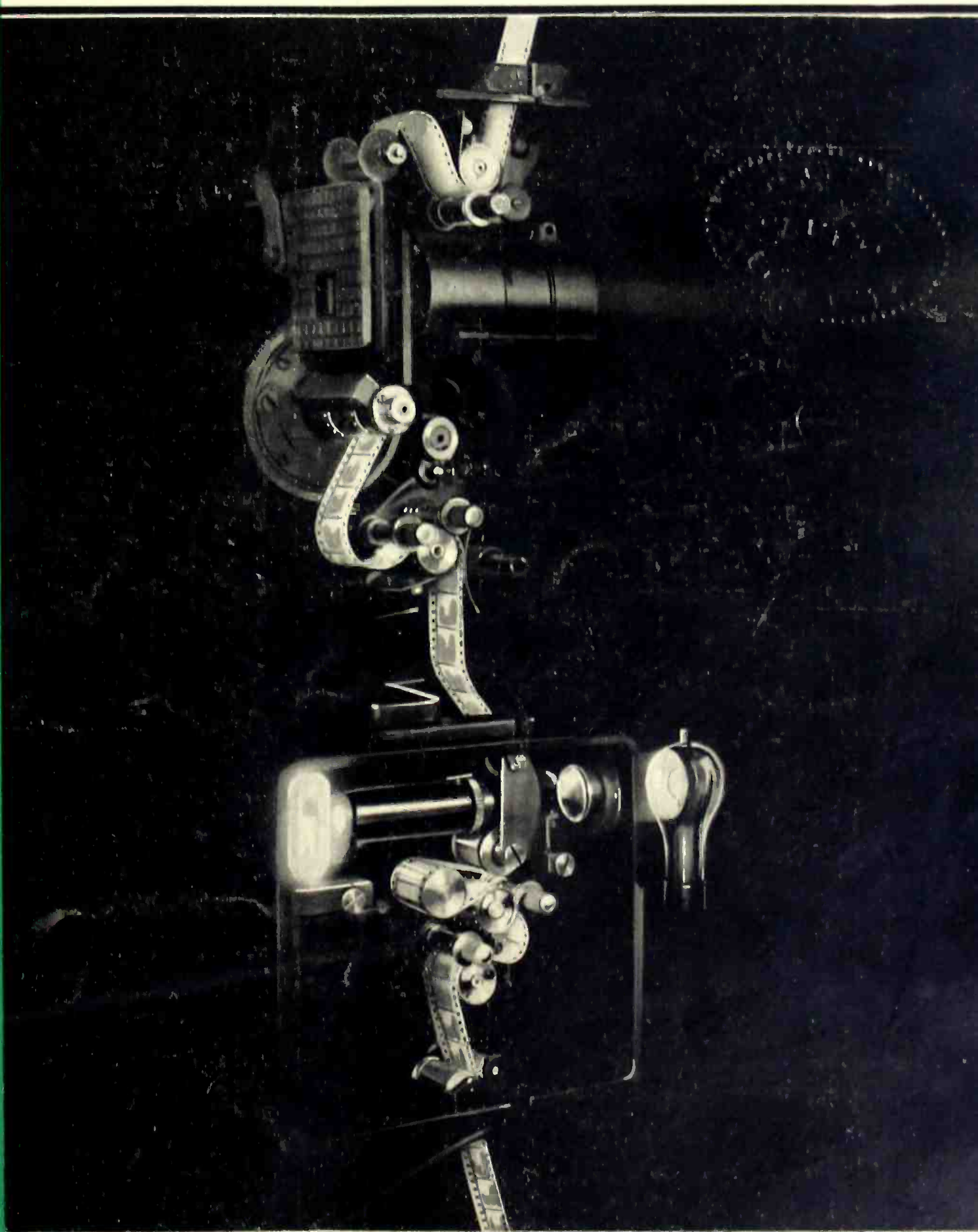
electronics

radio, sound, industrial applications of electron tubes + + + design, engineering, manufacture



Sound-on-film problems

Superheterodyne design

The dollar-value of tone

Acoustics for sound-picture theaters

"Unit" factory layout

A McGRAW-HILL PUBLICATION

Price 35 Cents

MAY 1931

COMPARE

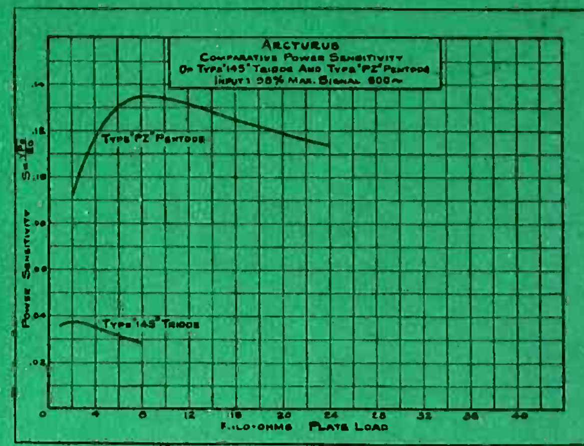
the* POWER SENSITIVITY *of the

PENTODE

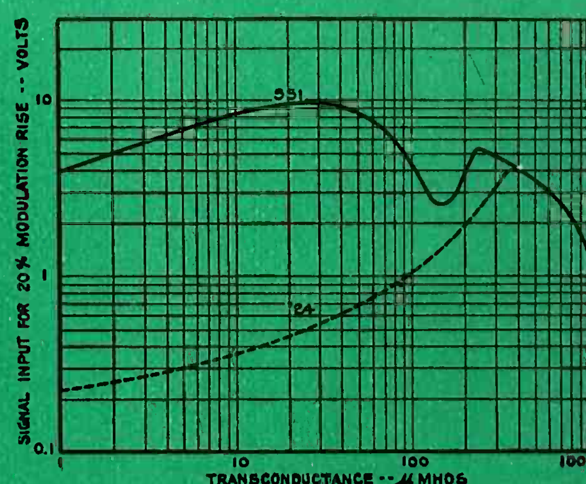
COMPARE

the* MODULATION DISTORTION LIMITS *of the

VARIABLE-MU



Because of its high "power sensitivity" the Arcturus Type PZ Pentode is almost 4 times as sensitive as the '45 power tube — a feature of decided importance when considering output, detector overload and plate supply arrangements. Greater volume, increased efficiency, and compactness of set design are the natural results.



MODULATION DISTORTION LIMITS

These two curves show the maximum input voltages at which the Arcturus Type 551 Variable-Mu and a typical '24 tube operate with practically undistorted amplification. The limits shown correspond to a rise in modulation of 20%. The 551 tube operates without distortion at about 20 times the voltage permissible with the '24 tube.

This and other features of the Arcturus 551 eliminate the need for double pre-selectors, dual volume controls, and "local-long distance" switches. Maximum cross-talk is divided by 500; receiver hiss is reduced. Circuits using this new tube are simplified as well as more efficient.

Send for Technical Bulletins giving complete performance data on the Arcturus Type PZ Pentode and the Arcturus 551 Variable-Mu Tube.

ARCTURUS RADIO TUBE CO., NEWARK, N. J.

ARCTURUS

***The* TUBE *with the* LIFE-LIKE TONE**

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electronics

A McGRAW-HILL PUBLICATION

New York, May, 1931

Some fundamental specifications for

The Midget

THE popular demand for a small, compact, low-price radio receiver is unmistakable. Already two-thirds of set sales are in the form of these handy inexpensive little units. Certainly there is a place for such sets in the radio line,—they fill a need in places *where a more expensive set is beyond the purchaser's financial reach,* and as a second or third set *in homes already provided with other receivers.*

But we see the midget not as an inferior set built down to a price, but as a unit of good tone fidelity for service in areas of high broadcast field strength. For such use, it should be characterized by,

1. Highest quality audio fidelity.
2. High quality acoustics.
3. Small, and inexpensive—but only consistent with high fidelity.
4. Sensitivity and selectivity limited to local reception.

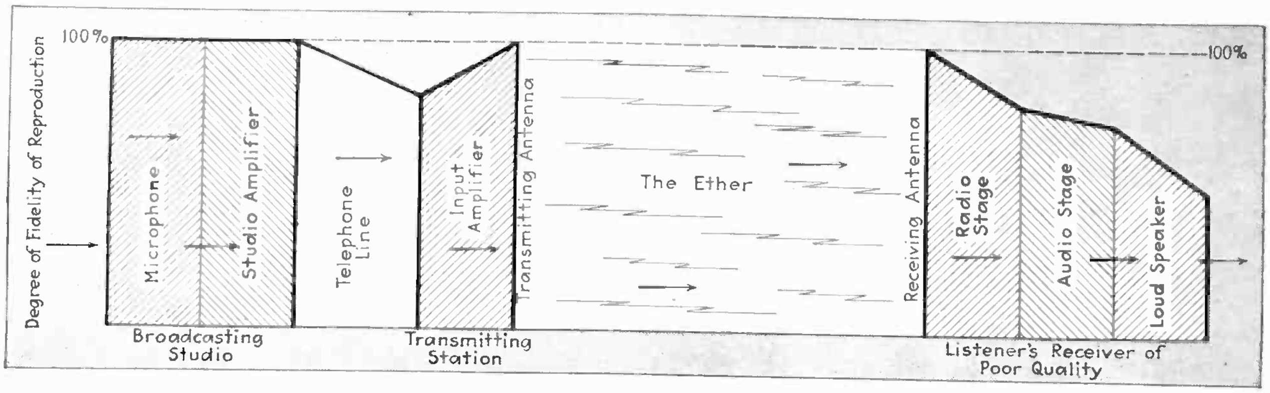
THE price should be low, but not too low. There is a legitimate need for receivers getting only local programs; there should be no skimping on transformer iron, or loud-speaker copper.

Years ago radio men tried to introduce a low-sensitivity or "metropolitan-area" receiver but the time was not ripe. People were then buying "distance." Now they want fidelity. Why not provide it?

There is no legitimate or permanent need for an ultra-cheap receiver. It is unfortunate that the mantel set should appear cursed because of the skimping process that characterized some members of the midget family.

ELECTRONICS believes that designers should accept the inherent advantages of midget construction; should realize the desires of many thousands of listeners who care not for distance; should design a receiver for 90 per cent reproduction and about 10 per cent sensitivity and selectivity. Such a set would be a dignified addition to the receiver group. Whereas a set hitting only about 40 per cent on everything, has no place in modern radio.

THE DOLLAR VALUE



Where the losses in tone fidelity occur, between broadcast studio and listener's living room. Radio of "100 per cent perfection" is delivered to listener's antenna, but a poor set may lose 50 per cent of tone values

IN ALL the sound-reproduction industries, one striking fact,—linking together technical advances and economic results,—stands out in the history of the past five years.

As fidelity of reproduction and realism have increased, the dollar gross of the business thus benefited has swung up to new totals. The public, served better, has responded in greater numbers and with a willingness to dig deeper into its pocketbooks.

For example, this was well illustrated when the movies, after a long period of silence, became vocal through the agency of the vacuum tube. The movies added "sound," realism was increased, and within two years the box-office receipts of the motion picture theaters of the United States had doubled!

Broadcast 100 per cent tone; receivers lose

Broadcasting stations have undergone a parallel history during the last five years. Formerly there was little attempt to achieve full tonal fidelity; it was then quite satisfactory to the average radio fan merely to hear a distant singer or orchestra, without thinking of "reality" in reproduction.

▼

TONE AND DOLLARS

HOW commercial expansion has always followed in the wake of increased realism.

The recent experiences of the sound-picture and broadcasting businesses.

Some lessons for the radio receiver, amplifier, and associated industries.

▲

But the broadcasting engineers and managers were looking further ahead. *Before the public itself knew that it wanted something better,* the broadcasters had begun to widen their range of tone reproduction, into the lows and the highs, until today a modern transmitter is capable of sending out a flat tone characteristic, from 30 cycles in the bass, up to 7,500 cycles in the treble.

And the result in the dollar total of income raked in by the broadcasting stations? Every radio man knows that the broadcasters' gross has doubled during the past three years, and every business man envies the broadcasters in having come through difficult 1930 as the most profitable year in their experience.

Receiving-set manufacture obeyed a similar trend. The radio business limped along from an acoustic standpoint, until realism was brought to it by the dynamic-reproducer speaker. Greater realism and tone fidelity summoned buyers in increasing numbers. Sales went up, with, of course, the advent of a number of factors, but important among these was the realism achieved by electrodynamic reproduction.

Broadcasters and set designers working in opposite directions

In each case as the "reality" index has gone up, the dollar index has risen with it.

But between the broadcasting engineers and the set designers there has been too little comparison of purpose or agreement of method. Radio broadcasting-station engineers have been pushing their sets chiefly into the higher frequencies, in order to get better transmission of overtones. Already standard broadcast transmitters put on the air a sound range from 30 cycles to 7,500 cycles, although the telephone lines serving the chain stations are capable of only the range from 75 cycles to 4,800 cycles. This compares with a top piano frequency of 4,096 cycles.

While the broadcast engineers have been pushing into the higher frequencies, the set designers have been emphasizing the bass notes, and driving the range of

OF TONE FIDELITY

receiver-set response lower and lower, under the impression that the public demands low-note amplification even to the extent of distortion! But in view of the fact that these radio sets are for the most part tuned in on chain programs, which have a lower limit of 75 cycles (imposed by the telephone lines), it appears that a whole octave of effort is lost because the two sets of designers have not coordinated their work.

Present amplifier design apparently suffers from two influences which are likely to have a permanent effect both on tone fidelity and on public response.

The first influence is the impression, already mentioned, that the public desires over - emphasis of the lows, and prefers actual distortion of tone values, to true balance of tonal qualities in bass and treble. As a result of this feeling, bass notes are now overstressed, and the recent tendency of manual "tone control" was started, placing in the listener's hands his own regulation of tone emphasis.

The second cause of tone distortion is the old matter of price pressure. In the effort of competitive reductions, prices have been forced down, and with such price whittling of course in some quarters there has been inevitable skimping of product and of tone response.

In this connection it is significant that the trend in broadcast transmitters and sound pictures has been definitely always to *increase* the tone fidelity of the equipment. Invariably and continually the standards of sound reproduction are forced higher and higher in these two fields. Although popular response is not immediately involved, nevertheless the broadcasting and movie managements have been far-seeing enough to realize that the public's acceptance for their mediums will be held in the long run, only by the highest possible standards of reality.

Ever-higher acoustic standards in two fields

And so under the discriminating dictatorship of the movie and broadcasting potentates, standards have been forced ever higher—much higher in fact than the standards imposed by competition in the democracy of the radio industry.

At the present time the whole industry of sound reproduction and amplification is on trial before the bar of public opinion. Radio broadcasting, sound pictures, amplifying devices, electric phonographs, home talkies, electronic musical instruments,—all are before the discriminating public on charges of lack of reality, lack of tone fidelity.

Reality of reproduction a basic need

The movies and the broadcast stations are leaving no technical stone unturned to drive their tone fidelity up to 100 per cent. The new sound-track inventions of movies, reveal the incessant effort being exerted to achieve realism in the theater auditorium.

And the broadcasters have attained remarkable fidelity right up to and into the ether, and through it, to the listener's antenna. As the accompanying diagram shows, the broadcasters are putting out practically 100 per cent perfect tone quality into the air. Any losses in the studio, studio lines or station, are painstakingly and accurately restored. Well - nigh perfect radio is being delivered right to the listener's door.

But what the listener does with that marvelous fabric of vibrations, representing only a few millionths of a watt of energy as picked up—how much of it the listener's set converts into music is quite a different matter. For with losses in the audio amplifier and loudspeaker, hardly 50 per cent of the original music may get through to the listeners in the room (see diagram), in the case of an obsolete or poorly designed radio set.

Unless a high standard of tone fidelity can be maintained in all of our sound-reproducing equipment, the public will become alienated from electrical sound devices. Discriminating listeners will be lost first, and then the general public's confidence and support will be impaired. If this takes place, the whole sound-reproduction family may slip back into second place, as a minor and imperfect art, instead of the dominant, all-embracing position which it should occupy, and toward which it has seemed to be headed.

Realism of reproduction, and *fidelity of tone* all along the audible range, are the *basic requirements* on which the business future must be built. Tone fidelity has dollar value which must not be sacrificed, either to fads or to competition in cheapness. Only through tone fidelity can the electronic sound arts be built up to the full dimensions of their destiny.

How sound realism has affected dollar volume

Motion-picture theater admissions

1926	**(silent)**	**$625,000,000**
1927	**(silent**	**$750,000,000**
1928	**(50% sound)**	**$1,000,000,000**
1929	**(75% sound)**	**$1,300,000,000**
1930	**(all sound)**	**$1,560,000,000**

Broadcast-station incomes

1926	**$9,000,000**
1927	**$10,000,000**
1928	**$17,000,000**
1929	**$25,000,000**
1930	**$35,000,000**

Sales of radio receivers and accessories

1926	**$506,000,000**
1927	**$425,000,000**
1928	**$690,000,000**
1929	**$842,548,000**
1930	**$500,000,000**

Undesired responses in superheterodynes

By RALPH H. LANGLEY

THE fundamental theory of the superheterodyne method states that a new frequency is created by combining the incoming signal with the output of an oscillating tube in the receiver. The combination contains a beat which when rectified appears as the new frequency, still carrying any modulation that was on the original signal. The new frequency is capable of further amplification, before it, in turn, is rectified, to produce the audio current.

As usually designed, the new (or intermediate) frequency is the same for all signal frequencies. This requires that the oscillator shall be tunable, in order that it may produce the correct frequency for each incoming signal. The reason for the high selectivity of which the system is capable, is the use of additional tuned circuits in the intermediate amplifier. These circuits are not adjustable in operation, but are permanently tuned to the chosen intermediate frequency.

In designing such a receiver, a decision must first be made as to whether the oscillator frequency is to be kept above or below the signal frequency. In the early superheterodynes, the oscillator was independently tuned, and thus might be adjusted either above or below the signal. This not only gave rise to a number of difficulties but it also required two major tuning controls, and it has therefore given way to the uni-control type in which both the oscillator and the carrier circuits are tuned by the same control. This maintains a constant difference in frequency between the signal and the oscillator, this difference being equal to the intermediate frequency.

If the design is such that the oscillator frequency is always higher than the signal frequency, then the oscillator will not be required to cover as large a range of frequency as the carrier circuits. This is in the direction of economy and is therefore common practice in modern designs. If the oscillator were below the carrier frequency, it would be very difficult to design its circuit so that it would adequately cover the range, unless the intermediate frequency were quite low.

When two frequencies are combined and rectified, beats corresponding to both the sum and the difference occur. Some receivers have been built commercially in which the sum rather than the difference was used for the intermediate frequency. It is much more difficult, however, to design an efficient intermediate amplifier for these higher frequencies, and modern practice therefore is to use the difference frequency.

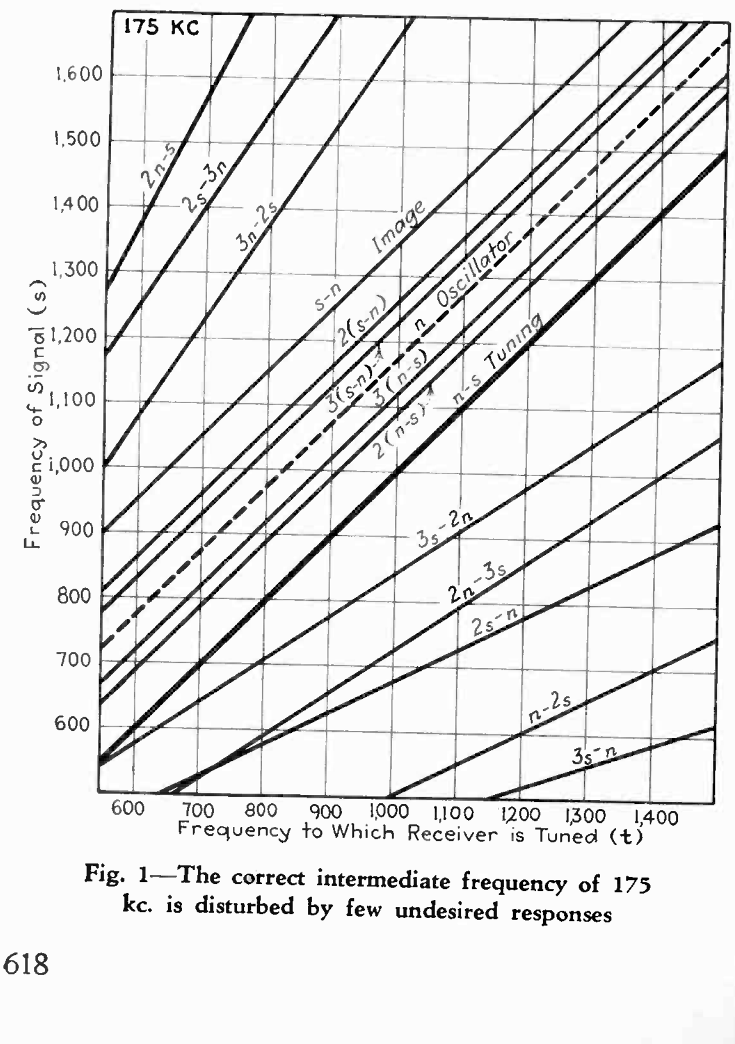


Fig. 1—The correct intermediate frequency of 175 kc. is disturbed by few undesired responses

Choice of intermediate frequency

A great deal depends upon a proper choice of the intermediate frequency. Serious difficulties would arise if it were placed in the audible range, and equally serious troubles would be encountered if it were placed within the range of the frequencies of the signals themselves. And since there are reasons for not placing it above the broadcast range, the choice seems to lie between the highest audio frequency and the lowest radio frequency, or between 10 kilocycles and 550 kilocycles.

The first superheterodynes were built with a 40 kilocycle intermediate, but there are today numerous "carrier current" communication systems on the transmission lines, and the carrier frequencies on these systems run as high as 90 kilocycles. This further limits the choice, because of the possibility of interference from these carrier systems, to the range between 100 and 550 kilocycles.

To make an intelligent choice in this range, factors must be taken into account which were at first quite mysterious to superheterodyne experimenters. The system is capable of responding in a number of ways which do not correspond to the desired performance. Undesired signals, from stations to which the carrier circuits are not tuned, can find their way through to the loudspeaker if they are strong enough. It is necessary, in fact, to use a considerable amount of carrier frequency tuning, in order to improve the ratio between the desired and the undesired signals, before the change in frequency is made.

The amount of carrier frequency tuning necessary, and the care with which both the carrier circuits and the

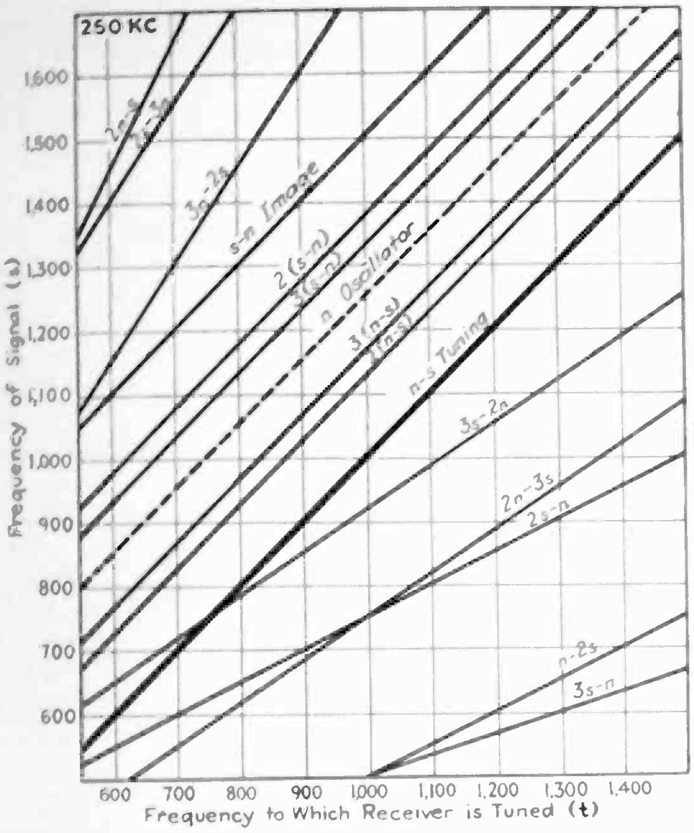


Fig. 2—An intermediate frequency of 250 kc. does not give freedom from undesired response

oscillator circuits and the shielding must be designed, depends upon the choice of the intermediate frequency. A very large amount of work has been done in order to arrive at the best value, and the 175 kilocycle intermediate now in general use can be shown to have definite advantages over any other possible frequency.

The first and most prominent undesired response is the "image." This corresponds to a signal higher than the oscillator in frequency, by the amount of the intermediate frequency. The desired signal is below the oscillator. Obviously, the higher the intermediate frequency, the easier it will be to "tune out" this undesired signal in the carrier tuned circuits. The difference in frequency between the desired and the undesired image signal is twice the intermediate frequency.

There are, however, many other undesired responses. These occur because both the signals and the oscillator may have harmonics. If we take into account only the second and third harmonics, there are at least 16 possible undesired signals that may give trouble. Whether they will or not depends, among other things, upon how strong they are. A powerful local station may give trouble at several of these points as the receiver is tuned through the range.

Sources of undesired responses

Curves showing where and how these harmonic responses occur may be drawn by first making a simple algebraic computation.

Let s = frequency of signal
t = frequency to which the receiver is tuned
n = frequency of the oscillator
i = frequency to which intermediate amplifier is tuned.

Then for normal superheterodynes as now built,

$$i = n - s$$

The image response is

$$i = s - n$$

And the possible harmonic responses are

$i = n - 2s$	$i = s - 3n$
$i = 2s - n$	$i = 3n - s$
$i = s - 2n$	$i = 2n - 3s$
$i = 2n - s$	$i = 3s - 2n$
$i = 2(n - s)$	$i = 3n - 2s$
$i = 2(s - n)$	$i = 2s - 3n$
$i = n - 3s$	$i = 3(s - n)$
$i = 3s - n$	$i = 3(n - s)$

The corresponding family of curves may be drawn by plotting the frequencies to which the receiver is tuned on one axis, and the frequencies of the signals on the other axis. The equation for the main tuning curve for the desired signal is then

$$s = t$$

On the same sheet we may plot a curve for the frequency of the oscillator for each tuning position and each corresponding signal frequency. The equation for this curve is

$$s = t + i$$

The signal that will give the image response is

$$s' = s + 2i = t + 2i$$

The method of obtaining the curve for each of the harmonic responses is illustrated in the following example. We will obtain the curve for the case in which the third harmonic of the signal beats with the second harmonic of the oscillator to produce the intermediate frequency, assuming that the signal harmonic is higher than the oscillator harmonic. The statement of this condition is

$$i = 3s'' - 2n$$

The oscillator frequency, as before, is

$$n = s - i$$

Substituting, we have

$$\begin{aligned} i &= 3s'' - 2(s - i) \\ &= 3s'' - 2s - 2i \\ 3s'' &= 2s + 3i \\ s'' &= \tfrac{2}{3}s + i \\ &= \tfrac{2}{3}t + i \end{aligned}$$

In figures 1, 2 and 3, families of such curves are shown

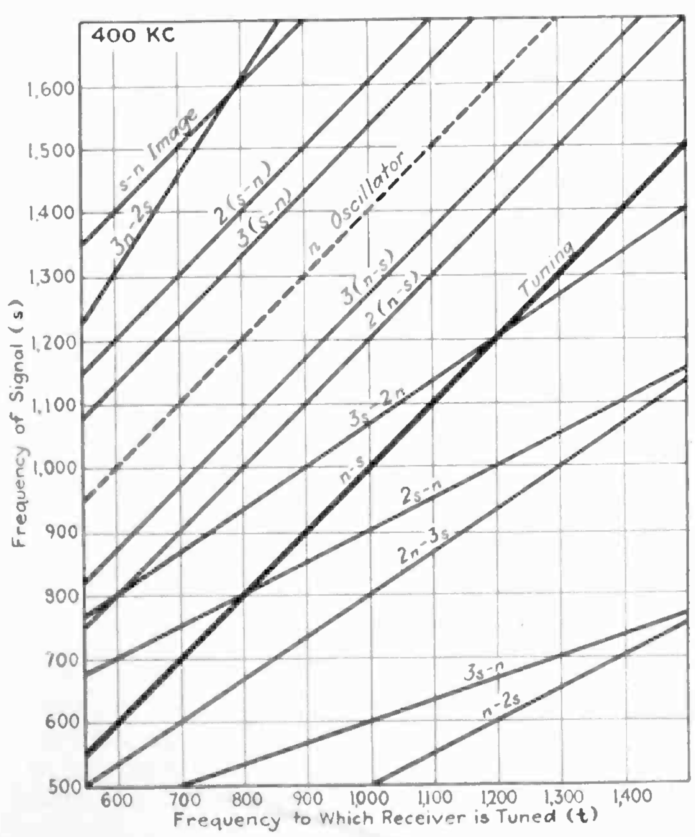


Fig. 3—A high intermediate frequency is troubled with other responses more than lower frequencies

for three different intermediate frequencies. Fig. 1 is for 175 kc., Fig. 2 for 250 kc., and Fig. 3 for 400 kc. It will be noted that not all of the possible responses fall within the tuning range, for any of the intermediate frequencies shown. Some of those that do lie within the range, are possible only over a portion of it. Others, however, are possible throughout the range.

Some of the curves are parallel to the main tuning curve, and some are not. The non-parallel curves intersect the main tuning curve for certain intermediate frequencies, and these intersections are definite danger spots. Consider, for example, the $3s—2n$ curve, in the three cases shown in the figures. For a 400 kc. intermediate (Fig. 3) this curve intersects the main tuning curve at 1200 kc. For 250 kc. intermediate the intersection falls at 750 kc. For 175 kc. intermediate there is no intersection within the range, but one would occur just below 550 kc.

It is not the intersections themselves that are dangerous. These points represent two different methods of receiving the same desired signal. At these points, the normal beat between oscillator and signal is numerically equal to the beat between signal third harmonic and oscillator second harmonic.

But just above, or just below these points, trouble is encountered. In Fig. 2, for example, let us suppose that we are attempting to listen to WEAF of New York City on 660 kc. on a receiver located in Toronto, where CKGW broadcasts on 690 kc. The selectivity of the intermediate amplifier would normally be ample to separate these two signals. The normal beat for WEAF is 250 kc., to which the intermediate amplifier is tuned, and the normal beat for CKGW is only 200 kc., 30 kc. or 12 per cent off. But the $3s—2n$ beat is exactly 250 kc. for the 690 kc. station. Unless the carrier tuning in the receiver is sufficient to greatly reduce the CKGW signal, and unless both the signal and the oscillator have very low harmonics, it will be impossible to receive WEAF.

Such examples of difficulty in receiving particular stations at certain receiving locations can easily be multiplied by a study of the curves. A vertical line drawn through the frequency corresponding to any desired station, will show, by its intersections with the other curves, the frequencies of the stations which may produce an undesired response. The locations of these stations can be found in any list, and these are the places where difficulty may be expected.

A horizontal line drawn through the frequency of any particular broadcasting station, will show the frequencies at which this station may give trouble. For example, let us assume a 175 kc. superheterodyne, and examine what station WOC on 1000 kc. at Davenport, Iowa, might do. Referring to Fig. 1, the intersections occur at the frequencies shown below, and for each frequency another station whose reception might be rendered impossible in the neighborhood of Davenport, is shown.

550	WKRC	Cincinnati, Ohio
650	WSM	Nashville, Tenn.
740	WSB	Atlanta, Ga.
770	WBBM	Chicago, Ill.
880	KPOF	Denver, Colo.
910	CJGC	London, Ont.
1240	KTAT	Fort Worth, Texas
1400	WKBF	Indianapolis, Ind.

The elimination of the undesired response to WOC where its signal is strong, in listening to any of the stations listed, is largely a matter of sufficient carrier frequency tuning to greatly improve an otherwise adverse field strength ratio. If harmonics of appreciable amplitude are present in the signal or in the oscillator, nothing in the intermediate amplifier can prevent this station from coming through.

An examination of the three families of curves given, shows that for some of the undesired responses, the higher the intermediate frequency the better. The curves corresponding to $n—s$, $2(s—n)$, $3(s—n)$, $3(n—s)$, and $2(n—s)$ move away from the tuning point as the intermediate frequency is increased. For several of the other responses, however, the situation is made worse. This group includes $3s—2n$, $2n—3s$, $2s—n$, $n—2s$, and $3s—n$. From the curves presented, the indications are that 175 kc. is the best intermediate frequency to choose.

No consideration has been given to harmonics higher than the third. In general, the interference points corresponding to these upper harmonics are still further removed from the tuning point, and are therefore more easily eliminated by the carrier tuned circuits. Nevertheless, actual responses to harmonics as high as the sixth will be heard if the signals are fed directly to the first detector.

Importance of carrier tuning

Most broadcasting stations today radiate only a very small amount of energy on the harmonic frequencies. In the case of one station of 50 kw. capacity, on which the author supervised the construction and installation, the actual measured radiation on the second harmonic was only 0.05 watts, a ratio of a million to one. It is not necessary, however, that there be any harmonic in the signal as received. If the carrier-frequency tubes in the receiver are overloaded by the strong signal from a local station, the harmonics are generated in the receiver itself. This is a matter demanding especial care in design. The new exponential tubes have a real value in this respect.

Unless the circuits of the oscillator are carefully designed, harmonics will be present in the output. The voltage delivered by the oscillator may easily be great enough so that the first detector tube is overloaded, and harmonics not otherwise present may be generated there. The oscillator voltage varies with frequency and unless precautions are taken, harmonics may be present over certain portions of the range, if not throughout.

The actual signal level created by the undesired response may be quite small, so faint in some cases that the interfering modulation is not heard. Yet it does definitely contribute to the background of noise, and the only way in which the extent of this trouble may be determined is by actual comparison, on the same signals, with a tuned radio frequency receiver of the same sensitivity, and as closely as possible the same selectivity.

The curves have been extended somewhat above and below the frequency range of the broadcast signals. As the receiver is tuned toward either end of the range, stations other than broadcasting may give trouble. Many instances of this have actually occurred. This possibility must be definitely kept in mind in the design and test work. Aircraft land stations and police stations are particularly to be watched in this respect.

The superheterodyne method by itself, without the assistance of carrier tuned circuits ahead of the first detector, is quite hopeless. But when coupled with an adequate amount of carrier tuning, it produces a receiver that cannot be surpassed, in its abiity to definitely and completely separate each of the 96 broadcast channels.

Design problems of

Sound-on-film

for home movies

By A. J. KOENIG

New York City

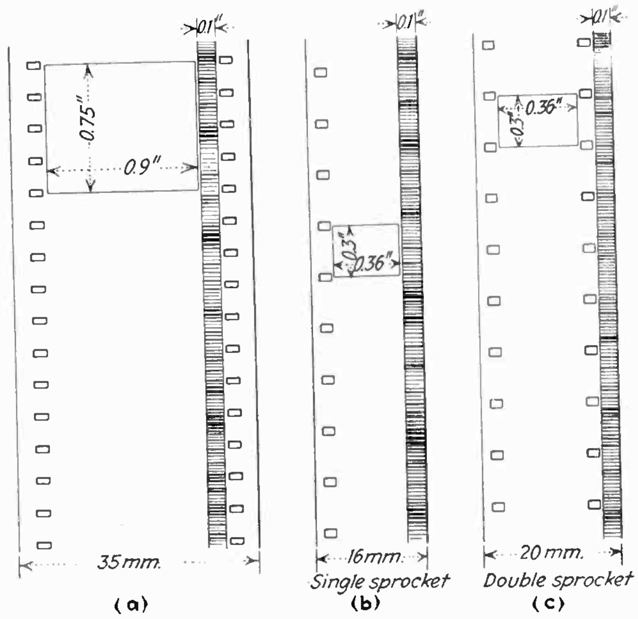


Fig. 1—Illustrates the comparative dimensions of sub-standard film widths with position of sound tracks found practical

THERE are many important engineering as well as economic problems to consider in designing equipment suitable for recording and reproducing sound-on-film for home use. While equipment perfected in the laboratory may be capable of handling a wide range of frequencies, the economic cost of manufacture together with consideration of standard equipment already having national use, means that deficiencies in frequency range within certain limits may be acceptable in commercial equipment. This refers particularly to the lower projection speeds of standard 16 mm. film compared to standard 35 mm. film.

Since the advent of sound pictures, the speed of professional 35 mm. film is 24 frames per second or 90 ft. per minute for both recording and reproducing. For 16 mm. film the projection speed for sound pictures would also be 24 frames per second but only 36 ft. per minute, which is 40 per cent of 35 mm. film's velocity. With the exception of the width of the sound track and sprocket holes, all other dimensions are 40 per cent of the standard 35 mm. film. Figures 1 (a) (b) and (c) illustrate the principal film widths and dimensions in which we are immediately interested. Fig. 1 (a) shows the relative position and dimension of the sound track for 35 mm. film while (b) and (c) illustrate the proposed position and dimensions for sub-standard film.

Inasmuch as the quality and definition of speech and music are both functions of the frequency range of the system, we shall consider the frequency limitations. Based on acoustic research, a great deal of material has been published on the effects eliminating frequencies from various parts of the spectrum especially within the range of 50 to 5000 cycles. It is a well-known fact that when frequencies below 150 cycles are eliminated, a great deal of the "timber" is lost, but the characteristics of the voice or music do not seem markedly different than if these frequencies were present. On the other hand, frequencies above 4000 cycles, while they add "brilliance," the energy content in these frequencies is relatively small. Elimination of these frequencies will result in a noticeable lack of definition of such letters as *s, z, th,* and *f*. It will not, be sufficiently serious to warrant their inclusion when the increase in cost is considered. In fact, satisfactory quality can be realized if a band of from 100 to 3500 cycles is utilized.

The effects of finite slit widths in recording and reproduction are well known. Recently an excellent article was published on this subject[1] in *Electronics*. It must be borne in hind, however, that the analysis is based on a perfectly rectangular slit such as is never attained in ordinary commercial practice, due to spherical aberration in the lens system. Actually the slit image is somewhat elliptical in shape and the effects of this would require an extremely complex analysis. Suffice it to say, however, that the actual attenuation and phase shift of the higher frequencies is a great deal more serious than might be deducted. We can conclude from this that the slit width is of paramount importance in determining the frequency band to be covered.

▼

DESIGN problems in connection with recording and reproducing sound on 16 mm. and 20 mm. film are set forth in the accompanying article. Progress with sound-on-film for home talkies is sufficiently promising to expect early commercial use.

▲

Reduction in slit width necessary

For 35 mm. film with a velocity of 90 ft. per minute, the slit width used is .001 in. By the same propensity we must reduce the width of the slit to .0004 in. for 16 mm. film with a velocity of 36 ft. per minute. As a matter of fact, the writer found it necessary to resort to a slit width of .00025 in., to compensate for the deviation from an absolutely rectangular slit, as mentioned above. While the attentuation of the higher frequencies

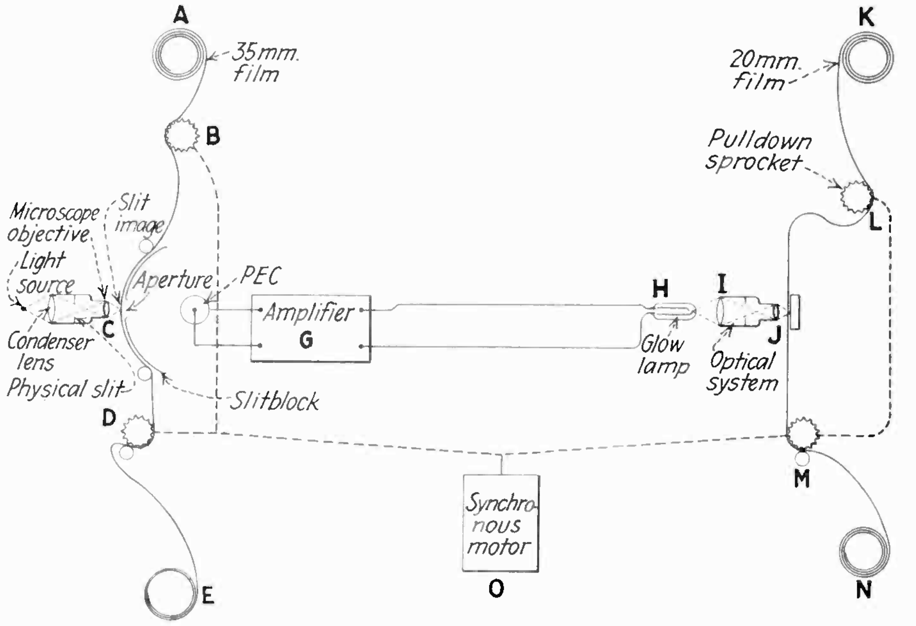


Fig. 2—Diagram of re-recording machine for "dubbing" sound from a standard; 35 mm. film to 16 mm. or 20 mm. film

impairs quality, the effect is not nearly so pronounced as the lack of definition caused by phase shift. It can be readily seen that a slit width of .00025 in approaches the limits of mechanical accuracy, not to mention accuracy in production. Indeed the result of such a slit is an increase in effective intensity of the noise due to film grain and the inevitable dust and scratches on the film. As a result of recent research, various methods have been devised which would reduce this noise very appreciably.

It is imperative that any developments on narrow gauge sound-on-film be guided largely by present manufacturing standards particularly with regard to distances between sprocket holes, size of pictures, etc. With this in mind, the logical solution for 16 mm. film is to use sprocket holes on one side of the film only and to put the sound track on the other side where the sprocket holes have been eliminated. With this method, the width of the sound track can be made 0.1 in. which is the same as for 35 mm. film. It is well to point out here that in reproduction, the aperture in the slit block between the film and the photo-tube is usually about .005 in. narrower than the sound track on either side. This is necessary to compensate for sidewise motion of the film caused by irregularities in the edge of the film or in the sprocket holes. This represents a sacrifice of 10 per cent in the width of the sound track for a width of 0.1 in.. It is not difficult to see that if we made the width of the track .05 in. or half the former width, the sacrifice of .01 in. would be 20 per cent. In other words, the efficiency decreases with track width. A 16 mm. film using a single sprocket hole with a sound track width of 0.1 in. is shown in Fig. 1 (b).

The greatest objection to this method is that in reproduction with a standard eight-tooth sprocket only two sprocket holes are engaged at any instant of time, with the result that the load imposed upon such a small area was entirely too great. This often results in a slight tear at the edge of the sprocket holes and causes the film to jam in the intermittent movement. For sake of simplicity, the usual pull-down sprocket is eliminated. In view of the fact that the film must be under tension from the reel to the slit block in order to maintain it at the point of focus of the slit image, it can readily be understood why the load at the sprocket holes is too great. Even though the number of sprocket holes engaged are doubled there is always present the tendency for the film to be pulled at an angle and warped so that the striations of sound are drawn across the slit image at an angle instead of parallel. This is very detrimental to say the least. In spite of the fact that it can be made to operate satisfactorily, the results are not consistent and the plan was discarded for this reason.

[1]Frequency Characteristics in Optical Slits by J. P. Livadary, *Electronics*, February, 1931.

Of the various methods of adding a sound track, there is one which appears to give the greatest promise of success. This plan calls for increasing the width as in Fig. 1 (c) to 20 mm. The sound track is placed upon this additional width. It is worthy of note that the size of the picture has not been altered nor have the distances between the sprocket holes. With a 20 mm. film we have sprocket holes on both sides and a standard width sound track. This arrangement was decided upon as the logical solution to the reproducing problem in so far as the film was concerned. A feature of this plan is that 20 mm. film may be used on any standard 16 mm. projector now in use. The adoption of this width of film would result in having all sound film available from film libraries 20 mm. in width which could be run on either the present silent 16 mm. projectors, or on the new sound projectors of the future. The silent 16 mm. film could be run on either projector. It has been estimated that there are upwards of 125,000 silent 16 mm. projectors and a large number of 16 mm. cameras in use in this country. There will no doubt be a demand for equipment to fit present projectors with some form of sound attachment. For this reason it seems sensible to take this into consideration, as owners of these projectors and cameras represent a potential market for home sound movies.

"Dubbing" from 35 mm. to 20 mm. film

The principal subject material for home movies is available only through reduction printing of present professional 35 mm. film. It is doubtful if recording sound and scene on sub-standard film will assume any great proportions except by using professional films for producing such pictures. The problem of re-recording from 35 mm. to 16 mm. film has been accomplished by the apparatus shown in Fig. 2.

Many attempts have been made to optically reduce the sound track from 35 mm. film to sub-standard film, but to date none of the methods have met with any degree of success as far as it is known. The reason is quite apparent when we consider that the slightest vibration in the optical systems would produce a very serious waver in the sound film record. It was found necessary to resort to electrical re-recording or "dubbing" which has proved its worth as a satisfactory solution.

In Fig. 2 a schematic layout is given of a 20 mm. recorder and a 35 mm. projector head connected mechanically to the same motor to insure absolutely constant relative speeds. The 35 mm. film on reel *A* is drawn down by pull-down sprocket *B*. Sound sprocket *D*

[*continued on page 655*]

A dynatron vacuum-tube voltmeter

By RINALDO de COLA

Chief Engineer
The Victoreen Radio Company

DURING the past several years the vacuum-tube voltmeter has won for itself an enviable position in practically all phases of electrical engineering. It is ideally adaptable to tests in the performance of radio equipment. However its uses have been limited in some cases because of its relatively poor sensitivity.

This paper is therefore devoted to the use of the Pliodynatron, as a means of obtaining considerably greater sensitivity than formerly possible with single-tube voltmeters.

The Pliodynatron

The Pliodynatron was originally invented by Dr. A. W. Hull.[1] Its fundamental circuit is shown in Fig. 1. It is a tetrode device and has two grids, a control grid, and the high potential grid which may be quite accurately called an "acceleration grid." The plate in this device is usually operated at potentials of approximately one-fourth to one-half of the acceleration grid. The operation of this tube is due to secondary emission from the plate to acceleration grid.

If an E_p-I_p curve is plotted for changes in plate potential ranging from zero to approximately the potential of the acceleration grid, a curve of the type shown in Fig. 2 will be obtained. The section of the curve of particular interest is that between the points marked *A* and *B*. This region is known as the "region of dynatron action." During this region the tube possesses negative resistance, since an increase in plate voltage gives a decrease in plate current. If a tuned circuit is inserted in the plate circuit, and the plate resistance is negative, oscillations will result.

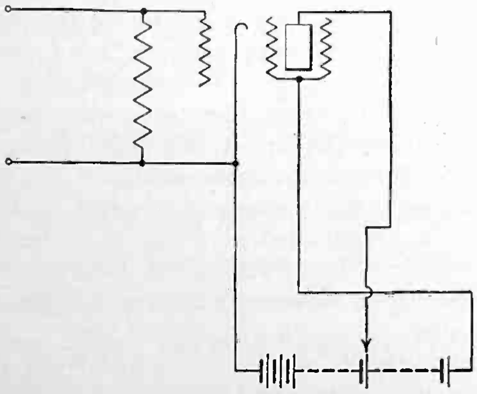


Fig. 1—Fundamental pliodynatron circuit

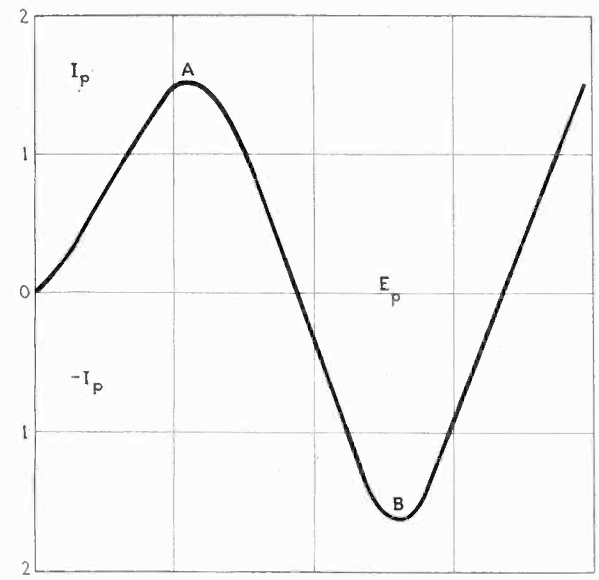


Fig. 2—Characteristic of lower part of E_p-I_p curve of screen-grid tube

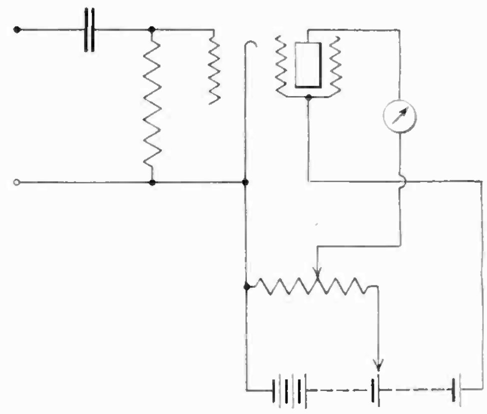


Fig. 3—Pliodynatron vacuum tube voltmeter circuit

Also if a positive resistance of the same ohmic value as the negative plate resistance is inserted in the plate circuit the total plate circuit resistance will be reduced to zero. From this consideration it can be seen that if any voltage whatever is applied to the plate circuit, an infinite change in plate current will result. This voltage can of course be introduced in the plate circuit by applying a voltage to the control grid. In practice, however, the value of plate resistance corresponding to zero or very nearly so is almost impossible to obtain.

In Fig. 3 is shown a diagram of a vacuum-tube voltmeter of this type. Because of the negative slope of the plate current, grid circuit rectification will give an increase in the plate current.

Ordinary screen-grid tubes were used for obtaining these results, although some specially designed Pliodynatron devices were experimented with also. Operating

[1]*Proc. I.R.E.* February, 1918.

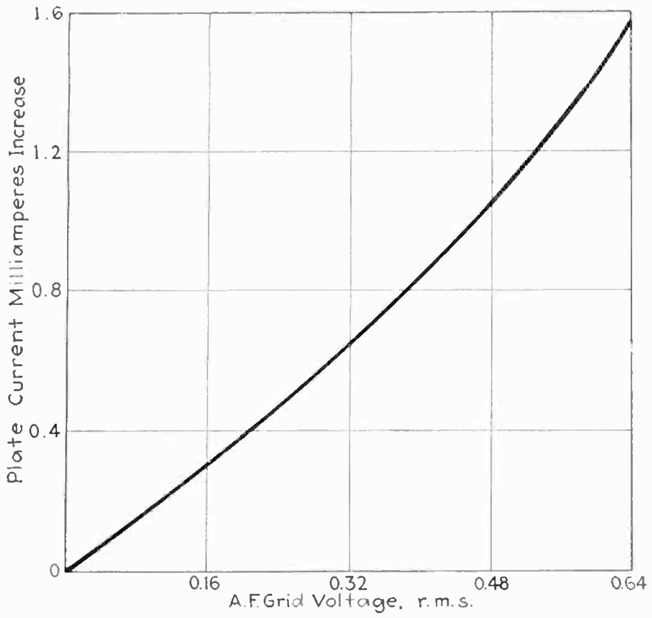


Fig. 4—Dynamic characteristic of voltmeter

the ordinary 224 tube in the fashion indicated, and with approximately 90 volts applied to the screen-grid, and a variable plate potential as shown in the diagram between zero and 45 volts the curve shown in Fig. 4 was obtained, for impressed audio-frequency grid voltages. A d.c. meter with a range of 0–1.5 m.a. was used in the plate circuit. The sensitivity of this device will be seen to be excellent. A deflection of 0.05 m.a. was obtained in the plate circuit for a grid voltage of 0.02 r.m.s.

A survey of Fig. 1 will show that the point of best operation, should be at the base of the curve marked *B*. Operation at any other point between the limits *A* and *B* will reduce the range of the meter. A mental curve of the plate characteristic can be visualized when attempting to locate the proper operating point. Varying the plate potential by means of the potentiometer as shown in Fig. 1 will serve to locate the particular point wanted.

A close study of Fig. 1 will disclose that even greater sensitivity can be expected from a device of this nature, since any change in the integral current will directly affect the value of screen current, as it is an integral part of the plate circuit. Thus for any change in grid potential there will result a change in screen current which is the *sum of the change of screen current and the change in plate current*. This point may be made clearer perhaps by stating that since the plate current, during the time that its locus is negative, is always supplying some

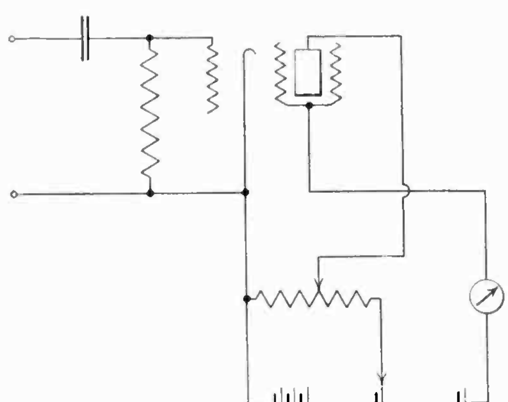


Fig. 5—Voltmeter with meter is screen-grid circuit for improved sensitivity

electrons to the screen. The farther negative the plate current becomes the higher the value of normal screen current. Any effect therefore which tends to make the plate current more negative or more positive will respectively result in making the normal screen current increase or decrease. Consequently, if a milliammeter is placed in the screen circuit, and with rectification taking place in the grid circuit, any voltage impressed upon the grid will cause a decrease of current to the screen, both from the electronic source of the cathode and from the plate.

A schematic arrangement of this type voltmeter is illustrated in Fig. 5. A calibration curve is shown for audio-frequency voltages impressed upon the grid, against total change in the screen-grid circuit in Fig. 6. This arrangement gives about twice the sensitivity obtained with the meter placed in the grid circuit. The current deflection is downward however.

Some care should be exercized before inserting sensitive meters in the plate circuit, since a relatively small change in plate voltage, perhaps 1.0 volt or so will cause the plate current to swing through very wide limits. The circuit should first be adjusted with a fairly rugged meter before inserting the more sensitive one. No

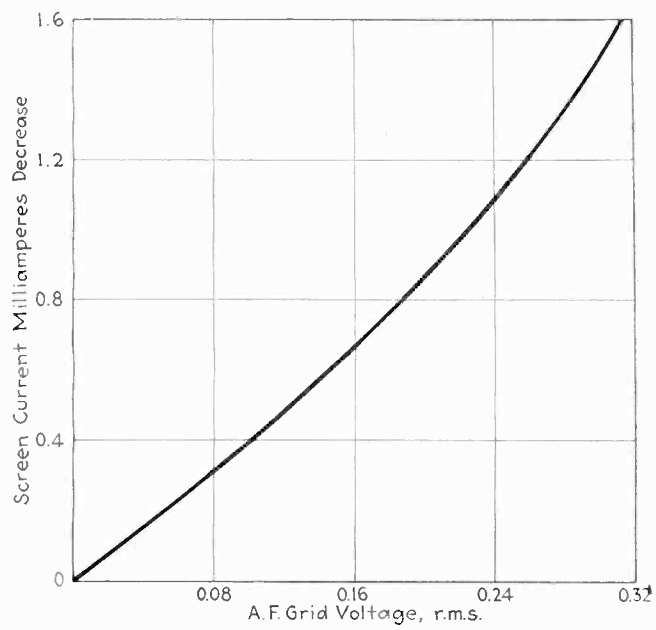


Fig. 6—Dynamic characteristic of sensitive Pliodynatron voltmeter

trouble should be encountered, however, using meters with a maximum range of 1.5 m.a.

The device is not recommended for use in r.f. circuits. The writer has found from an investigation of the dynatron theory, that if a voltmeter of this type is placed across an efficient circuit such as a r.f. amplifier, the system will very probably start oscillating. In fact a grid dynatron oscillator can be readily constructed by placing a tuned circuit in the grid input. However, oscillations are comparatively weak.

Bucking-out the average d.c. plate and screen-grid current is recommended in order to increase the range of the meters. The bucking-out battery for the value of current in the screen should be capable of supplying about 5 mils.

A double-range meter may be devised by inserting meters in both screen and plate circuits, with provisions for cutting out either meter when not in use.

Unbalanced absorption in

Acoustic treatment for sound-picture theaters

By VESPER A. SCHLENKER

Consulting Acoustical Engineer, New York City

THE beginning of modern acoustics was made by Professor W. C. Sabine in 1895 at Harvard University. Since Sabine's work there has been practically no change in the technique of acoustic diagnosis of acoustical defects in auditoriums. In fact, there has been very little contributed to auditorium or theater acoustics since Professor Sabine's work. This condition is not due to the lack of capability of the succeeding investigators but, rather, it should be attributed to the lack of adequate apparatus and technique to carry the experimental work beyond the laboratory into the auditorium itself.

Some of the recently developed units of electro-acoustic equipment which have made possible a more adequate technique of acoustic surveys include the condenser microphone, electric oscillator, amplifier, calibrated attenuator, thermocouple, improved oscillagraph and loudspeaker. The heart of the entire equipment is, of course, the vacuum tube.

▼

A NEW method of diagnosis and treatment of acoustics in sound picture theaters and other auditoriums is treated in this article. Electronic acoustimeters make possible improvements over former calculation methods.

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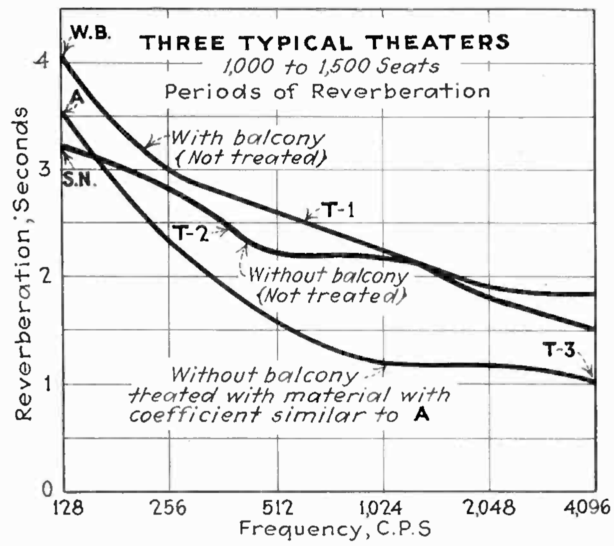

Fig. 1—Reverberation curves of three typical theaters with different acoustical treatment

During the last two years of acoustic research the writer developed a "Truck Mounted Laboratory" which includes some of the latest electro-acoustic equipment. This acoustic truck was developed for the Vitaphone Corporation, and has been used by the writer for obtaining experimental results. The method of measuring the period of reverberation consists of filling the room with a single frequency tone modulated over a half octave band. This warbling tone is projected into the room by means of transmitting amplifiers in the truck and loudspeakers placed in the room. When a steady-state condition has been reached the tone is interrupted electrically by means of a relay. Simultaneously, the shutter of an oscillograph mounted in the truck is opened so that the decay of the sound, which is picked up with a microphone placed in the room, is photographed.

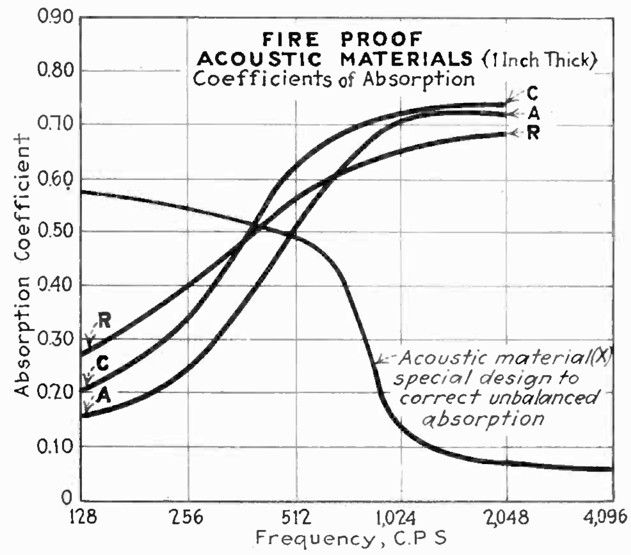

Fig. 2—Coefficients of absorption curves of well known materials for different frequencies, also one material of special design to correct unbalanced absorption in acoustic treatment

The sound is recorded on the oscillogram at a normal level and in addition it is recorded at a higher level which is adjustable in steps of three decibels above the lower channel. The time required for the sound to decay from the high to the low acoustic level will be indicated by the distance between the two points on the oscillogram where the low gain trace is equal to the high gain trace. If, for example, this distance on the rotating oscillogram, indicated a time of 1.2 second when the gain between channels was set at 30 decibels, the decay from 60 decibels is 2.4 second. The time of 2.4 seconds is, then, the period of reverberation. It is quite evident that extremely short, as well as very long, periods of reverberation can be measured with this method by simply changing the drum speed which is adjustable for this purpose.

Accoustics, or the science of sound as applied to buildings, must include loudness, reverberation, echo and extraneous noise. The resulting effect on articulation or intelligibility of speech is of most vital importance. Good or bad acoustics go hand in hand with good or bad articulation. Good articulation depends not only on the undistorted transmission of the components of speech but also upon the maintenance of sufficient loudness.

It is a known fact that a large part of the energy which reaches the ears of the listener in an auditorium comes by reflection. No further comment is necessary to point out the importance of the manner in which this reflection is accomplished. The relative absorption of the various components of the complex sound is of vital importance. It will naturally determine in a statistical way the reverberation or prolongation of the various frequency components.

A knowledge of the variation of reverberation with respect to pitch or frequency is not new. Apparently, no great importance has been attached to this variation except as it had an effect on music. There is every indication however, that the reverberation at all frequencies over the speech band should be considered as well as the 512 cycles per second which is ordinarily used for purposes of calculation. The reverberation for three small theaters is given in Fig. 1, to show the general trend of the curves as determined by actual measurements. Particular attention is directed to the slope of these curves with respect to the frequency axis. The low frequency portion of the reverberation curve is tilted upward. This condition can be described as "unbalanced." Theater "T-1," untreated acoustically, has a greater unbalance

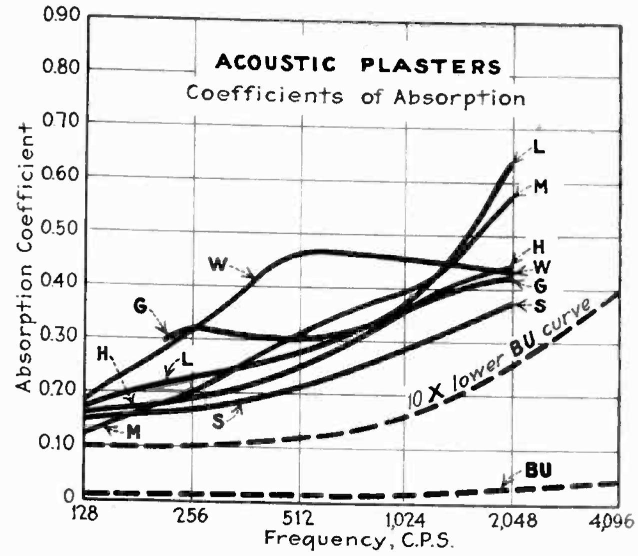

Fig. 3—Coefficient of absorption curves for acoustic plasters commonly used for various treatments

than "T-2." This is due largely to the fact that one has a balcony while the other has not. It has been the writer's observation that the theaters which he has actually measured fall into these two classes quite naturally. It is evident, then, that a great importance may be attached to the balance or slope as well as the magnitude of the reverberation curves. It has also been noted by the writer that the curve is further unbalanced when it is lowered by the installation of the common absorbing materials. This fact is shown by curve "T-3" which was taken in a theater without a balcony after being acoustically treated with a well known and widely used acoustic material.

During the last year a great activity has been made by Government officials in enforcing the requirement that acoustic materials be fire-proof as well as fire-resistant. The absorption curves of three important fire-proof materials for wall and ceiling treatment are shown in Fig. 2. The ordinates represent the fractional amount of incident sound energy which is absorbed and is called the absorption coefficient "a" of the Sabine equation* which is written:

$$T = \frac{0.05V}{Sa}$$

Where V is the volume of the room in cubic feet, S the surface in square feet, and T the period of reverberation in seconds.

It is evident that material R in Fig. 2 has a characteristic more nearly flat than the other two. By actual experience in sound studios it has been found that this treatment R improves the recording very noticeably.

Two different results obtained

It is quite necessary to keep in mind that there are two widely different results to be obtained by acoustic treatment of auditoriums. One is noise reduction and the other is increase in articulation of speech. The efficiency with which noise is reduced in loudness depends upon, (1) the frequency distribution of the noise itself, (2) the absorption characteristic of the walls inclosing the

Fire-proof acoustic materials

	Absorption coefficients				
	128	256	512	1024	2048
Acoustex					
1 in. thick spray painted	.16	.24	.51	.71	.72 Bu.St.
Calicel					
1 in. thick medium porosity....	.20	.34	.62	.71	.72 E.R.P.I.
Gimco rock wool					
1 in. thick....	.27	.40	.56	.65	.68 Knudsen
Gimco acoustic plaster					
$\frac{3}{4}$-in. thick....		.32	.30	.36	.42 Watson
Acoustic lime plaster					
$\frac{3}{4}$-in. thick....	.17	.23	.28	.36	.64 Bu. St.
Hachmeister-Lind acoustic plaster					
Stippled with pins 1-in deep....	.16	.19	.25	.36	.44 Bu. St.
Macoustic plaster					
$\frac{1}{2}$-in. thick stippled with pins $\frac{1}{2}$-in. deep....	.12	.20	.31	.39	.58 Bu. St.
Sabinite					
$\frac{1}{2}$-in. thick....	.15	.17	.22	.29	.38 Bu. St.
Audience seated in non-absorbing chairs—total absorption					
Women, without coats...	0.7	1.3	2.3	3.6	4.6 Bu. St.
Men, without overcoats.	1.3	2.1	4.1	5.5	7.4 Bu. St.

Table giving coefficients of absorption from some of the typical fireproof acoustic materials and acoustic plasters.

[1]Speech and Hearing, Harvey Fletcher, D. Van Nostrand & Co.

*In passing it is well to state that this equation is applicable to rooms which are "live." When a room has an average coefficient greater than 0.10 the more general equation

$$T = \frac{0.05V}{-S \log (1 - a)}$$ must be used

listener, and (3) the frequency characteristic of his ears. Analyses of the common room noises show that the frequency range above 500 cycles per second is the most important. For noise deadening the materials *C*, *A* and *R* of Fig. 2 are quite efficient and have been used for this purpose with success. (The curve *X* is discussed later.)

When reverberation of an auditorium is excessive the articulation is in general quite low. As the reverberation period is reduced by adding ordinary absorbing material to the walls the articulation increases to a maximum, after which it again falls. This falling off is due largely to the reduction in loudness of the upper frequency components of speech as compared with the lower frequency components. This phenomenon is especially true where no electrical amplification is employed. In the case of talking picture theaters the absolute loudness can be maintained by additional amplification and the absorption unbalance caused by ordinary acoustic treatment can, to some extent, be compensated by electrical filters properly designed. The writer has observed a case where the articulation was increased very little when the theater was treated with the material *C* Fig. 2. However, after readjusting the sound projection equipment to compensate for the unbalanced condition the articulation became very satisfactory.

In auditoriums where no electrical amplification is provided, and hence where no modification of speech is possible, the effects of unbalanced absorption are most pronounced. It has been the experience of many acoustical engineers that the installation of the ordinary acoustic materials created "dead spots" or areas of very low articulation in spite of the fact that the reverberation at 512 cycles per second was near the so-called "optimum" value. This situation is not surprising when the physical properties of speech are considered. Dr. Harvey Fletcher states in "Speech and Hearing" [1] that "A system which transmits only frequencies above 1000 cycles per second has a syllable articulation of 86 per cent" and "a system which transmits only frequencies *below* 1000 cycles per second has a syllable articulation of 40 per cent." As stated before, in large auditoriums a large portion of sound reaches the listeners' ears by way of reflection. If these reflecting surfaces subtract the high frequencies more efficiently than the low resulting articulation will suffer out of proportion because of this unbalance of absorption. The mere presence of the low frequencies also have a masking effect on the high frequency components which are so essential to good articulation.

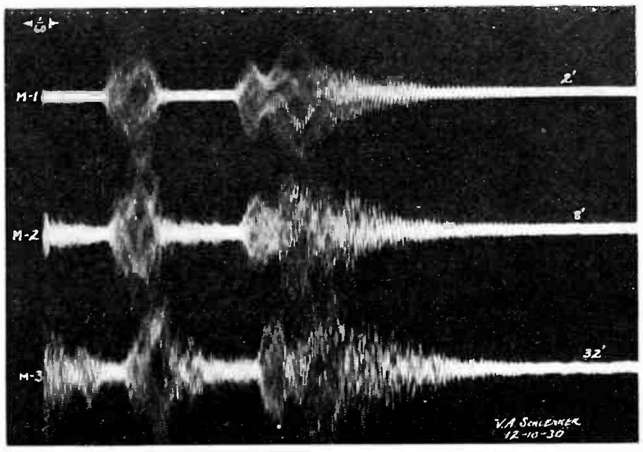

Fig. 4—Effects of acoustic distortion in speech measured with a microphone placed at varying distance form the speaker

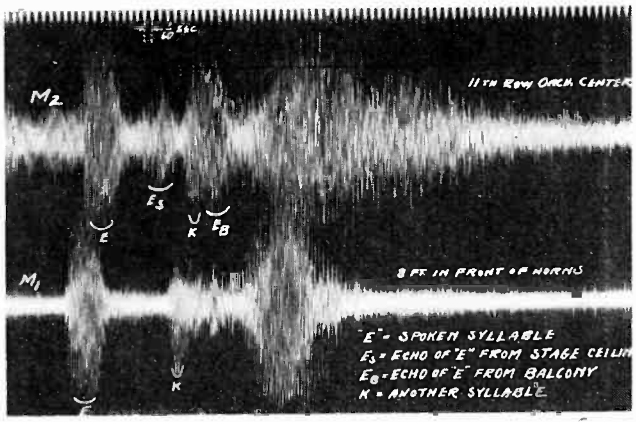

Fig. 5—Oscillograph trace of a spoken syllable recorded at two positions from a loudspeaker in a sound picture theater

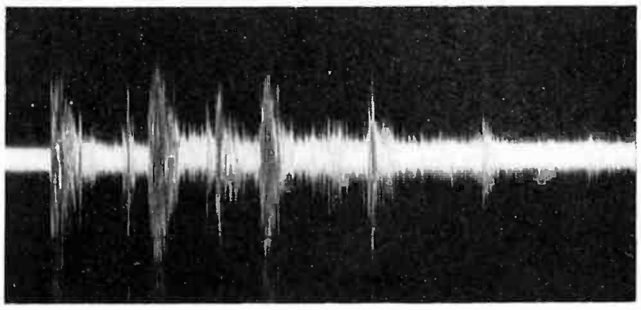

Fig. 6—Oscillograph trace of a multiplicity of echoes often present in auditoriums with large domes or parallel walls

Reversing the absorption curve

There is experimental evidence at hand now which indicates that a great improvement may be accomplished by reversing the absorption curve. The result of a treatment developed by the writer is given by the curve *X* in Fig. 2. The frequency at which the absorption changes abruptly is adjustable according to the acoustic requirements. It is evident that value of this means of maintaining and re-enforcing the high frequency components is great, especially in large auditoriums.

Some of the acoustic plasters which are on the market have absorption curves which are given in Fig. 3. It will be noted that the general trend is similar to Fig. 2. The plasters marked *G* and *W* representing considerable improvement over the others were put on the market during the last year. Both plasters have a mineral wool base which insures thermal insulation as well as acoustic improvement. A better perspective may be gained by comparison with the very low absorption of a hard smooth plaster on a brick wall as given in the lower curve marked *BU*. It is interesting to note that the absorption at 4096 cycles per second is only 0.04 but nevertheless four times the value at 128 cycles per second.

A physical picture of the effect of acoustic distortion on speech can be obtained from Fig. 4. The oscillographic trace *M*-1 was recorded from a microphone placed two feet from a speaker who spoke two syllables "ta" and "phone." Simultaneously, the traces *M*-2 and *M*-3 were recorded on the same film from microphones placed at distances 8 and 32 feet, respectively, from the speaker. The reverberation curve of this auditorium was low (less than one second) and quite well balanced with respect to frequency. Nevertheless, the "pick up" at

[*continued on page 660*]

SMPE to convene in Hollywood

J. I. CRABTREE
President Society of Motion Picture Engineers

OVER one hundred members of the Society of Motion Picture Engineers are expected to make the journey from the East Coast to Hollywood to attend the Spring Meeting, May 25-29 inclusive. The total attendance augmented by engineers from the numerous West Coast studios is expected to exceed the Washington meeting last year. Of particular interest will be an exhibit of new sound equipment developed during the twelve months.

An extensive program of papers covering every important phase of progress in the industry has been arranged by the Papers Committee of which O. M. Glunt is chairman. A session of special interest will be a symposium on color at which C. E. K. Mees of the Eastman Kodak Company will preside. Outstanding examples of color photography will be shown.

A few of the abstracts available as *Electronics* goes to press are presented in this issue.

Measurements with reverberation meter

By V. L. Chrisler, W. F. Snyder, *Bureau of Standards*

A description will be given of apparatus with which the rate of decay of sound energy in a room may be measured. A loudspeaker is used as a source of sound. When the sound has reached a steady state the loudspeaker circuit is opened and at the same time a timer is started. When the sound energy has decayed to some definite value the time is automatically stopped. If made in a portable form this equipment may be used to study the acoustical properties of auditoriums. Attention will be given to the errors occurring in these measurements.

Noise measurement

By S. K. Wolf, G. T. Stanton
Electrical Research Products, Inc.

The instrumental measurement of noise presents difficulties that have in the past generally defeated its successful accomplishment. While noise exists in a physical state and certain of its quantities are susceptible to direct measurement, the magnitude of a noise is evaluated through the interpretation of the human ear. The ear is non-linear in its evaluation of the various factors of noise. The degree and nature of the ear's non-linearity to the principal factors will be discussed, with respect to the chief interpretive impression, that of loudness.

An instrument will be described that measures intensity expressed in terms of loudness, evaluated for frequency and duration, and combining portions of a complex wave shape in a suitable manner. The characteristics of the meter and the ear are compared. The readings are in decibels above a zero reference point of audibility.

The mercury arc as a source of intermittent light

By H. E. Edgerton, *Massachusetts Institute of Technology*

The possibility of the use of intense intermittent light for moving pictures and special photography will be covered in this paper. Physical limitations of sources of intermittent illumination will be reviewed. The characteristics of the mercury-arc thyratron that are advantageous for flashing intermittent light are enumerated. These include:

1. The light is photographically actinic.
2. The duration of a light flash can be made less than ten microseconds.
3. The light intensity is high.
4. The frequency of flash is easily and accurately controlled by means of a grid.

An example of the use of intense intermittent light will be given showing how stroboscopic moving pictures of the angular transients of synchronous motors are taken.

An apertureless optical system

By Dr. Robert C. Burt
R. C. Burt Laboratories, Pasadena, Cal.

An optical system will be described which uses positive and negative cylindrical lenses with their axes at right angles. The image of a source is optically elongated and flattened by these cylindrical lenses to the proportions desired and is then focused on the film. Advantages claimed for this system include: maximum possible brilliancy with a given source temperature; not sensitive to position of the lamp filament or sharpness of image; and intrinsically it gives perfectly uniform brilliance throughout the length of the beam.

A moving coil microphone

By W. C. Jones, L. W. Giles, *Bell Telephone Laboratories*

A new microphone will be described in this paper which retains all of the inherent advantages of the moving coil type of structure but unlike the earlier forms of this microphone it responds uniformly to a wide range of frequencies. It is more efficient than the conventional form of condenser microphone and its transmission characteristics are unaffected by the changes in temperature, humidity, and barometric pressure encountered in its use. Unlike the condenser microphone the moving coil microphone may be set up at a distance from the associated amplifier and efficient operation obtained. Owing to its higher efficiency and lower impedance it is less subject to interference from nearby circuits. It is of rugged construction and when used in exposed positions is less subject to wind noise.

Additional papers on program

Other papers scheduled include the following: "Detail in Television" by D. K. Gannett, American Tel. & Tel. Company; "Pioneer Experiments in Sound Recording" by Eugene Lauste; "The Latin-American Audience Viewpoint to American Films" by C. J. North and N. D. Golden, Department of Commerce; a group of six papers on color photography, which will be presented at the symposium headed by Dr. C. E. K. Mees.

A symposium on sound recording will also be held, and the following papers are scheduled: "Noiseless Recording" by H. C. Silent, Electrical Research Products, Inc.; "A Shutter for Ground Noise Reduction" by E. W. Kellogg and M. C. Batsel, RCA Victor Company; "Noise Reduction with Variable Area Recording" by B. Krauzer, RCA Photophone, Inc.; "The Ribbon Microphone" by H. F. Olson, RCA Photophone, Inc.; "A Sound Film Reproducer for Re-Recording Work" by J. J. Kuhn, Bell Telephone Laboratories; "Re-Recording, Recording and Editing of Sound" by Carl Dreher, RKO Studios, Inc..

Additional papers scheduled are: "High Speed Oscillograph" by A. M. Curtis and C. H. Rumpel, Bell Telephone Laboratories; "Improvements in Motion Picture Laboratory Apparatus" by C. E. Ives, A. J. Miller, and J. I. Crabtree; "Recent Developments in Thermionic Devices" by M. J. Kelly, Bell Telephone Laboratories. A special group of papers will also be given on studio practices. A symposium on laboratory practices will include the following papers: "Universal Developing Machine" by J. Dubray; "M-G-M Developing Machine" by J. M. Nicholas; "Variable Area Processing" by D. D. Foster; "The Study of Exposure and Film Processing for Variable Area Recording" by E. W. Kellogg and G. L. Dimmick; "Directional Effects in Sound Film Processing" by J. Crabtree, Bell Telephone Laboratories; "Straight Line and Toe Records with Light Valve," by D. Mackenzie, Electrical Research Products; "Reducing and Intensifying Solution for Motion Picture Film" by J. I. Crabtree, and L. E. Muehler; "A New 35 mm. Portable Sound Equipment" by H. Griffin, International Projection Corporation; "A New Newsreel Camera," by J. L. Spence, Akeley Camera Inc.

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IRE program to cover many subjects

THE Sixth Annual Convention of the Institute of Radio Engineers scheduled for June 4, 5 and 6, at the Hotel Sherman in Chicago, is expected to have a large attendance. The fact that this meeting precedes the annual RMA convention and Fifth Annual Trade Show to be held June 8-12 inclusive, will probably draw an unusual attendance to the Chicago meeting. A number of important technical papers are to be presented covering the latest advances in the industry.

Inspection trips have been arranged to some of the leading radio and other industrial plants in the vicinity. An exhibition of component parts for receivers, measuring and laboratory equipment and other materials of interest to engineers will be held in connection with this meeting. The tentative program of the convention is as follows:

R. H. MANSON

President, Institute of Radio Engineers

Wednesday, June 3: 2 p.m.-8 p.m. Registration.

Thursday, June 4: 8 a.m.-10 a.m. Registration and inspection of exhibits; 10 a.m.-12 noon. Opening session. Addresses of welcome by Ray H. Manson, president of the Institute and Byron H. Minnium, chairman of the Chicago section. "The 'Spokesman' for the Radio Engineer," by Captain S. C. Hooper, U. S. Navy. "Thyratron," by J. C. Warner, General Electric Company. "Music in Colors," by E. B. Patterson, RCA Radiotron. "Amplitude, Phase and Frequency Modulation," by Hans Roder, General Electric Company. 12 noon-1:30 p.m. Official luncheon. Address by Colonel Ishan Randolph, president of the Association of Commerce of Chicago.

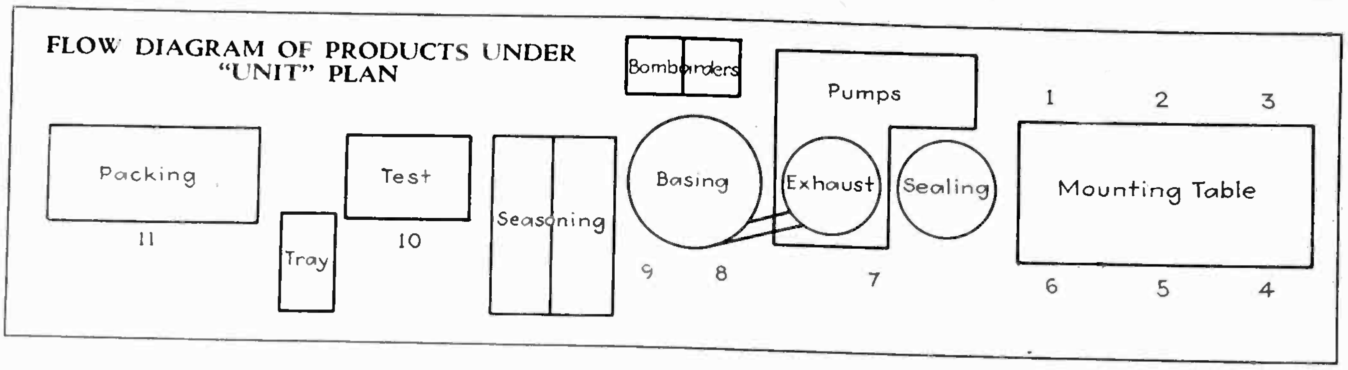
Afternoon session: 1:30 p.m.-2 p.m. Inspection of exhibits. 2 p.m.-5 p.m. Trip No. 1 to Grigsby-Grunow Company and Stewart-Warner Corporation. 2 p.m.-3:30 p.m. Technical session. "The Saxonburg Radio Station," by Frank Conrad and R. L. Davis, Westinghouse Electric and Manufacturing Company. "Field Strength Measurements and Broadcast Coverage," by C. M. Jansky and Bailey. "Developments in Common Frequency Broadcasting," by G. D. Gillett, Bell Telephone Laboratories. "New Method of Frequency Control Employing a Long Line," by C. W. Hansell, J. L. Finch and Conklin, RCA Communications. "Some Observations of the Behavior of Earth Currents and their Correlation with Magnetic Disturbances and Radio Transmission," by Isabel S. Benis, American Telephone and Telegraph Company.

Other events planned for Thursday afternoon include: 2 p.m.-3:30 p.m. Trip No. 2. Shopping trip for ladies. 3:30 p.m.-5 p.m. Inspection of exhibits. 3:30 p.m.-5 p.m. Trip No. 3. Ladies' tea and fashion promenade. 4 p.m.-5:30 p.m. Trip No. 4. American Telephone and Telegraph Company and Illinois Bell Telephone Company. 4 p.m.-5:30 p.m. Trip No. 5. National Broadcasting Company studios. 8 p.m. Lecture on "Modern Conception of the Electron," by Professor A. H. Compton of the University of Chicago. 8:15 p.m.-11 p.m. Theater party for ladies. 9 p.m. Inspection of Ryerson Laboratory of the University of Chicago. 9 p.m. Annual meeting of the Committee on Sections at the University of Chicago.

Friday, June 5: 10 a.m.-12 noon, Technical Session. "Technique of Loud Speaker Sound Measurements," by Stuart Ballantine, Boonton Research Corporation. "Acoustic Problems of Sound Picture Engineering," by W. A. MacNair, Bell Telephone Laboratories. "Rochelle Salt Crystals as Electrical Reproducers and Microphones," by C. B. Sawyer, Brush Laboratories. "High Audio Output from Relatively Small Tubes," by L. E. Barton, RCA Radiotron. 9 a.m.-12 noon. Trip No. 6. Ladies' sight-seeing tour. 12 noon-1 p.m. Inspection of exhibits.

Friday, 1 p.m.-5 p.m., Trip No. 7. Hawthorne Works of the Western Electric Company. 1:30 p.m.-4:30 p.m. Trip No. 8. Luncheon and bridge for ladies. 5 p.m.-7 p.m. Inspection of exhibits. 7 p.m. Banquet, entertainment and dancing.

Saturday, June 6: 9:30 a.m.-12 noon, Trip No. 9. Ladies' trip to Art Institute, Field Museum, or Aquarium. 10:30 a.m.-12 noon. Technical Session. "Constant Frequency Oscillators," by F. B. Llewellyn, Bell Telephone Laboratories. "Electron Tubes as High Frequency Alternators," by E. D. McArthur and E. E. Spitzer, General Electric Company. "Development of Directive Transmitting Antennas for Short Wave Transmission," by P. S. Carter, C. W. Hansell and N. Lindenblad, RCA Communications. "Development of Short Wave Directive Antennas," by E. Bruce and H. T. Friis, Bell Telephone Laboratories.



From the mounters, trays are passed to the sealing operator who places mounts in the exhaust machine, where they are tipped, then to basing machine. In sets of 50, tubes are seasoned, then tested and packed

From parts to packed tubes in 45 minutes under new

"Unit" tube manufacturing layout

By ERNEST KAUER[1] and ROBERT BRINDLE[2]

THE "unit" system is the grouping together of the mounting, sealing, exhausting, basing, seasoning, testing and packing machines, used in the manufacture of radio tubes.

Such a "unit" or group is so arranged that the mounters place the finished mounts in trays that are passed on to the sealing operator, who after sealing the mounts, places them in the exhaust machine—where they are tipped off by the automatic tipping torch—and then down a chute which carries them to the basing machine. The base threader threads the base onto the tube and places it in the basing machine. When it is based, the wires are cut and soldered, and the tube placed in the seasoning rack.

When the baser has filled fifty sockets on this seasoning rack, she turns the switch for seasoning, and then proceeds to fill the second set of fifty sockets which the tester is unloading and testing. The good tubes she places in a tray near the packer, who cleans and packs them. At no time, is there an accumulation of tubes between operations.

It takes a finished mount about 45 minutes to become a packed tube, which gives a very quick check on quality. In contrast, with the departmental method, trays of tubes are stacked between each operation, and a finished mount does not become a packed tube for sometimes several days.

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FORMERLY employing the "departmental" method of tube manufacture in which machines of the same type are grouped together by operations, the Ceco Manufacturing Company of Providence, R. I., has now completely rearranged its factory layout, adopting the "unit manufacture" principle here described.

Marked savings in both floor space and labor have resulted, and the close supervision of all operations from raw parts to packed tubes affords the closest possible check on quality.

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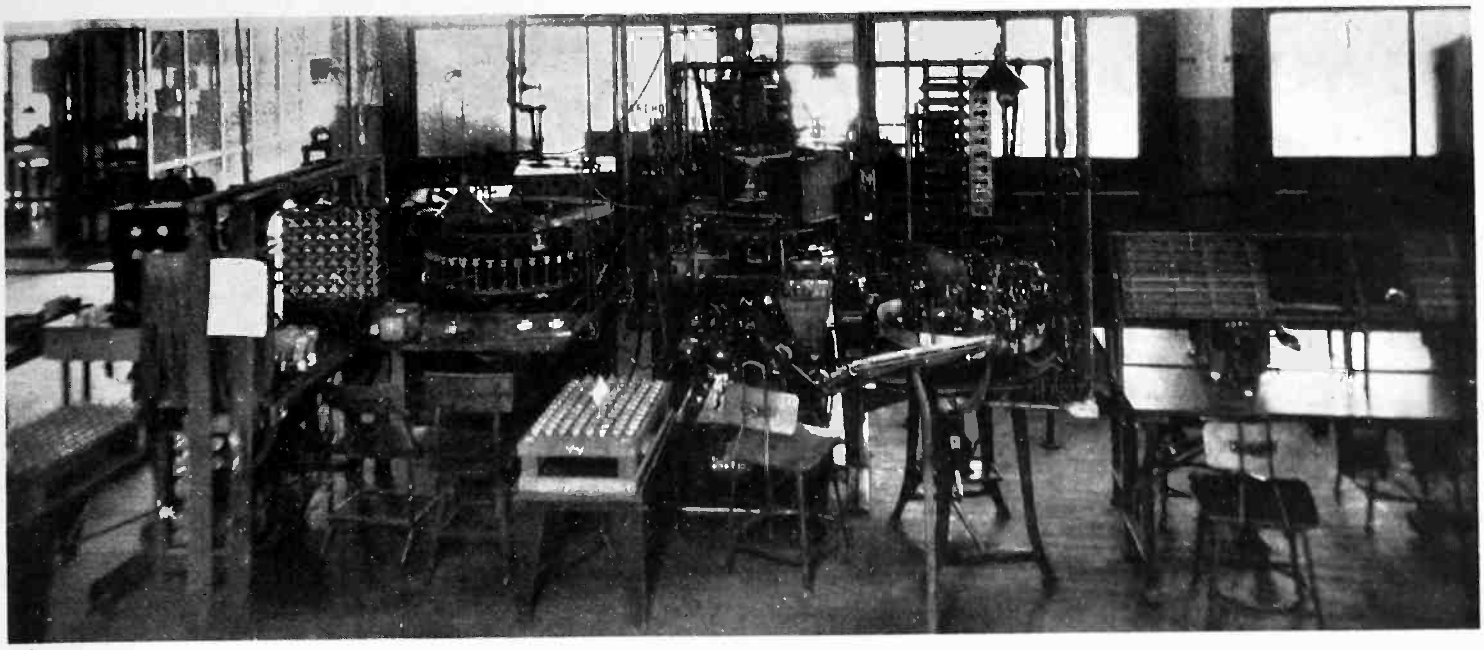
Quick check on quality

Let us consider each operator separately: Mounting requires a highly skilled operator, with dextrous hands and keen eye-sight. Sealing, combined with exhausting, requires an operator who is not affected by heat, and who is a good, steady worker able to keep all heads on the machine filled. Threading is a job that requires a girl fast with her hands, and accurate in placing the right wires into the right prongs. Basing and soldering require good judgment, to get the proper alignment of the base and the bulb. Seasoning and testing operators must take great care that proper schedules are maintained, and that no bad tubes are passed. Cleaning and packing are the last operations, and the last chance to pick out the defective tube.

Payment of operators, penalties

The operators on the unit are paid the same rate. They are paid for the number of good tubes packed, and penalized for the shrinkage. That tends to make each



TYPICAL "UNIT" LAYOUT OF TUBE-MAKING MACHINERY

How machines are grouped together under the "unit system." The mounting, sealing, exhausting, basing, seasoning, testing and packing are all carried on in a small compact group

operator vitally interested in the production and also the quality of the tubes. They will not allow one operator to hold up production or cause unnecessary shrinkage which will decrease his pay. Competition between units is very keen, and very little supervision is necessary. Parts are delivered to the unit, and must be accounted for in either packed tubes or shrinkage.

In the old departmental method of manufacture, the bulb and stem were heated at sealing-in, then trayed and allowed to cool, then heated again at exhaust, and trayed and cooled, at basing again heated and cooled. On the unit, the bulb and stem are heated at sealing-in and are not allowed to cool until after basing. This helps keep the tube free from glass strains that are set up in the heating and cooling process.

Contrast with "departmental" plan

The unit system does away with the different inspections that are necessary in the departmental manufacturing. Each operator inspects the work passed on from the preceding operator, and if it is defective, hands it back for correction, as all the operators are paid for the net good, and penalized for the shrinkage. They therefore are very careful not to accept defective work.

In the departmental method, it is necessary to have a girl for checking the work coming into the department, and the work leaving the department; and each individual operator's work must be checked when they are on piece work. On the unit it is only necessary to check the total raw material coming to the unit, and the packed tubes, and the shrinkage. This eliminates a lot of factory help and increases the packed tubes per operator per hour about 60 per cent.

The unit cuts down the floor space about 50 per cent, and takes less supervision. It eliminates about 95 per cent of the material in process. It is either raw material or a packed tube.

In addition to factory inspection and test the sales department makes a warehouse test on tubes packed for shipment. This insures the customer getting the best quality that it is possible to maintain.

[1]President and [2]Plant Engineer, Ceco Manufacturing Company, Providence, R. I.

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THE GREEKS HAD A WORD FOR IT—

WHO discovered electricity is anybody's guess. I guess it was some primitive woman, proverbially known for curiosity, who was polishing a string of amber beads on a fur skin. Anyway, the Greeks had a name for *it*—I mean the amber—it was *electron*.

Now, Miss Electron dominates the world. She dances in our vacuum tubes each evening to the tune of Amos 'n Andy, and vibrates in the remotest stars to pique the curiosity of the astronomer.

Dr. HARLAN T. STETSON,

Director, Perkins Observatory

Delaware, Ohio

Power control by means of phototubes

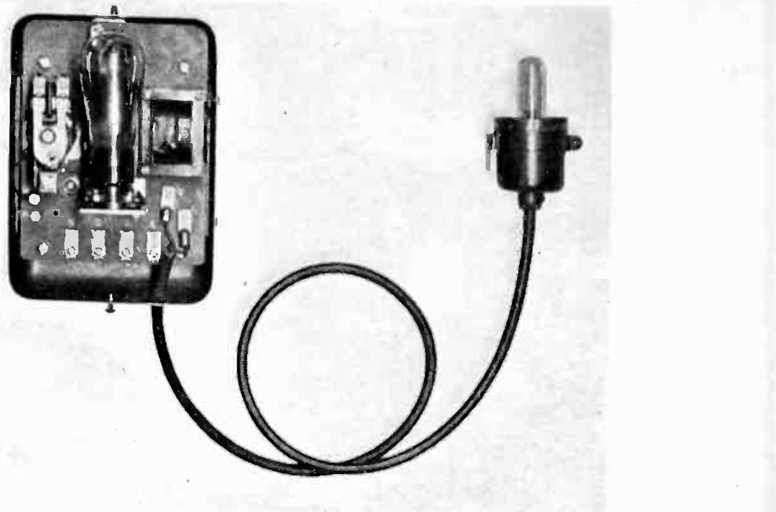


Fig. 2—Commercial model of phototube relay unit

By W. R. G. BAKER[1]
A. S. FITZGERALD[2]
and C. F. WHITNEY[3]

FOR generations light has been considered only as "something to read by"; of late, however, engineers have begun to realize that beams of light can be put to work.

The medium through which light serves engineering is the phototube in which is a surface which emits electrons under the stimulation of visible or invisible light. These electrons can be used to operate relays and thereby control power of any amount.

For example, the circuit shown in Fig. 1 combines a phototube and triode to form a light-operated relay. The Pliotron grid is "biased" negatively by means of a potentiometer across the winding of a transformer and serves to keep the plate current at a low value insufficient to energize a small relay in the plate circuit. A phototube also connects to the grid and a winding of the transformer in such a manner that when light strikes the phototube the grid is made less negative increasing the plate current so that the plate relay is energized. Thus the relay is energized when light strikes the phototube and de-energized when the light is cut off. A contactor capable of controlling usual circuits is operated by the plate relay contacts. By means of normally closed and normally open contacts on the plate relay the contactor may be either energized or de-energized when the light strikes the phototube. A photograph of a commercial unit of this type is shown in Fig. 2. The phototube is mounted in the light shielded housing shown at the right and is connected to the unit by means of a flexible cable allowing it to be mounted in a variety of positions as required by the application.

A modification of this circuit is shown in Fig. 3. Here a phototube and triode are similarly combined but with special features. The negative bias of the triode is adjusted by means of a variable capacitor which facilitates the setting of the device for operation at a given light intensity. Small thermally operated time-delay relays are interposed between the plate relay and the position relay making it necessary for a given change of light to be maintained for several seconds before the position relay is operated. This circuit is particularly adapted for the control of artificial illumination in accordance with daylight. It has been used for street light and sign control. Such apparatus will automatically turn on and off lights.

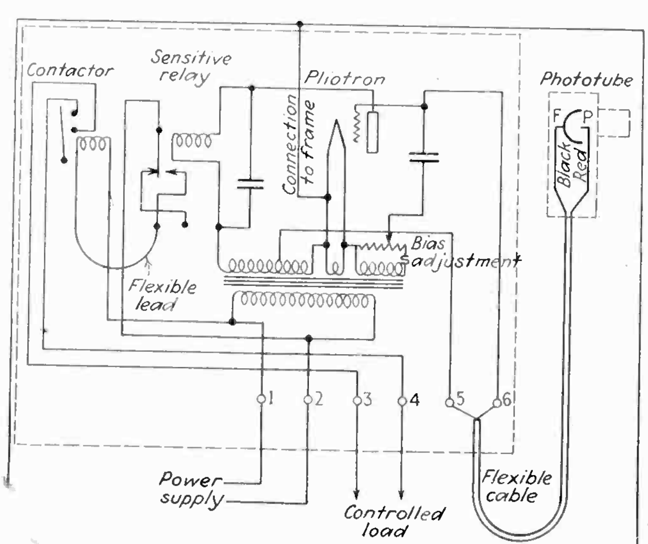


Fig. 1—Light-operated relay circuit

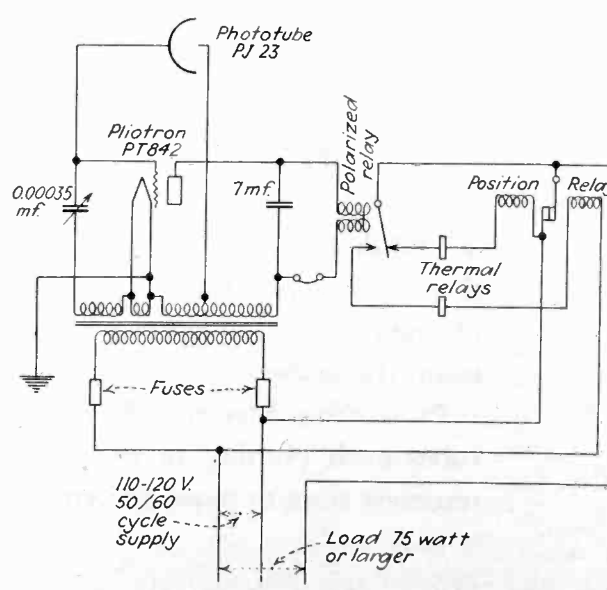


Fig. 3—Controlling power by light beams

The circuit shown in Fig. 4 which combines a Thyratron and a selenium photo sensitive tube provides an "on" and "off" relay sensitive to light and capable of controlling a large contactor or load directly without the use of a sensitive mechanical relay. The circuit is arranged so that the Thyratron has positive bias when no light falls on the selenium tube. When the selenium tube is exposed to sufficient light, the positive bias is overcome and the Thyratron ceases to pass current.

Fig. 5 shows a schematic diagram of a smoke density recorder which has been in operation for over a year.

The apparatus was built in two units. One box contains a source of light giving a nearly parallel beam, a rectifier-filter system, a photo-electric tube measuring circuit, and a motor-rotated glass dust shield with a wiper to keep the lens system clean. A second box contains a pair of adjustable mirrors set to right angles together with another rotating glass shield with wiper. The shields with cleaning mechanism are important as the smoke to which the whole apparatus is exposed is heavily laden with carbon, oil, and gasoline fumes. The units were set about 80 feet apart giving a total beam length of 160 feet.

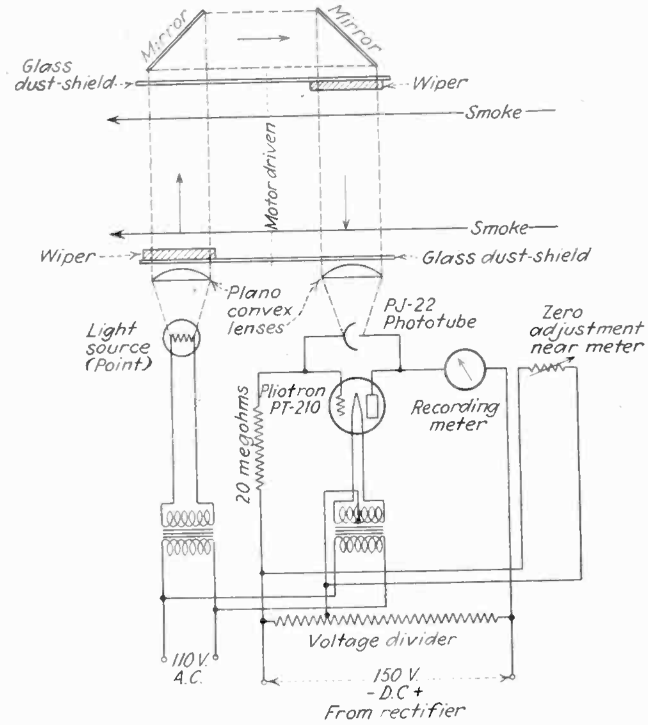


Fig. 5—Smoke density recorder circuit diagram

The system operates as follows: With no smoke interposed between the lens system and mirror system, a fixed amount of light reaches the photoelectric tube which keeps the grid positive with respect to the cathode allowing the plate current to assume a high value. When smoke is carried by the forced draft through the light beam the light is diffused depending upon the density of the smoke. The decreased light on the phototube causes the potential of the grid to become more negative and thus causes a decrease in plate current. This current is brought to the main supervisory control room and a graph is made on a recording milliammeter.

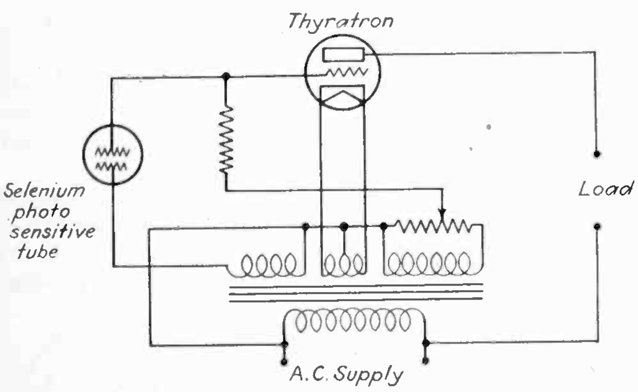


Fig. 4—Selenium-Thyratron system for illumination control

The photoelectric tube provides a means of matching colors or shades more accurately than can be done by eye. A simple method of accomplishing this is to measure the light reflected from a given sample of material by means of a phototube, an amplifier and a meter. The meter being in the plate circuit of the amplifier indicates the relative quantity of light reflected from the various samples. Color filters may also be used to obtain matches at given points in the spectrum.

The circuits described in this article (and in those in January and April *Electronics*) have been selected more or less at random from a large number which have been found to be operative. Some represent the only proven means of accomplishing the desired result. Others represent entirely feasible systems intended to displace existing elctro-mechanical arrangements, thus eliminating such items as contacts, springs, pivots, cams, and other moving parts which require accurate workmanship and continual servicing. In considering the question of utilizing electron tubes, the engineer should not overlook the fundamental limitations of the electron discharge devices. Yet, he should distinguish such limitations from those present short-comings which, in all probability, will be mastered as the art progresses. The electron tube, though still an infant among electrical devices, has made radio one of our major industries; certainly it will influence, to no less a degree, the methods and equipment associated with the generation, transmission, distribution, and control of electric power.

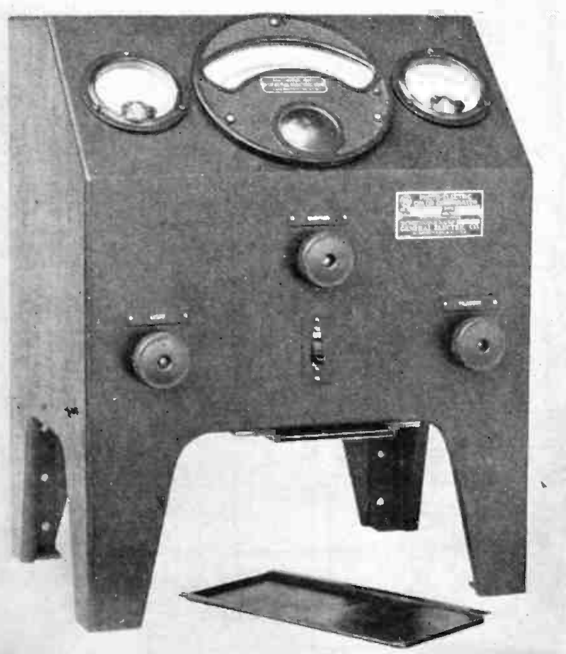


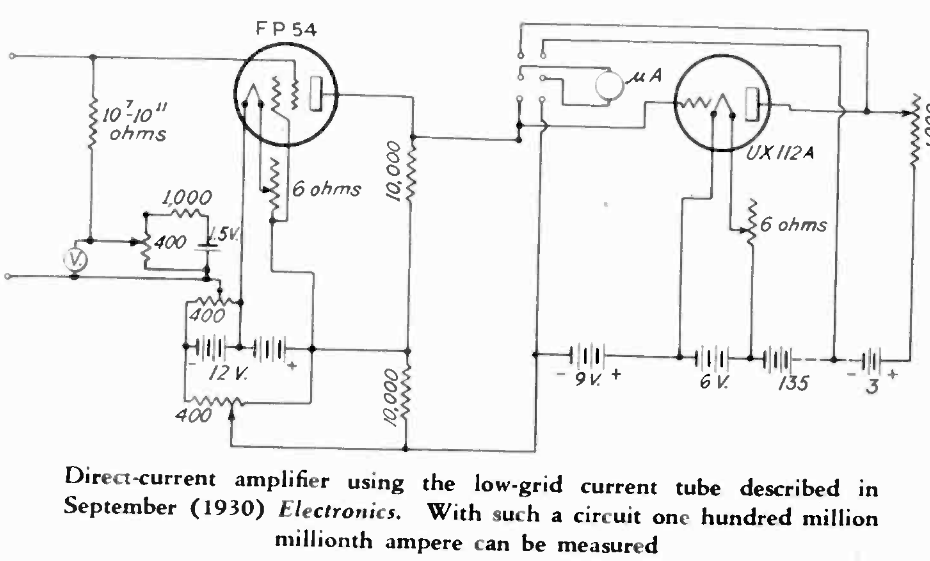
Fig. 6—Color comparator by which phototube matches the roast of coffee

[1]Vice-president in charge of manufacturing, RCA Victor Company.
[2]Engineering department, RCA Victor Company.
[3]Radio department, General Electric Company.

+ + + ELECTRONIC TUBES

Amplification of very low direct currents

A REPORT OF experiments to determine lower limits of direct current measurement will be found in the *Physical Review*, February, 1931, in an article by Lee A. DuBridge. Three circuits have been tested in connection with the low grid-current tubes (FP-54 Pliotrons) developed by Metcalf and Thompson (*Electronics*, September, 1930). With a single tube circuit similar to the one shown in *Electronics* the highest sensitivity is limited by the fluctuations in battery voltages. By using large storage batteries and by careful shielding a voltage sensitivity in excess of 50.000 mm. per volt has been obtained with a galvanometer of sensitivity 5×10^{-10} amp. per mm. With a grid leak resistance of 10^{10} ohms. (10,000 megohms) accurate measurements can be made of currents of one-tenmillion millionth ampere or larger. A higher sensitivity is obtained by dispensing with the grid resistor, that is by observing the steady natural leakage across the tube (seven mm. per sec.); in this case an estimate has to be made of the capacity of the grid circuit. Smaller currents are measured by means of a two-tube circuit (Wheatstone bridge with tubes in two of the arms and resistances in the other two, the entire circuit being enclosed in a metal container which is almost airtight). When a ten times more sensitive galvanometer is used, the current sensitivity is four tenthousand million millionth (or 4×10^{-16}) amp. per mm. With the rate of drift method (floating grids) the passage of 30 electrons per second can be detected and measured, and the unevenness in their flow makes itself felt. If tubes can be constructed having a tenthousand times smaller grid current, and this is not impossible, the individual electrons might be indicated by the electronic tube. At the present stage the instrument is decidedly more rugged and much more sensitive than the best electrometers with the exception of the Hoffman electrometer. For practical use a FP-54 tube followed by a 112A tube give a current amplification of over 10 million, currents of one hundred million millionth amp. can therefore be measured by means of ordinary microammeters. When the input terminals of the amplifier are connected to a caesium phototube illuminated by a small headlight lamp, an output of several microamperes is observed when the lamp filament is at a temperature such that it is scarcely visible to the eye in a dimly lighted room. (Voltage sensitivity of one stage is equal to mutual conductance times sensitivity of galvanometer, current sensitivity equals voltage sensitivity times grid circuit resistance).



Direct-current amplifier using the low-grid current tube described in September (1930) *Electronics*. With such a circuit one hundred million millionth ampere can be measured

Phototube amplifiers

IN *Electrotechnische Zeitschrift*, February 26, 1931, H. Simon describes amplifiers for phototubes.

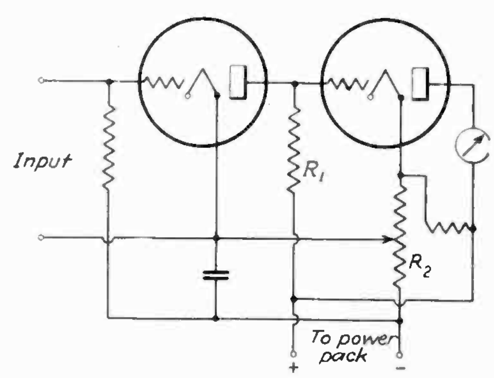
Slow variations. For amplifying phototube currents down to 10^{-15} amperes the cell is used as a grid leak for a screengrid tube with well insulated grid (Hausser, Jaeger and Vahle 1922). The control or inner grid and the plate are given about 6 volts, the screen-grid is connected to the cathode, the anode of the phototube to the positive end of the filament. For currents above 10^{-8} amp. an amplifier with ordinary tubes is sufficient, the phototube and battery being placed in parallel with the grid-leak resistor as shown in manufacturers' bulletins. So long as no grid current flows, the ratio of plate to phototube current is equal to mutual conductance times grid resistor. For a 1 milliamp. per volt tube and a grid leak of 10 megohms, the amplification is 10,000. Relays and thyratrons may be introduced.

Rapid variations. Circuits of special interest are those which work on 60 cycle current. They may be so adjusted for instance, that a change in the resistance of the phototube (illumination) throws plate and grid out of phase so that the current across the relay decreases. For making measurements, a push-pull circuit using two cells can be so adjusted that variations in the source are compensated.

Vacuum tube voltmeters for a.c. operation

THREE ARTICLES APPEARING in the German technical press point out that the usefulness of the vacuum tube voltmeter will be enhanced if reliable instruments are made available which do not require batteries for their operation.

The first article, by K. Schlesinger, (von Ardenne Laboratory, Berlin,) in *Zeitschrift für technische Physik*, February, 1931, describes a two-stage

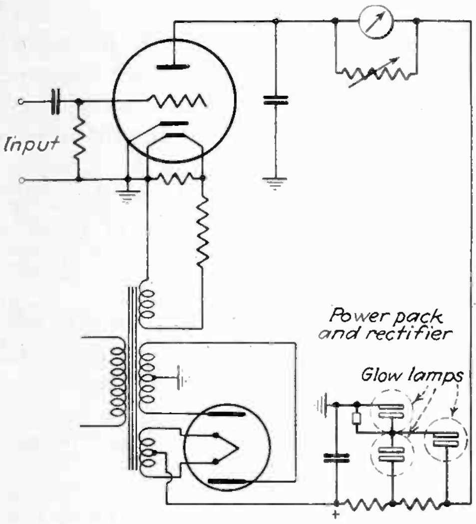


vacuum tube voltmeter using rectified current from a power-pack and measuring voltages from 0.1 to 0.8 at 50 to 10 million cycles per sec. The meter is rendered independent of the frequency by rectifying the alternating voltage in the grid circuit of the first tube. Separate windings are used for heating the filament. Resistances serve to ensure sensitivity at full load, one by maintaining the grid bias of the second tube, the other by shifting the grid bias of the second tube to more positive values in order to ensure good rectification.

The second article by H. E. Kallmann (C. Lorenz, Ltd.,) appearing in *Zeitschrift für Hochfrequenztechnik*, February, 1931, describes a one-stage instrument for alternating and direct voltages between 1 and 20 volts. Accidental changes in the rectified and

IN THE LABORATORY + + +

smoothed grid bias voltage are compensated by automatic larger changes in the plate voltage, by taking both potentials from a resistor which is traversed by the rectified line current. Plate rectification is used for the meter. For potential differences of 0.1 and 4 volts grid rectification is resorted to.



(grid leak 3 meg.) In this case great care is needed for keeping the plate voltage at a constant value. This is accomplished by using the constant voltage drop in two glow discharge tubes. A constant difference of 70 volts is obtained even when inductances in the power-pack circuit are dispensed with. Feedback is suppressed by condensers between plate and cathode. For greater sensitivity an elaborate two-stage voltmeter which can be used for frequencies from 50 to 1,000,000 cycles is described and discussed. The incoming a.c. voltages are first amplified in a screen-grid tube (1 milliamp. per volt, amplification 10) and then rectified in the grid circuit of a resistance-coupled (1,000 to 10,000 ohms) second tube (3.5 milliamp. per volt). As, for 50 cycles, a mica grid-leak condenser would be unduly large, two grid-leak condenser units are used with ordinary paper condenser in series (0.5 mfd. acting at the same time as coupling condenser and 10 meg., then 0.1 mfd. and 3 meg.). The plate voltage is kept constant by means of two five-electrode glow discharge tubes, the filament voltage by means of iron-in-hydrogen voltage regulators. When the plate current is compensated, the readings being made with a microammeter, the sensitivity is 35 to 150 millivolts for a coupling resistance of 1,000 ohms and 3 millivolts for 10,000 ohms. The constancy of the calibration may be checked by measuring the doubly regulated heating voltages.

In a companion article by F. Below (Lorenz, Ltd.) the loss in sensitivity due to the natural capacity of the tubes is described.

Other material on vacuum-tube voltmeters will be found in *Chemische Fabrik*, March 18, 1931.

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Measuring weak magnetic a.c. fields of known frequency

WRITING IN THE *Elektrotechnische Zeitschrift*, March, 1931, G. Lubszynski of the High Tension Laboratory, Berlin Institute of Technology, describes an instrument using a vacuum tube amplifier for exploring a.c. fields. The author states that shielding against stray magnetic fields is important if electronic instruments are used for precision measurements. Alternating magnetic fields of a few thousandth gauss distort the records obtained by means of the electronic or cathode ray oscillographs working with a 70-cm. beam of electrons of as high as 70 kilovolts. A portable vacuum tube instrument is described which indicates and measures minute magnetic fields of 10 to 300,000 cycles per sec. Small interchangeable search coils, varying from 3 cm. diameter and 10 turns to 10 cm. and 10,000 turns are mounted at the end of an ebonite holder. The currents induced in the coils are detected and then amplified by means of a resistance coupled d.c. amplifier. By mounting the first tube which acts as detector inside the coil holder and removing its socket, the input capacity could be reduced to 4 micromicrofarads. Sensitivity increases with frequency. In the case of 50-cycle fields the range of the instrument when used with a 2 milliampere meter is from 10 one-millionth to 400 gauss. It was used to explore the a.c. magnetic fields in the neighborhood of 50,000 kilowatt generators (2.5 gauss at 1 m., 0.1 gauss at 4.5 m. distance).

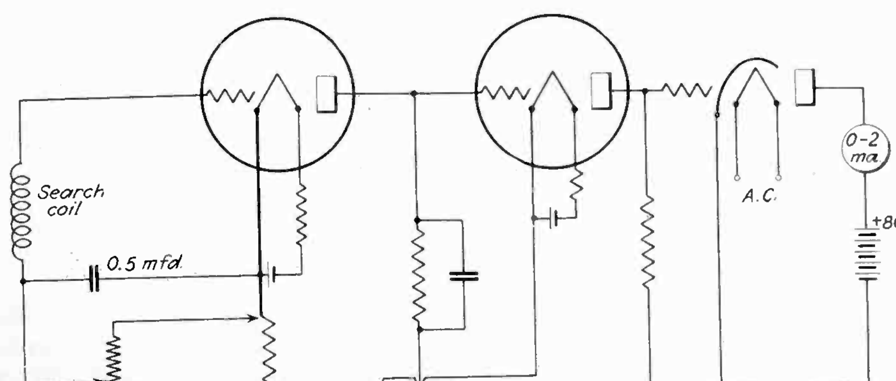
Twenty million volts required release atomic energy

DR. ARTHUR H. COMPTON, in a lecture recently given at the College of the City of New York, announced that the University of Chicago would shortly undertake a extensive study of the problem of releasing atomic energy. The solution of this problem, according to Dr. Compton, would create a limitless reservoir of power, and would bring undreamed-of changes to civilization. The work will begin shortly under his supervision.

One goal to be sought will be to impress an extremely high voltage on electrons in X-ray tubes. Dr. Compton believes that if this voltage can be raised to between ten and twenty-million volts pressure, that the door for releasing atomic energy will be opened. This high voltage, which has never been attained in any laboratory on the earth, would approach the high temperatures existing normally on the sun, where atomic energy is being released.

Dr. Compton, speaking before the same group on a previous day, revealed some interesting data on his most recent researches on the measure of spacing in atoms. His investigations have shown that the previous notions on the structure of atoms, given by Kelvin, Thomson, Rutherford and Bohr, must be discarded in view of the most recent explanation offered by Dr. W. Heisenberg of Leipzig, Germany.

Measurements made by Dr. Compton and his associates at the University of Chicago, disclosed the space between the electrons in an atom of helium, as one-billionth of an inch. These precise measurements have been made of atomic structure, so as to disclose the wave-length of a particular beam of X-ray, to be .00000000707862 of an inch.



Circuit diagram of apparatus for exploring weak magnetic fields of varied but known frequency. It is conventional; a search coil and a current amplifier

Permanent magnets for Electronic instruments

By W. H. HOPPE

PERMANENT magnets are used for many purposes. In the electronic arts, they supply the necessary magnetic fields for the operation of galvanometers, meters and relays, as well as being essential elements in sound pick-ups and certain types of reproducers. With the status of the midget type of radio receiving set assured, it is possible that permanent magnets will be considered for use in the field structures of small moving coil or dynamic speakers with subsequent problems in design. This paper is an attempt to outline the theory of permanent magnet design so that a practical approach may be made for the design problems encountered.

The material for use in a permanent magnet should be selected with care. It should be machinable, easily hardened, and for quality products, have high magnetic retentivity. Certain magnet steels which contain cobalt have been given much publicity because of their retentivity and their ability to withstand abuse. Experimenters substituting the new material for magnets formerly made from the more common magnet steels, without redesigning the original magnets, have not been rewarded by results commensurate with the cost of the cobalt alloy. In general, the use of cobalt magnet steels is justified only when the space requirements and electrical characteristics of the device with which the magnet is to be used are such that they may not be realized by using a cheaper material. A material should be chosen for the magnet which will satisfy requirements with a minimum cost. This may involve the economical use of a "strong" high-priced steel or the more flexible use of a "weaker" low-priced permanent magnet steel. The designer is guided in his selection by the following considerations.

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PERMANENT magnets represent an inconspicuous but important part of many electronic devices; e.g., measuring instruments, sound pick-ups and other well-known apparatus. Principles of design of such magnets are described.

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Magnet steel characteristics

When a magnetic material is magnetized under closed-circuit conditions (negligible air gaps) the maximum magnetizing force, H_{max}, is adjusted to produce some value of maximum flux density, B_{max}, in the sample under test. If the magnetizing force now be decreased, the induction will follow the curve in Fig. 1 produced by plotting the corresponding B and H values. As the magnetizing force is decreased, the curve will intersect the B-axis corresponding to a value of residual induction, Br; continuing, the induction will be reduced to zero at the point Hc which is the *coercive force* for the material. The Hc-Br portion of the curve is known as the *demagnetizing curve, Br* representing the *induction* available in the closed magnetic circuit for zero magnetizing force; Hc, the magnetizing force available in the closed magnetic circuit at zero induction.

If the induction and magnetizing force be considered for the point "b," Hb represents the magnetizing force available for driving flux through the closed magnetic circuit at an induction Bb. When an air gap is introduced into the magnetic circuit, the flux density and magnetizing force adjust themselves so that a maximum value of flux is driven through the particular air gap. This corresponds to the storage of a maximum energy in that air gap. It is readily apparent that for the air gap that a designer may select there will be a magnetizing force and induction in the permanent magnet material corresponding to the maximum energy available from the material under closed circuit conditions, providing that the air gap has a finite set of dimensions.

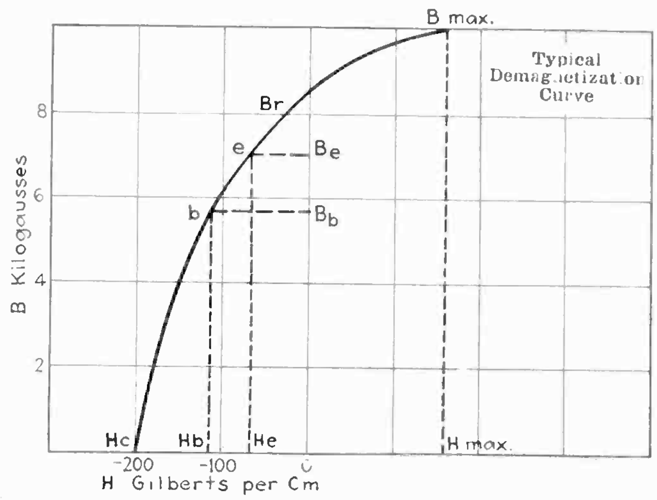

Fig. 1—Typical magnetization curve for permanent magnet steel

In selecting the magnet steel, the designer then is concerned with the determination of the induction to be used in the permanent magnet to obtain the greatest energy per unit volume of material used. The energy available per cubic centimeter of the magnet steel is proportional to the product of the H and B values for any point on the demagnetizing curve. Curves are then plotted for the magnet steels available to the designer. Some typical demagnetizing curves are shown in Fig. 2. The points H_e and B_e correspond to the maximum energy product

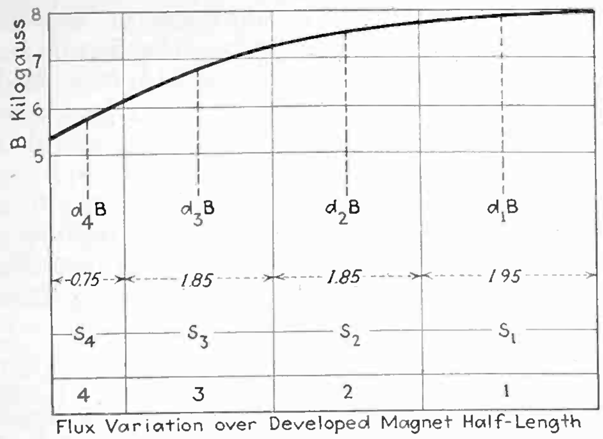

Fig. 2—Magnetizing curves for some familiar types of magnet steel

and are the optimum values for induction and magnetizing force for the particular material for a chosen value of H_{max}. Obviously a well designed magnet will have dimensions proportioned as nearly as possible to the above optimum values of induction and magnetizing force per unit length.

A preliminary estimate is then involved to estimate the cross-section and length of the magnet to be made from the steel selected as outlined in the preceding paragraph. These dimensions will be optimum values and will of necessity be modified in the final calculations, dependent upon the detail to which those calculations are carried as well as by the physical limitations determined by the overall dimensions desired for the finished device.

To get magnet dimensions

If Φ be the total flux required, and F the magnetomotive force necessary to deliver that flux to the device in question, the optimum dimensions for the required magnet are given by the relations

$$A_e = \phi / B_e \text{ c.g.s. units} \quad (1)$$
$$L_e = F / H_e \text{ c.g.s. units} \quad (2)$$

where H_e and B_e represent optimum energy values read from the demagnetization curve for the material chosen; total flux, being given in maxwells; and magneto-motive force being in gilberts.

The magnet length determined by (2) will seldom have to be altered materially provided that the physical dimensions desired are not exceeded. The cross-section is not so readily fixed. The reason for this difficulty lies in the magnetic leakage predominant in the permanent magnet itself. This may be made clear by considering an ideal form of permanent magnet. Such a magnet would be one of uniform flux density throughout its length. To realize this condition the magnet would have to be in the form of a circular ellipsoid; the total flux from the magnet equalling the total leakage flux.

Effect of magnetic leakage

It is apparent that the magnet described as an ideal magnet would not have any practical use. To design the practical form of magnet, we must carefully consider all sources of leakage and then knowing the useful flux required apply corrections to the foregoing theory. This involves the calculation of leakage factors which in themselves are dependent upon the dimensions of the magnet.

Conductance factors for the leakage flux between points of opposite magnetic polarity or at different potentials in the magnetic circuit may be calculated in a number of ways. A general expression for the leakage conductance from bar magnets is given by the following expression[1]

$$q = \pi \frac{d^2}{c^2}\left(\frac{4\pi}{A} - 1\right) \quad \text{lines per cm. zone} \quad (3)$$

where d = the equivalent diameter of the magnet in cm.
c = the length of the magnet in cm.
A = cross-section of the magnet in cm²

To apply the above formula to magnets having rectangular or other section it is only necessary to determine the equivalent diameter using the value

$$d = \frac{\text{perimeter of section}}{\pi} \quad (3a)$$

For the conventional U-type magnet, having the limbs of the U separated by a distance l, the conductance factor for a centimeter width of leakage zone is given by the expression

$$q = \frac{\pi}{ln_e[n + \sqrt{(n^2 - 1)}]} \quad (4)$$

where $n = l/d$
l = separation of magnet limbs in inches or cm.
d = equivalent diameter of magnet in inches or cm.

A more general leakage factor for any type of magnet may be calculated from the expression

$$q = 2.5 \sqrt{p/L} \quad \text{lines per cm. zone} \quad (5)$$

where p = perimeter of magnet section
L = total length of magnet

In using any of the above leakage conductance factors, the leakage flux emanating from a zone of length V, having a difference of magnetic potential, F, between its extremities is given by the product

$$\phi \text{ leakage} = F \, x \, L \, x \, q \quad \text{c.g.s. units} \quad (6)$$

As noted under the discussion of the demagnetizing curve of Fig. 1, the final design for a permanent magnet depends upon the leakage and self-demagnetization for the working density and magnetizing force calculated from the demagnetizing curve for the closed- magnetic circuit conditions. Having chosen a tentative value for the length and section for the desired magnet with (1) and (2), leakage factors are determined and a process of integration resorted to. The purpose of this integration is to fix the cross-section and establish a working flux density for the final design.

The method of step-by-step integration used here was first suggested by S. Evershed in his paper "Permanent Magnets in Theory and Practice." The magnet no matter what its shape is drawn as a developed bar magnet. The developed magnet is in turn divided into a number of regions or zones, symmetrically placed, on either side of the central neutral region. The number of zones used determines the accuracy of the calculation. Magnets to be used without pole-pieces will require finer division because of their inherently greater flux variation.

Figure 3 shows the developed half-length of such a magnet divided into regions. In this discussion the number of zones is four because of an example to follow. Since the junctions between the regions are the centers of the leakage zones, there will be four pairs of leakage zones on either side of the neutral zone. The conductance of the leakage path between any pair of zones will be equal to the estimated leakage conductance value, q, for the particular zone, multiplied by the zone width. These conductances are considered to be connected at the centers of the zones, resulting in concentrated leakage at junctions, between regions of uniform density.

The form of integration process is evident from this description and tabulated integration for the typical example to follow. An arbitrary choice of flux density,

B_1, is made for the central zone. The corresponding value for H_1 is read from the demagnetizing curve for the material. (See Fig. 1.) When H_1 is multiplied by the length of the region $(\frac{1}{2} s_1 + \frac{1}{2} s_2)$, the potential F_1, between the centers of the first pair of leakage zones is obtained. With the sectional area denoted by A and the conductance of the first leakage zone by $q_1 s_1$, the decrement in flux density at the junctions between the central region and the adjacent regions on either side of it will be $H_1 q_1 s_1 / A$. This decrement is denoted by $d_1 B$.

Subtracting $d_1 B$ from B_1, the density at the bottom of the first step in each limb is ascertained. The new density is denoted by B_2 and the corresponding surplus magneto-motive force is found from the demagnetizing

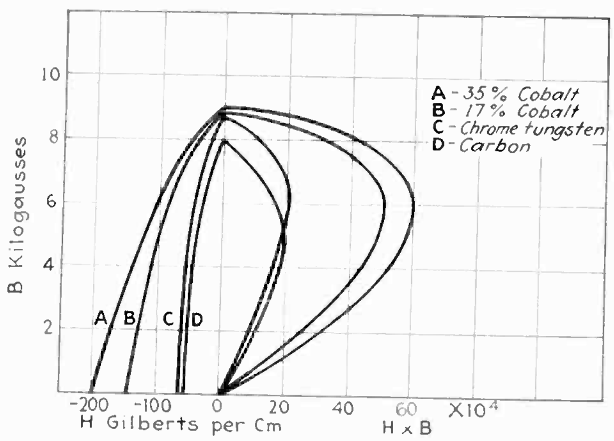

Fig. 3—Flux density variation along developed length of magnet; by step-by-step integration

curve to be H_2. The next increment in potential difference is then $H_2 (s_1 + s_2)$ which when added to H_1 gives the potential difference F_2 between the center of the second pair of leakage zones. The new decrement in the flux density will then be given by $F_2 q_2 s_2 / A$ and corresponds to $d_2 B$. The density for the next pair of zones is then B_3; the surplus m.m.f is then $H_3 (s_2 + s_3)$ which when added to F_2 gives F_3: the new decrement is then $F_3 q_3 s_3 / A$. And so on.

When the terminal flux density B_t is multiplied by the tentative cross-section the terminal flux, Φ_t, is obtained corresponding to the terminal potential difference, F_t. Since the value for the useful and leakage flux required by the device with which the magnet is to be used was originally fixed, it is apparent that the ratio for the terminal conditions is a constant. The above integration is then repeated as many times as necessary to realize this ratio, the tentative area and related leakage factors being changed with each successive integration.

Let us assume that a small moving coil speaker is to be designed, four magnets supplying the field in the air gap through an annular pole plate. It is desired that a density of 5000 gauss be maintained in the air gap. The length of the magnet is limited to $5\frac{1}{2}$ inches because of the speaker mounting. The thickness of the magnet material is limited to $\frac{3}{16}$ inch, material of that dimension being in stock, what should the finished dimensions of each magnet be as cut from bar stock before forming?

Noting the dimensions on Fig. 3, it is found that the necessary m.m.f. can be obtained using a large magnet length corresponding to the developed half-length of the magnet using a cobalt steel, the demagnetization curve for which is given in Fig. 1. The terminal requirements and final integration are given by the following schedule:

Flux Requirements at Air Gap (including leakage)		
Air gap density		5,000 lines
Total flux		16,000 lines
Flux per magnet		4,000 lines
Terminal Magneto-motive Force		
Air gap	725	gilberts
Pole-pieces	1.5	gilberts
Contact drop	25.4	gilberts
Core	9.40	gilberts
Contact drop	25.70	gilberts
Total	787.00	gilberts

Terminal ratio = BA_t / F_t = ... 5.10

Length to be 12.8 centimeters. Assume area to be 1 in. x 3/16 in. = 1.21 cm²

Zone	Flux Density	Surplus MMF	Length region	Potential diff.	Fqs/A	qs/A	q	A	s
(1)	7900	30	1.90	57.0	97	1.71	1.75	1.21	1.95
	—97								
(2)	7803	35	3.80	133.0	561	2.90	1.90	1.21	1.85
	—561			190.0					
(3)	7242	55	3.70	203.5	1141	2.90	1.90	1.21	1.85
	—1141			393.5					
(4)	6101	100	2.60	260.0	765	1.17	1.90	1.21	0.75
	—765			653.5					
(5)	5336	140	0.75	105.0	....	....	....	....	....
				758.5					

It is apparent from the integration that the area assumed is too large for the desired terminal ratio. A second integration using an initial density of 7,850 lines will be found to satisfy the terminal conditions when the cross-section is 0.80 cm². This corresponds to a magnet having the desired length of 12.8 cm. and cross-section of $\frac{21}{32}$ in. x $\frac{3}{16}$ in. This is the solution to the problem.

In practice, the magnet would be formed and then aged to reduce internal stresses. Following an aging treatment the magnet is magnetized using an electro-magnet capable of producing an H_{max} in the material of the formed magnet of the same magnitude as the H_{max} for which the demagnetization curve used in the design was plotted. In general, a better magnet will be produced by magnetizing to some value in excess of the required magnetization and then demagnetizing until the required value is obtained with the magnet assembled in the device, in this way stabilizing the magnet to the structure with which it is to work.

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THE FIRING LINE OF BUSINESS!

AN increasing percentage of what business men call the firing line is being shifted into the laboratory.

E. J. KULAS.

Oscillations produced by gaseous diodes

By PALMER H. CRAIG, Ph.D.

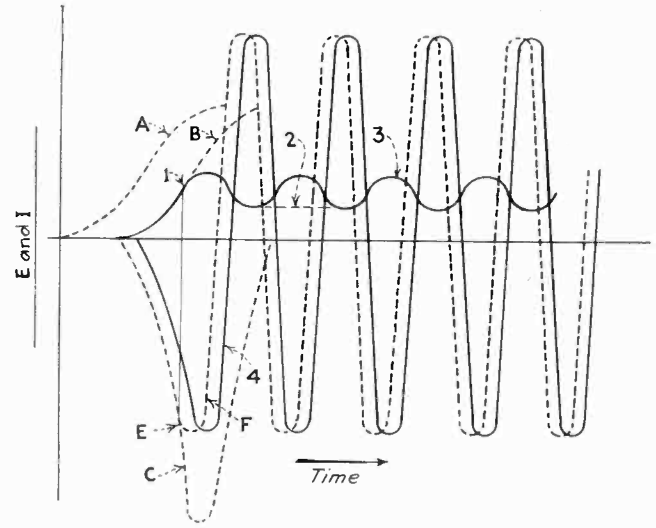

Fig. 2—Voltages and currents produced by the circuit shown in Fig. 1

MANY investigators have found that gaseous diodes can be made to oscillate when shunted by inductance and capacity in series, or when shunted by capacity and fed by power through a rather critical, relatively high resistance. Typical circuits for making neon tubes oscillate at both radio and audio frequency are given, for example, on pages 43 and 44 of

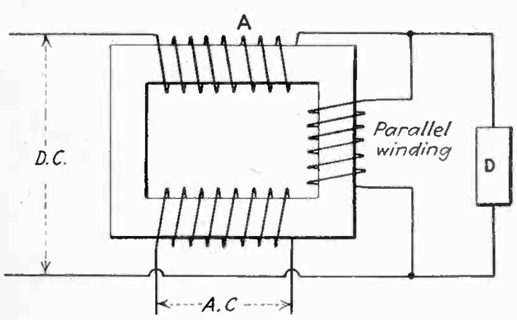

Fig. 1—General diagram of the oscillator system

QST, March, 1931. Some work has even been done in the field of higher power diode oscillators, employing Tungar tubes shunted by inductance and capacity[1], and the oscillating diode arc of the Pointolite lamp[2]. These latter circuits employ the conventional inductance and capacity in series, shunted across the diode, and the constants are rather critical. Difficulty has been experienced in obtaining appreciable power output from these circuits, since when the series resistance, which is normally used, is decreased to obtain greater power, oscillations cease altogether.

The system described herewith normally employs no capacity at all, and is capable of delivering much higher power to the output than has heretofore been considered possible with diodes, and incorporated a rather radically new circuit.

Referring to the circuit of Fig. 1, and the graph of Fig. 2, if direct current is impressed upon winding *A* of the transformer and if this winding were the only thing in the circuit, the voltage in this winding would build up according to curve *A* of the graph of Fig. 2. Because of the inductive reactance of the iron cored winding, however, the current would be represented by curve *B* "lagging" the e.m.f. curve by the angle φ, where φ is the phase angle. However, there is connected in the line another winding in parallel with a device *D* which will only pass a current when certain impressed voltages are present, e.g. Tungar tubes which possess the property of having a definite voltage at which the arc is struck, and below which voltage pass very little current. This is also true of gaseous diodes not having a filament, and even of copper oxide and similar rectifiers. These devices do not obey Ohm's law in this range, but instead they rather suddenly cease to pass current when the voltage across them is reduced to less than their "critical" value.

These windings are so designed that winding *A* usually has less turns than the other, with a correspondingly lower impedance. The winding is so connected to the interrupter device *D* that a changing flux produced in the core due to current starting to flow through winding *A* will induce a voltage in the parallel winding in such a direction as to "buck" or oppose the existing voltage across the interrupter with the result that the induced voltage in its parallel winding operates to lower the effective or net e.m.f. across the device. The complete operation of the system is as follows:

Upon the direct current being applied to the circuit current tends to build up in winding *A* according to curve *B* of the graph. However, the flux in the core will be in phase with the current through the windings and consequently the flux will be increased momentarily also

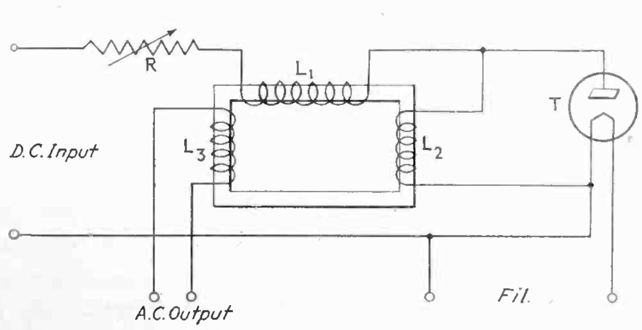

Fig. 3—Practical circuit for generating oscillations

according to curve B. This increase of flux, however, induces a voltage in the parallel winding according to curve C. When this induced voltage reaches a certain value, which may be represented at E, it has applied enough "back" e.m.f. to device D to cause it to stop passing current. Previous to this time, practically no current from the direct current source has passed through the parallel winding because the impedance of D was much lower than that of its parallel winding. Now, however, since the net voltage across D has been reduced to a lower value than its critical potential, the circuit can be considered as opened, which fact compels the current to pass through the parallel winding. Graphically this action is illustrated by the fact that curve B instead of continuing upward as indicated, "breaks" at point 1 and returns to level 2 which is the direct current level of current through the windings in series, due to the high impedance of the parallel winding. This variation of current in winding A, however, causes the induced voltage of the parallel winding to approximate curve F instead of dotted curve C which it would have followed had the current in A continued on curve B. Now when equilibrium has again been momentarily reached the current has built up to value 2 in the coils. This current through the parallel coil, however, produces such a large RI drop across it, (because of its relatively large resistance) that the effect of impressing RI drop or e.m.f. on the interrupter is to cause it to begin to pass current again, whereupon the complete operation is repeated and continuous fluctuations of the current in A occur according to curve 3, the result being that curve F continues as shown and the current in the parallel winding varies as shown by curve 4. Thus there are two fluxes set up in the core either of which may be used to induce voltage and current in the alternating current output coil or a separate transformer may be employed, the primary of which is in series with the other windings.

One of the practical forms this system may take is illustrated in Fig. 3. In this figure T represents a Tungar rectifier tube of any size from the 0.6 ampere type to the large 30 ampere Tungars, depending upon the amount of output current required, in this model being a type 206,501 Tungar. R is a variable resistance which in this case was a universal range, super-power "Clarostat:" L_1, L_2, and L_3 were respectively the primary, high voltage secondary, and 5 volt windings of an "Earl" radio power transformer. The direct current input was obtained either from a d.c. generator or storage batteries. With the arrangement of Fig. 3 it was possible to obtain audio frequencies of any desired value from about 50 cycles up to and beyond the range of audibility, phones being placed across L_1 to make the oscillations audible. Varying the inductance of L_1 and L_2 or the effective cross-section of the magnetic path through their cores will change the frequency of oscillation, as will also varying the filament temperature of T or in input d.c. voltage. The a.c. output voltage is, of course, dependent upon the number of turns in L_3 as compared with L_1. It should be noted that no condensers of any kind were employed, and the output was not limited to the amount of power stored in a condenser and liberated through its discharge.

Good results were also obtained in the production of radio frequency oscillations by this system, in which case the transformer was made of extremely thin laminations or the powdered compressed rings of permalloy or iron dust as made by the Western Electric Company. Several sizes of Tungar tubes were used with satisfactory results. With one model where the transformer was constructed of very thin iron laminations, L_1 was 100 turns of No. 22 wire, and L_2 was the primary winding of an ordinary audio frequency transformer of standard characteristics.

Figure 4 is a photograph of a model for the demonstration of the production of both audio and radio frequency oscillations, both circuits employing the same Tungar tube and with switching arrangements for cutting in either transformer, the large one shown being the audio and the small one (of thin laminations) to the rear of the carbon compression resistor being the radio frequency transformer. It is obvious that tuning may be introduced into the radio-frequency circuit, although the natural period of L_1 and L_2 together with other circuit constants will determine the oscillation frequency if no other resonance conditions are impressed elsewhere in the circuit.

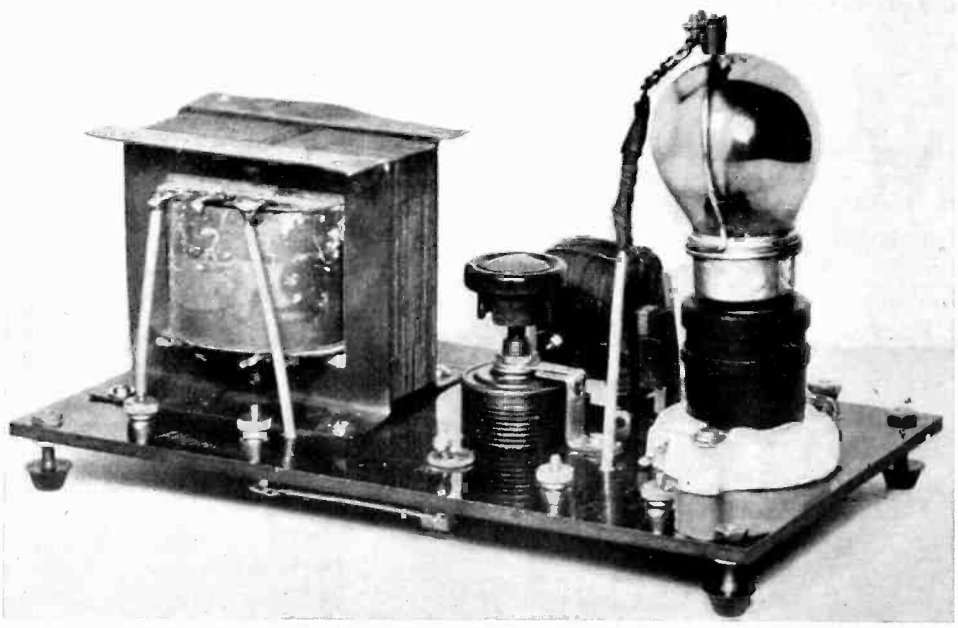

Fig. 4—Apparatus used for producing either audio or radio frequency oscillations

With the model illustrated in Fig. 4 oscillatory currents of the order of 250 milliamperes were obtained from the audio frequency circuit and about 100 milliamperes from the radio frequency arrangement. Undoubtedly, these currents could be increased many fold by adjustment of the circuit constants.

The Tungar tube has been mentioned to illustrate the general class of gaseous diodes, but this classification may include the "Pointolite" arc, neon and rare gas tubes, and any such device which exhibits an assymetric voltage-current curve.

[1]"Radio Possibilties of the Tungar Rectifier," M. L. Synder, *Radio News*, November, 1921, page 387.

[2]*Dictionary of Applied Physics*, Glazebrook, under article on Duddell Arc.

Small-signal detection

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CONSIDERABLE has been written during the last ten years on the theory of detection in diodes and triodes, much of it highly technical and mathematical. The purpose of the following paper is to reduce this theory to its simplest form and to present a graphical aid to a visualization of detection.

To obtain the audio-frequency current that flows as a result of detection in a diode or triode the problem is best divided into two quite separate parts. The *first* part, the radio-frequency part, deals with the rectification caused by the non-linear characteristic, and its solution gives a series fictitious audio-frequency voltage. The *second* part, the audio-frequency part, deals only with the calculation of the audio-frequency current that flows as if it were produced by the series fictitious voltage.

I. Detection with diode

This simple method of treatment will first be explained for the case of a crystal detector or diode as shown in Fig. 1. A detector is there shown in series with an impedance Z which may be a telephone, and the usual tuned circuit across which exists the modulated radio-frequency voltage given by the following expression:

$$(\Delta e_o)_A = \sqrt{2}(\Delta E_o)_A(1 + m \sin Bt) \sin At \qquad (1)$$

where $(\Delta E_o)_A$ is the r.m.s. or effective value of the unmodulated voltage, m is the degree of modulation, A is 2π times the radio frequency, and B is 2π times the audio, or modulation frequency. The Δ is used to indicate small values.

The first step in the solution of the problem is to calculate the r.m.s. value $(\Delta E)_A$ of the radio-frequency voltage $(\Delta e)_A$[1] which exists across the detector by

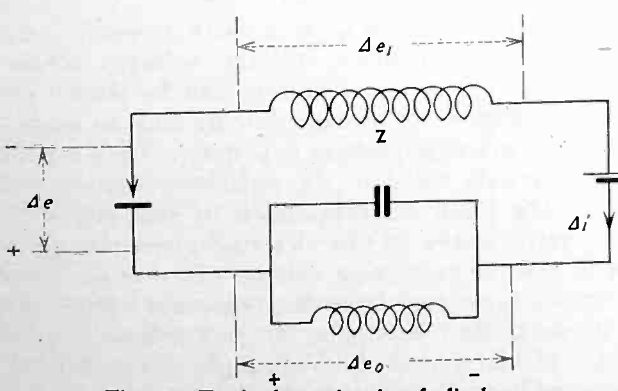

Fig. 1—Equivalent circuit of diode or crystal detector

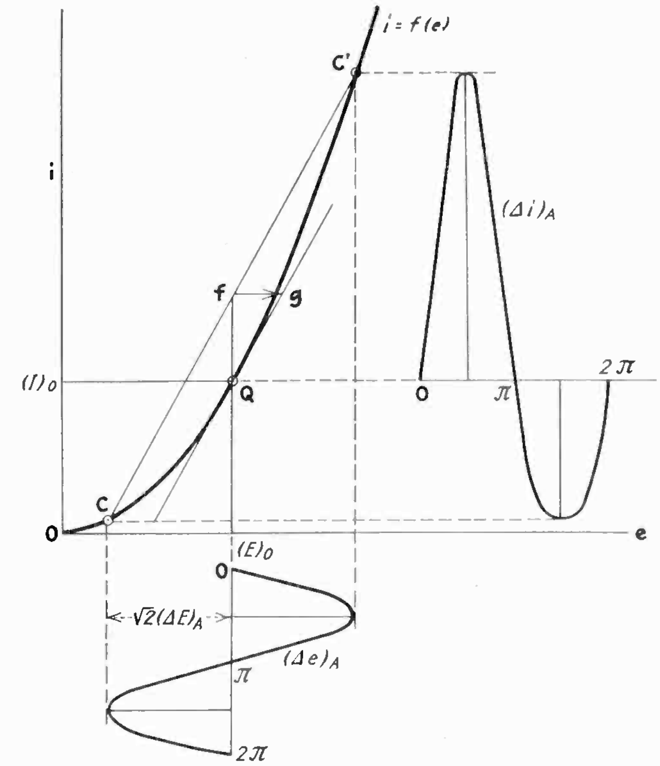

Fig. 2—Curved characteristic of diode detector

treating the circuit as a simple series circuit. The detector has a resistance r, which is the variational resistance to be defined later, and the impedance Z has a value $(Z)_A$ at the radio-frequency. The impedance Z often has a condenser by-pass so large that there is little loss of radio-frequency voltage across Z, in which case $(\Delta E)_A = (\Delta E_o)_A$. It is assumed that Z is not sharply tuned to the radio-frequency so that the degree of modulation of $(\Delta e)_A$ is the same as for $(\Delta e_o)_A$. Then,

$$(\Delta e)_A = \sqrt{2}(\Delta E)_A(1 + m \sin Bt) \sin At \qquad (2)$$

We will now fix our attention on the detector. Let curve $i = f(e)$ (Fig. 2) be the curved characteristic of

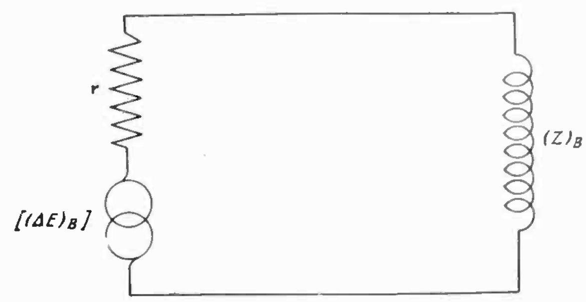

Fig. 3—Equivalent audio-frequency circuit of diode

the detector; and let $(E)_o$ be the steady polarizing potential at the detector, and $(I)_o$ the steady current that flows when no signal is impressed. Point Q on the curve is known as the *quiescent* point. If now a signal is impressed having an instantaneous maximum value $\sqrt{2}(\Delta E)_A$, the operating point moves over a portion of the curve which, within the region covered, is assumed to be a part of a parabola and expressable in the form,

$$\Delta i = a\Delta e + \frac{b}{2}(\Delta e)^2 \qquad (3)$$

In Eq. (3) Δi and Δe are measured from Q as origin. The constant a is equal to $\frac{di}{de}$ of the curve at Q. $\frac{di}{de}$ is also known as the variational conductance k, or the reciprocal of the variational resistance referred to above. The constant b is obviously $\frac{d^2i}{de^2}$ or $\frac{dk}{de}$. The assumption regarding the parabolic form of the curve within the region covered by the operating point imposes the limitation upon the size of $\sqrt{2}(\Delta E)_A$ for the theory to be accurate.

In Eq. (3) the Δe represents the total variation in voltage about point Q that acts upon the detector, whereas $(\Delta e)_A$ in Eq. (2) represents only the radio-frequency part of the detector voltage. There may be an audio voltage across Z which we may denote by $(\Delta e_1)_B$, and also a steady voltage $(\Delta E_1)_o$. Since there is no audio-frequency impedance in the circuit except $(Z)_B$ and the detector, then the audio-frequency voltage across the detector denoted by $(\Delta e)_B$ is the negative of $(\Delta e_1)_B$ and similarly for the increment of steady voltage across Z and the detector. Hence, we have,

$$\Delta e = (\Delta e)_A + (\Delta e)_B + (\Delta E)_o$$
$$= (\Delta e)_A - (\Delta e_1)_B - (\Delta E_1)_o \qquad (4)$$

We may now substitute Δe from Eq. (4) into Eq. (3) and we have,

$$\Delta i = a(\Delta e)_A - a(\Delta e_1)_B - a(\Delta E_1)_o + b(\Delta E)_A^2(1 + m \sin Bt)^2 \sin^2 At + \frac{b}{2}[(\Delta e_1)_B + (\Delta E_1)_o]^2 - b(\Delta e)_A[(\Delta e_1)_B + (\Delta E_1)_o] \qquad (5)$$

As shown by the right-hand side of Eq. (5), Δi is made up of components of zero frequency, of the fundamental and second harmonic of the modulation frequency, $\frac{B}{2\pi}$ and of the fundamental and second harmonic of the radio-frequency and of some sum and difference frequencies as well. If we select from Eq. (5) only the terms of frequency $\frac{B}{2\pi}$, and substitute the values for a and b, we have,

$$r(\Delta i)_B + (\Delta e_1)_B = r\frac{dk}{de} m(\Delta E)_A^2 \sin Bt \qquad (6)$$

Eq. (6) shows clearly that the voltages of audio-frequency across Z and across a resistance r add up to a fictitious voltage of effective value

$$[(\Delta E)_B]^{(2)} = \frac{1}{k}\frac{dk}{de}\frac{m}{\sqrt{2}}(\Delta E)_A^2 \qquad (7)$$

Similarly, we may pick out of Eq. (5) the steady components and find that the series fictitious voltage which would give the steady increment of current $(\Delta I)_o$ is, neglecting terms containing $(\Delta E_1)_o^2$

$$[(\Delta E)_o] = \frac{1}{k}\frac{dk}{de}\frac{1}{2}\left(1 + \frac{m^2}{2}\right)(\Delta E)_A^2 \qquad (8)$$

Referring now to Fig. 2, if a chord cc' be drawn connecting the ends of the excursion on the curve, then the tangent to the curve at Q is parallel to chord cc'. Using Eq. (3) it is easily shown that the vertical distance between the chord and Q, i.e., fQ is $\frac{dk}{de}(\Delta E)_A^2$. Then, the horizontal distance fg from f to the tangent, indicated by the arrow, measured in volts is

$$\frac{1}{k}\frac{dk}{de}(\Delta E)_A^2,$$

and is hence, as shown by Eq. (7), the maximum value of the fictitious audio-frequency voltage for one hundred per cent modulation. If the arrow with its point on the tangent points in the positive direction, the voltage is in phase with the modulation envelopes on the positive side of the radio-frequency oscillations. The phase of the fictitious voltage changes by 180° if the curvature of the characteristic is opposite to that shown in Fig. 2, in which case the arrow would point in the negative direction.

Examining Eq. (8) it is evident that the arrow fg also gives twice the steady *fictitious* voltage for m equal to zero.

The first or radio-frequency part of the problem is now finished and we come to the second part of the problem. The audio current that flows in the circuit is now calculated by the usual method for the series circuit shown in Fig. 3. That is

$$(\Delta \mathbf{I})_B = \frac{[(\Delta \mathbf{E})_B]}{r + (\mathbf{Z})_B} \qquad (9)$$

where the bold-face type represents complex or vector quantities.

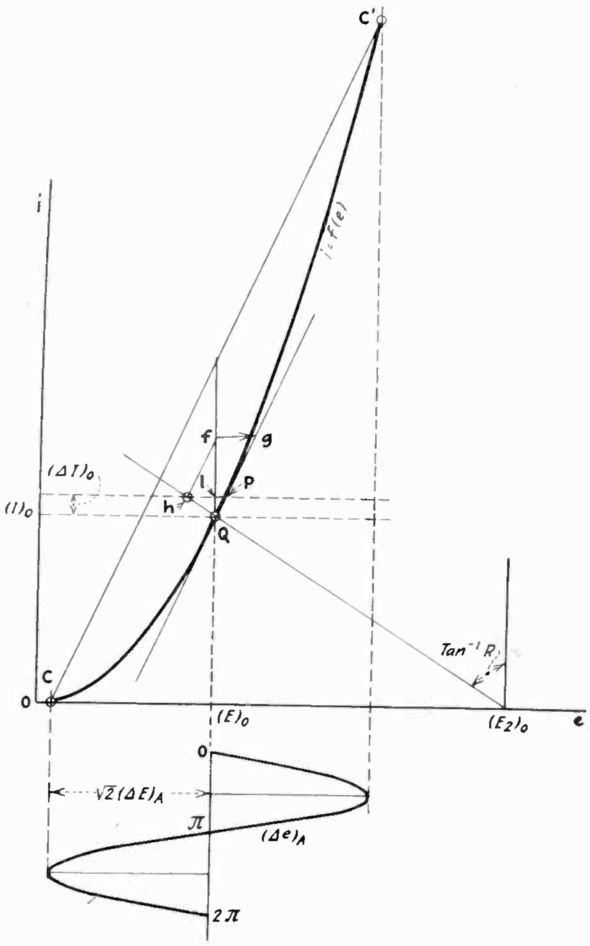

Fig. 4—Audio frequency working characteristic of diode detector

If the impedance $(Z)_B$ is a pure resistance R, the steady current that flows and the voltages across the resistance R for m equal to zero can be shown graphically as in Fig. 4. A straight line making an angle with the vertical whose tangent is R is drawn from a point on the voltage axis equal to the polarizing battery voltage $(E_2)_o$. The point of intersection of this line with the characteristic curve of the detector gives the quiescent point Q and the polarizing voltage $(E)_o$ on the detector. The arrow fg, drawn from the *mid-point* of the vertical line between the chord and Q is the steady fictitious voltage $[(\Delta E)_o]$. A line through f parallel to the tangent intersects the resistance line in point h which is above Q by the steady increment of current $(\Delta I)_o$. The voltage represented by line hp, which is equal to $[(\Delta E)_o]$ is divided by the vertical line fQ into two parts, the part hl is the voltage across the resistance R due to $(\Delta I)_o$ and the part lp is the voltage drop through r.

II. Detection with triode

Detection with a triode may take place either in the grid circuit or in the plate circuit. Of course, both types of detection may take place simultaneously, in which case the two results calculated separately may be combined.

Grid circuit detection is diode detection in the grid circuit plus amplification of the audio-frequency voltage on the grid. The series fictitious audio-frequency voltage in the grid circuit due to detection is calculated by the method just given, the characteristic curve of Fig. 2 now being the grid-current curve corresponding to the plate voltage of the triode. It is assumed as is usually the case that the plate load is by-passed for radio-frequency currents by a condenser so that practically no radio-frequency voltage exists on the plate of the tube.

The impedance $(Z)_B$ of Fig. 3 is now the grid leak as affected by the by-pass condenser and is hence practically a pure resistance except at high audio-frequencies. The audio-frequency voltage across $(Z)_B$ is then calculated by multiplying Eq. (9) by $(Z)_B$. This voltage is then multiplied by the amplification factor μ_p of the tube and treated as a fictitious voltage in the plate circuit in series with the plate resistance r_p and the external plate-circuit impedance $(Z_b)_B$. The audio-frequency plate current is thus easily calculated.

Plate circuit detector

Plate circuit detection results because of the curved characteristic of plate current plotted against grid voltage. The grid is always polarized negatively so that no grid current flows. The author has shown[3] that, taking account of all effects, the fictitious series voltage of modulation frequency due to detection in the circuit is

$$[(\Delta E_p)_B] = \mu_p \left[\frac{1}{s_p}\frac{\delta s_p}{\delta e_g} - \frac{2(R_b)_A}{r_p + (R_b)_A} \cdot \frac{1}{k_p}\frac{\delta s_p}{\delta e_p} + \left(\frac{(R_b)_A}{r_p + (R_b)_A} \right)^2 \frac{\mu_p}{k_p}\frac{\delta k_p}{\delta e_p} \right] \frac{m}{\sqrt{2}} (\Delta E_g)_A^2 \quad (10)$$

where μ_p, s_p and k_p are the amplification factor, mutual conductance and plate conductance, respectively, and $(R_b)_A$ is the resistance at radio-frequency of the non-reactive plate load.

If in Eq. (10) we assume that μ_p is constant, an assumption not greatly at variance with fact, then since $i_p = F(e_p + \mu_p e_g)$ we write

$$\frac{\mu_p}{k_p} \cdot \frac{\delta k_p}{\delta e_p} = \frac{1}{s_p}\frac{\delta s_p}{\delta e_g}$$

and

$$\frac{1}{k_p} \cdot \frac{\delta s_p}{\delta e_p} = \frac{1}{s_p}\frac{\delta s_p}{\delta e_g}$$

Eq. (10) now reduces to

$$[(\Delta E_p)_B] = \frac{\mu}{s_p}\frac{\delta s_p}{\delta e_g}\frac{m}{\sqrt{2}} \left[\frac{r_p}{r_p + (R_b)_A} \right]^2 (\Delta E_g)_A^2 \quad (11)$$

$$= \frac{1}{k_p}\frac{\delta k_p}{\delta e_p} \cdot \frac{m}{\sqrt{2}} \left[\frac{r_p}{r_p + (R_b)_A} \mu_p (\Delta E_g)_A \right]^2 \quad (12)$$

Equation (11) shows that we can obtain the voltage $[(\Delta E_p)_B]$ in the plate circuit by first finding the fictitious grid voltage by the method for the diode illustrated in Fig. 2, and provided we use the $s_p - e_g$ curve of the triode and reduce the applied grid voltage by the factor $\frac{r_p}{r_p + (R_b)_A}$. The fictitious series voltage in the plate circuit is then obtained by multiplying by μ_p.

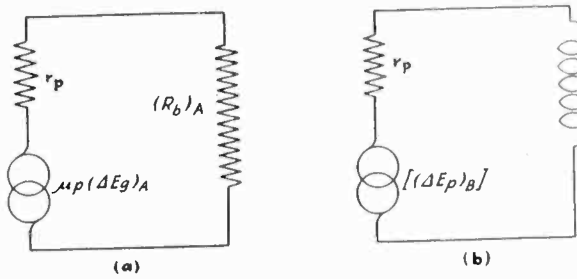

Fig. 5—Circuits used for calculation of r.f. voltage and a.f. plate current of triode detector

Eq. (12) is more illuminating because it shows that plate-circuit detection also can be reduced to simple diode detection. Since we have assumed μ_p constant and since $s_p = \mu_p k_p$, then the curvature in the curve of $i_p - e_g$ measured by the quantity $\frac{\delta s_p}{\delta e_g}$ is expressed also by the curvature in the curve of $i_p - e_p$ as measured by the quantity $\frac{\delta k_p}{\delta e_g}$. Therefore, let us substitute for the triode a diode of resistance r_p as in Fig. 5a, in series with the external plate circuit resistance $(R_b)_A$ and the average effective value of the modulated radio-frequency voltage $\mu_p(\Delta E_g)_A$. Following the methods outlined in the first of this paper we may calculate the radio-frequency voltage across the equivalent diode detector by multiplying $\mu_p(\Delta E_g)_A$ by $\frac{r_p}{r_p + (R_b)_A}$. Then according to Eq. (12) we calculate the fictitious series voltage of detection by the method given early in this paper, using the curve of $i_p - e_p$ for constant e_g, the value of k_p and $\frac{\delta k_p}{\delta e_p}$ being taken at the quiescent point. The second part of the problem then consists merely in calculating the audio-frequency plate current by the usual method, using the circuit shown in Fig. 5b.

In the above discussion we have assumed that the plate circuit load is a pure resistance to the radio-frequency currents. The method given above gives an approximately correct result, if the plate load has reactance as well as resistance for the radio-frequencies in which case, of course, the total impedance must be used in calculating the radio-frequency voltage across r_p of Fig. 5a.

It has been shown that all of the common methods of detection of small signals can be explained in terms of the simple theory of detection in a diode. The chief value of the graphical analysis given in Figs. 2 and 4 is to aid in visualizing the problem rather than furnish a method of calculation. The numerical solution of detection problems can best be done by substitution in Eqs. (7), (11) or (12) the values of the factors, the quantities k and $\frac{\delta k}{\delta e}$ being obtained from curves of k plotted against voltage.

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[1]A capital subscript *outside* parenthesis inclosing a quantity indicates the frequency pertaining to the quantity.

[2]Square brackets about a quantity indicate equivalent or fictitious value.

[3]Chaffee and Browning, *I.R.E.*, Vol. 15, Feb. 1927.

electronics

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O. H. CALDWELL, *Editor*

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Replacement of antiquated radios

MANUFACTURERS while striving at the moment to design their future radios to have the widest appeal from a production and price viewpoint should also keep in mind the replacement market for radio sets. It has been estimated that there are some 4,500,000 obsolete radios now in the hands of the public. To get present owners to part with such equipment for something newer will require a stronger appeal than was required in the first sale. A large percentage of these buyers will require some important additional physical feature to make this appeal attractive. The automatic record-changing feature in a combination phonograph may be a solution to a part of the problem if unit cost can be kept reasonably low. The incorporation of a home movie projector in the radio cabinet may be another. Both have interesting possibilities.

Selenium-cell versus photo-cell

FOR years the photo-cell was the plaything of the scientists; it suffered from fatigue, had a very low order of current output, was erratic and difficult to build. Now engineers have taken the "bugs" out of the photo-cell; it is today sold and used in increasing numbers. It has become an electronic article of considerable commercial importance.

The selenium cell, or "bridge," another form of light-sensitive cell seems to be not far behind the photo-tube in commercial exploitation. Popularly, the selenium cell is supposed to suffer from temperature changes, to be unable to withstand high voltages, to have a bad frequency characteristic, have a non-linear response, and generally to be quite worthless.

But is it?

Activity in many directions indicates that the selenium cell is anything but "dead." In England it is being used to detect smoke in steamer holds, to turn on and off street lights, to control the flow of oil in oil-burning furnaces, and generally to perform all the multitudinous functions for which the phototube is being sold.

In this country selenium is being used in a large chain of sound-picture theaters, and a device is ready for the market which, by means of a selenium tube, regulates the amount of illumination in a room or building.

Russia leads off with 500 Kw. broadcasting

SOVIET Russia is now building a broadcasting station at Noghinsk, a suburb of Moscow, which will have a power of 500 kw., the largest in the world. The Soviet government also hopes to have eleven new 100,000-watt stations and twenty-eight 10,000-watt broadcasters in operation before the end of 1933. Amtorg, the official Russian trading agency in the United States, further reports that 47 stations are already built and operating, that about 2,746,000 receiving sets are in use and that 14,000,000 will have been distributed by 1933.

Noghinsk thus becomes a name to remember, for it will have by far the highest powered station in Europe where the trend seems to be toward higher and higher powers, as in the United States. In free America, however, the Federal Radio Commission has placed a limit of 50 kw. on the power that broadcasters may use; and even so permits only half of the available candidates to use this much, while 20 other clear channels are wasted on 5-kw. stations and millions of listeners are deprived of the programs they might otherwise hear.

"The only authentic record—"

POPULAR vote dictates that the patents digest section of *Electronics* shall not be discontinued. One reader commenting on this feature states "a review of patents recently issued is the only authentic record of what is new in the art and to whom credit really belongs." Unfortunately history seems to indicate that not even such records are proof positive of invention, but it is certainly the most authentic record. There is always room for doubt as to where credit is due when reading less exact publications than the Patent Digest.

For example several years ago several tube manufacturers announced within a few weeks of each other that they had independently "discovered" a way of making a new humless and crackle-less tube. In spite of the fact that screen-grid tubes had been used in Europe for some time to the common knowledge of all engineers, a number of manufacturers were naïve enough to announce this new tube as their own private development. Undoubtedly copywriters will be claiming a dozen new inventors of the old pentode tube before many months go by.

Electronics will not discontinue its patents digests. On the other hand it will endeavor to supplement the present service with a digest of patents issued abroad.

"For $1 and other considerations"

IT IS the usual practice for companies manufacturing products protected by patent or patent processes, to require all engineers on employment to sign a contract to the effect that any inventions developed by the employee during his term of employment, shall automatically be assigned to the company. The employee receives for his signature the sum of $1, and other considerations, this being generally recognized as the job itself.

Where inventions of great commercial value have sprung from this union, there are relatively few cases where the individual received a participating interest. In large research organizations it is admitted that giving special financial recognition to one inventor or group over another, has its difficulties, especially where research problems having no immediate commercial development possibilities exist. In smaller organizations, certainly no such difficulty exists. In 99 per cent of the cases, an opportunity exists for companies to share their success with the individual inventor.

Of even more importance in creating initiative, would be a contract with each employee, containing some provision for a percentage participation, however small, from any invention that becomes *commercially successful.* It would mean the placing of all research and production engineers on a *commission basis.* The company and the employee would greatly benefit under this new arrangement, and idle time and idle thoughts, now the inventor's sole property, could be stimulated to maximum efficiency. The new plan would cost the company nothing, unless such inventions become commercially successful, and in which case it would still get the lion's share.

Long-time cosmic echoes of radio waves

IF Dr. Einstein is right and space is "curved," then the Einstein theory is of special curious interest to broadcast listeners who want to hear their favorite radio programs repeated a second time.

For "curved space" means that every radio program will, years hence, return to earth, after having made the circuit of the universe. Such radio waves, even though weakened by their long journey, should return intact,—although soprano voices will probably be found an octave or so lower, by reason of the same lowering of frequency which makes far distant nebulae reddish in color.

The only discouraging thing about these "Einstein encores" of Amos 'n Andy, and the Cliquot Club Eskimos is the long wait that will be necessary. Sir James Jeans, the distinguished British astronomer, computes that 500,000 million years is the time required for electro-magnetic waves, like radio waves or light waves, to make the round trip to the ends of space and to return to their starting point.

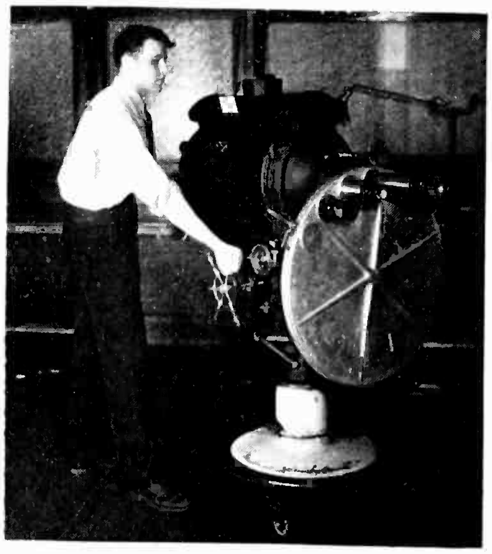
The march of the electronic arts

Government loses suit against Dubilier

THE U. S. GOVERNMENT suit against the Dubilier Condenser Corporation for title to three important radio patents perfected by F. W. Dunmore and Percival D. Dowell, while employees on Government time, and later sold to Dubilier, was dismissed by Judge Nields in the Federal District Court at Wilmington, Del., on April 27. The Government contended in this case that it possessed the right of employer in the patents. Judge Nields ruled that to hold every invention perfected by Government research workers is the property of the Government, would be not only contrary to the law laid down by the Supreme Court, but would have a strong tendency to destroy the morale of its employees and take away a just incentive to their inventive ability.

The Lowell and Dunmore patents were acquired by the Dubilier Condenser Corporation, which later instituted proceedings against the Radio Corporation of America for infringement. These patents were upheld as to their validity by Judge Morris in the United States District Court, but the decision was appealed, and the Circuit Court of Appeals refused to consider the validity of the patents anew until the questions of the Government's ownership were settled.

TELEVISION FLYING SPOT



The flying spot scanner developed by Deforest Radio Company engineers for television station W2XCR, New York City

✦

Course in modern physics

THE DEPARTMENT OF PHYSICS of the Massachusetts Institute of Technology will offer this Summer a program of graduate subjects in modern physics, covering radiation, spectroscopy and electron emission. These subjects are offered particularly for the benefit of engineers and physicists in industry. The subjects offered include a course on electron emission, by Dr. L. R. Koller of the General Electric Co.; spectroscopy and atomic structure by G. R. Harrison; Radiation measurements, by B. C. Stockbarger; and a course in modern physics by G. R. Harrison. This series of courses extends from June 22 to July 28.

✦

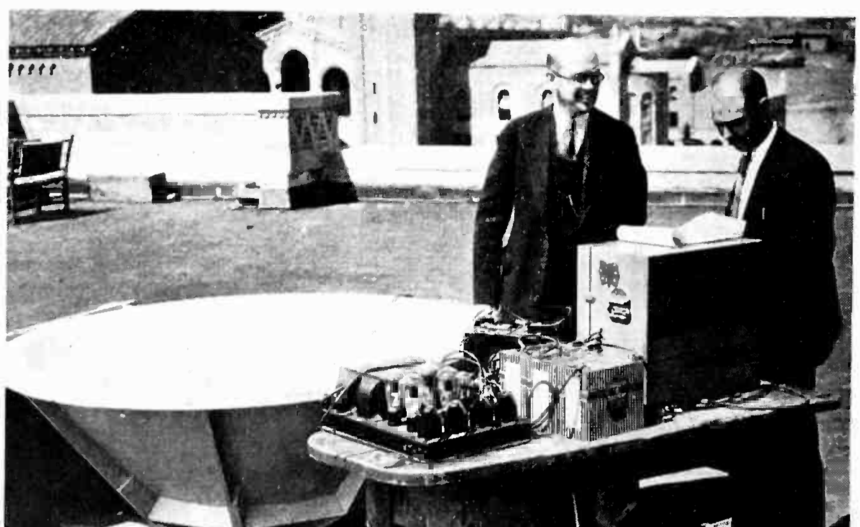
U. S. Supreme Court refuses review RCA Deforest case

THE SUPREME COURT of the United States on April 27, refused to review a lower court decision in the famous "Clause 9" case, in which the Deforest Radio Company won a permanent injunction against the Radio Corporation of American. The case before the high court involved questions of importance concerning patents and patent license contracts which were instituted by the Deforest Radio Company in the Federal District Court for the District of Delaware. The Deforest Company asked for an injunction, under Section 16 of the Clayton Act, to enjoin RCA from carrying out or enforcing certain provisions of the standard license contract made by RCA with some 25 manufacturers of radio receiving sets. The petition of RCA to the Supreme Court for a writ of certiorari was refused by Chief Justice Hughes. One of the principles set forth in this case and upheld in the courts was that the Clayton Act made it unlawful for a patentee to grant a license upon condition that he share with the licensee in the manufacture of the patented article.

As a result of the refusal by the Supreme Court to grant RCA a review of the case, the Radio Commission has asked its legal department for a ruling on Section 13 of the Radio Act of 1927, which "directs" the Commission to refuse to renew the license of any company held to have violated the Clayton law.

✦ ✦ ✦

SOUND TO MEASURE AIRPLANE HEIGHT



Dr. Vern O. Knudsen (left) and Dr. Leo P. Delasso of the University of California, experimenting with sound reflector to determine distance of airplane from the ground

✦

Grigsby-Grunow reports $3,061,407 sales for March

SALES OF GRIGSBY-GRUNOW radio sets and tubes for March were $3,061,407, as reported in the *Wall Street Journal* of April 3. The total number of sets sold during March were 63,681, and total number of tubes 576,888.

U. S. radio delegates sail for Copenhagen on May 13

RECENT DEMONSTRATIONS OF the efficacy of ultra-short wavelengths of a fraction on one meter will vie for interest with proposals to widen the broadcasting band to open up more long waves to accommodate high-power broadcasting, when radio experts from all over the world meet at Copenhagen, May 27-June 8, for the annual conference of the International Consulting Committee on Radio Communications.

According to advices from Copenhagen, many new advances in radio technique, especially applicable to broadcasting on short and long waves, will be brought to the attention of the engineers during their parley. This conference, meets to lay the technical groundwork for the international treaty-making conference which will be held in Madrid next year.

American delegates, appointed by President Hoover who will sail on the S.S. America, May 13, include: Senator Wallace White, Jr., co-author of the Radio Act, as diplomatic representative; Dr. C. B. Jolliffe, chief engineer of the Federal Radio Commission, and Dr. J. H. Dellinger.

✦

North American radio parley likely as Canada names envoy

WITH CANADA ABOUT TO send a new Minister to Washington, the Hon. W. D. Herridge, who has had a considerable experience with radio in his practice of patent and corporation law, events appear to be moving swiftly toward the calling of a North American broadcasting conference looking to a new division of the broadcast wavelengths among the United States, Canada, Mexico and Cuba.

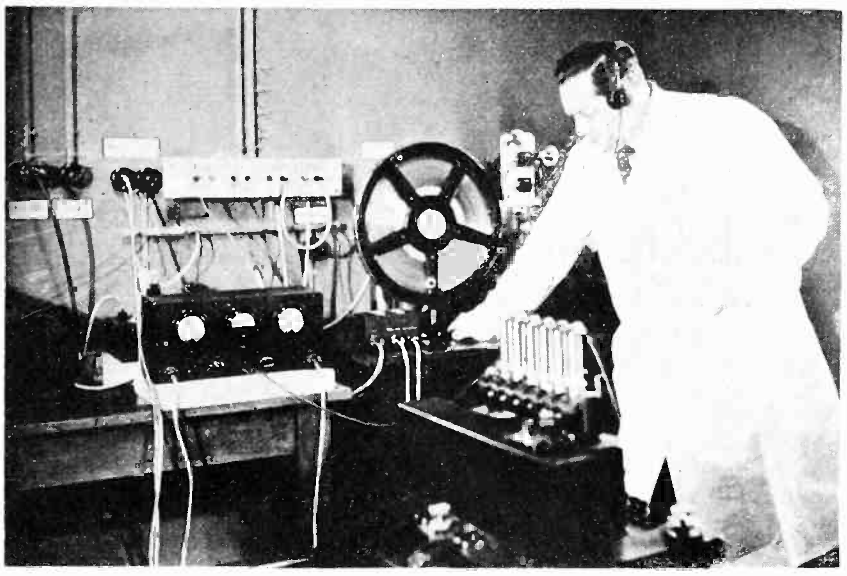
The initiative in calling the conference probably will be taken by the American State Department, whose officials lately have been in frequent consultation with officials of various American broadcasting interests.

✦

Super-midget radio transmitter

A TINY AUTOMATIC RADIO transmitter that is attached to free baloons and then tracked by radio direction-finding apparatus to trace air currents has been developed by Major William R. Blair of the Army Signal Corps. Believed to be the smallest and lightest radio transmitting outfit ever built, the weight of the combined transmitter, antenna and battery is only 17¼ ounces. It is said to be capable of sending on a frequency of 2,300 kilocycles (130.4 meters) for distances up to 25 miles.

VOICE RECORDED ON MAGNETIC TAPE



Prof. Carl Clewing of Germany with his voice recording machine using a magnetized steel band. It records for 20 minutes and may be reproduced immediately on loudspeaker and oscillograph

✦ ✦ ✦

Market for 100,000 American radios in Belgium

OF THE 150,000 radio sets estimated in use in Belgium, some 70,000 are said by the Belgian post office authorities to be "boot-legged," or non-licensed. Belgium imposes an annual tax of 20 francs, about 55 cents, on crystal sets, and 60 francs, about $1.70, on tube sets. C. C. Frick, American trade commissioner at Brussels, estimates there is a market for 100,000 American radios in Belgium.

✦

LATEST SOUND CAMERA

Self-powered electric driven sound picture camera developed by Lorenzo Del Riccio for Paramount Studios, New York City

Saturation point for radios still some distance off

OF THE FIRST 15 states and District of Columbia thus far reported, the number of families owning radio sets, according to the latest U. S. Census Bureau reports, was less than 33 per cent. Connecticut and the District of Columbia are well in the lead of the states so far reported, their percentage totals being 54.9 and 53.9 respectively. The complete tabulation of the reports available are as follows:

State	No. Families	Radios	%
New Hampshire	119,660	53,211	44.4
Delaware	59,295	27,183	45.8
Vermont	89,439	39,913	44.6
Alabama	592,530	56,491	9.5
Arizona	106,630	19,295	18.1
Arkansas	439,408	40,248	9.2
Colorado	268,531	101,376	37.8
D. C	126,014	67,880	53.9
Florida	377,823	58,446	15.5
Utah	116,254	47,729	41.1
Iowa	636,905	309,327	48.6
Connecticut	389,596	213,821	54.9
North Dakota	145,382	59,352	40.8
Nevada	25,730	7,869	30.6
Georgia	654,009	64,908	9.9
New Mexico	98,820	11,404	11.5

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League of Nations radio

FROM GENEVA COMES a consular report to the State Department announcing that the new League of Nations radio station, which will transmit on the short waves, will be completed by next December 1. Grounds and building are ready, but contracts remain to be awarded for the transmitter equipment. It is expected to have all technical operations in order before the general disarmament conference in February, 1932.

REVIEW OF ELECTRONICS LITERATURE

HERE AND ABROAD

Cathode ray oscillograph research

[M. Knoll and B. Borries; M. Knoll, W. Rogowski, E. Fleger and K. Buss]

In a series of recent publications from the High Tension Laboratory of the University of Berlin, the Aachen Polytechnic Institute a.o. improvements have been described which show how much thought is being given at the present moment to the perfection of the important electronic device.

The value of the oscillograph is determined in many cases by the highest speed of writing at which the beam of electrons gives a just discernable picture on the plate, by the size of the picture and the width of the line which is traced upon the photographic plate. The records may be obtained in four or more different manners: The electron beam acts directly upon the photographic plate placed inside, or touching the outside of the tube; or the electron beam falls upon a screen covered with a luminescent paint and is photographed by means of a lens system, or without lenses by letting the photographic plate make direct contact with the screen which in this case forms part of the wall of the tube. It is evident that the inter-position of a luminescent screen is of use only in the case where the photographic effect is increased by this auxiliary, either because the luminous paint produces light to which the plate is most sensitive, or because it multiplies the effect of the electrons. At the same time, the width of the trace should not be increased by the screen, a point which imposes the use of very thin materials, and no lag should be introduced. It was found (Rogowski, Knoll) that the whole thickness of the screen should not exceed 0.5 mm. in order to preserve the sharpness of the trace. In this case screens give improved performance when low velocity electrons (5,000 to 10,000 volts) must be used.

Knoll-Borries oscillograph

In the new Knoll-Borries oscillograph the photographic plate is placed outside, and makes contact with the wall of the tube. The electron beam is allowed to pass through the wall, or the wall may be covered with a thin deposit of luminescent substance (zinc-sulphide, 6 millograms per sq.cm.). In order to get large pictures, 9 x 12 cm., it was necessary to reinforce this part of the tube by mechanical means without introducing shadows; it has to withstand a pressure of 100 kg. The wall itself is formed by an aluminum foil of 7 thousandths mm. thickness, when direct photography is desired, to which is added a piece of wire gauze of phosphor bronze (10 wires per mm. each of 0.04 mm. thickness). When photography by luminescence is desired, a celluloid foil of one-eighth mm. thickness is used.

In both cases the foils are placed upon a grid formed by upright steel ribbons of 0.3 x 7.5 mm. section placed at 1 cm. distance.

The grid is attached to a brass frame which fits the end of the cathode ray tube, this end looks then like a piece of cross-section paper. A film-holder containing a film 140 m. long may be fastened to the frame. Oscillograms are reproduced of 890 m. and 160 m. waves, maximum recording velocity 50 km. per sec. and 300 km. per sec. resp (amplitude 5 cm., one-half wave per cm.; width of trace 1 mm.).

A comparison between the results obtained at the limit by means of the different methods of recording the electron beam has been made by Knoll. Electrons of 70,000 volts, corresponding to 0.474 times light velocity were used, and an accuracy of two per cent was desired. Line waves were applied to the deflecting plates, because they offer a convenient means of varying and determining the velocity of writing at which a just perceptible trace of blackening can be obtained. At 70,000 volts the electrons traverse completely the thickest emulsions used in the commercial photographic plates, but only those electrons are useful which act in the surface layers, because the developer does not penetrate very deeply. Part of the energy is also transformed into secondary radiations. In the case of the screen more than 1 to 10 per cent of the electron energy is transformed into light. Thus of the total number "n_1" of electrons hitting one unit surface of the plate or screen, only a certain number "n" are effective. The number "N" of grains which must be influenced in order to produce a just perceptible blackening of the plate is about 10^4 times smaller than the number of sensitive grains in the plate, or equal to about 10^5 grains per sq.cm. for the emulsions used. The results are summarized in the accompanying table where total current = 1 micro amp., diameter of beam at screen = 1 mm.; 70,000 volt electrons.

Method	Fraction of electrons or light transmitted	Emulsion	$N_1 \times 10^6$	$N/n \times 10^2$	Max. Velocity of writing, km. per.sec.
Direct exposure.....	1.00	Agfa film	2.4	4.2	670
Inside tube.......	....	Agfa x-ray	0.7	13.8	2,200
Electron (Lenard) window..........	0.24	Silver bromide paper	0.7	3.3	530
Lum. screen in contact..........	0.6	Silver bromide paper	4.6	1.3	200
Lum. screen good lens system......	0.01	Silver bromide paper	4.6	0.04	6

The article by Rogowski, Fleger and Buss is a report of the work carried out by the authors during the past three years in pushing up the speed of recording of the cathode-ray oscillograph. By using sufficiently high voltages, they were able to write at over one quarter of the speed of light (63,000 km. per sec.). At higher speeds the records are no longer faithful on account of the finite speed of the electrons constituting the recording beam.

By means of electronic device permanent records can therefore be obtained and studied of events which happen inside less than one thousand millionth of a second.—*Zeitschrift für techn. Physik, November, 1930, and January, 1931. Archiv für Electrotechnik, November, 1930.*

✦

Calculation for frequency doublers

[Aséef] Methods of practical calculation of the constants entering into the operation of a triode employed as frequency doubler, especially in short-wave transmitters.—*L'Onde Electrique, Paris, January, (February 7), 1931.*

The Störmer echos made clear

[F. N.] Report of a lecture by Brüche in which low-speed cathode rays were used to produce artificial polar aurora, and the existence demonstrated of a sharply defined zone of thororidal form round the earth in which no electrons are present. The Störmer echos are due to reflection from the outer limit of this zone. Excellent photographs of the demonstrations, diagrams of the apparatus used to produce the rays. Mention is also made of the use of a tube in which such rays are produced as an inertia-free compass and/or inclination indicator for aerial navigation, the earth's magnetic field keeping the rays in one direction so that any displacement of the tube becomes visible.—*Radio B.F.f.A., Stuttgart, March, 1391.*

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Radio and phonograph technique at the Leipzig Spring Fair

[SCHW] Points of especial interest are: the cessation of sale of the Telefunken flat-tube (capacity-controlled, "gridless") receivers; the appearance of new battery receivers, especially of such where only two B connections are needed, all adjustments of B and C voltages being made within the receiver by suitable resistances; a new receiver made for battery use but immediately convertible to mains supply, for use where it is known that the mains will be available shortly; so-called "Wired Radio" receivers for the Bavarian system (the name being incorrect, since it is in reality low-frequency energy that is supplied to subscribers over the wires).—*Funk, Berlin, March 13, 1931.*

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Grass growth, heartbeats and respiration heard in loudspeaker

[GRADENWITZ] Description of apparatus used in recent broadcast lecture from Vienna, where heartbeats and respiration were transmitted by means of a microphone with a special iron membrane and a rubber cone, the latter absorbing the purely mechanical vibrations and the former being part of an electro-magnetic system. Muscular currents were also transmitted [and, it may be added, the weaker currents associated, not with the actual movement of the muscle but by the subject merely *thinking* of the action involving this movement.] The ultra micrometer used for rendering audible the growth of plants is also described, this being based on the infinitesimal variation of capacity due to the movement of one plate of a condenser attached to the growing fibre, which variations are made to cause heterodyning between two circuits.—*La Nature, Paris, March 15, 1931.*

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Amateur use of selenium rectifiers

[SCHWANDT] Description with photographs and diagrams of uses of this rectifier (these Digests, January) the commercial form described consisting of an iron plate with a thin selenium layer, over which a very thin film of a soft metal is squirted: this is followed by a lead plate, a copper foil (for connections), another lead plate, soft metal film, selenium layer, and iron plate, the whole being clamped between massive copper plates for cooling purposes. Applications for accumulator charging, heating of d.c. filaments from the mains, energizing of electro-dynamic loudspeaker fields (low and high resistance: compare these Digests, April) are described.—*Radio B.F.f.A., Stuttgart, March, 1931.*

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Danger in line filter condensers

[A. DENNHARDT] The author discusses possible dangers offered when two condensers with ground between them are used in the primary of radio receiver power packs in order to eliminate line noises. If for any reason the frame of the power station generator is insufficiently grounded, the two condensers act as a voltage divider and put the metal case under tension. As the body of a person touching it may have a resistance of not more than a few thousand ohms, it will be traversed by a current from ground to frame of over 10 milliamp. if 2 mfd. condensers (1600 ohms at 50 cycles) are used. For safety's sake the condensers should not be larger than 0.02 mfd.—*Elektrotechnische Zeitschrift, March 12, 1931.*

✦

Electron tube telemetering system

[E. HUDES] The author examines several simple devices by which the low frequency (one to five cycles) telemetering indications are transformed into steady readings (See also *Electronics*, "Tubes in Industrial Service," April, 1931) without introducing a serious lag. The best solution is found to be an artificial line consisting of two sections (resistances in series, by-passed by condensers) with a resistance as the input element and an amplifier tube at the output measuring device.—*Elektrotechnische Zeitschrift, March, 1931.*

Latest gramophone and sound-film patents

[DR. T.] Descriptions with diagrams are given of: 498843, Vollmann, in which the effect of the weight of the needle-securing screw is reduced by making the axis about which movement takes place diagonal so that its prolongation passes through the head of this screw. 500900, Pfleumer, for the use of a very thin layer of metallic powder as the sound-registering material, in lieu of a metallic ribbon or wire. 510276, Tonbild Syndicate, for the addition of acoustic accompaniment to an existing film, one source of light being made to serve for projection, copying, and sound-recording. 500803, Zeiss-Ikon, for the use of the protecting slit separating the projector proper from the lower film-magazine also as the optical slit for the sound reproducer, making it possible to add this readily to existing projectors. 500871, Engl, for a device to ensure that the film lies evenly in place at the moment of sound-reproduction. 506233, Tonbild Syndicate, for the addition of sound-reproducing apparatus to existing projectors. 508958, Zeiss-Ikon, for the projection by one apparatus of films of different systems, whether having the sound-recording strip within or without the perforations, by means of a moveable doubling reflecting prism. 500044, Schultz, a device by which a photo-cell gives a warning if the film breaks.—*Funk, Berlin, March 13, 1931.*

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Power factor measurements with vacuum tubes

[W. B. WIEGAND, C. R. BOGGS AND D. W. KITCHIN] Addition of small amounts of certain carbon blacks to rubber compounds markedly improves their insulating properties, in particular the power factor and dielectric strength. The current for the power factor tests is supplied by a vacuum tube oscillator set at 580 kilocyles. An untuned grounded circuit couples the oscillator with the measuring circuit consisting of a coil L in series with a variable resistance R and condenser C, across which the test condenser C' holding the sample is connected. A small coil of fine wire near the low potential end of L couples this circuit to a single stage vacuum tube voltmeter. The circuit is tuned, first with both C and C' in (reading c_1) and then with C alone (reading c_2). Resistance (R ohms) is then added to bring the deflection of the meter back to the value it had when the first reading was taken. The power factor is equal to 6.28 fR $c^2_2 1$ (c_2-c_1), where f is the frequency.—*Industrial and Engineering Chemistry, March, 1931.*

Micro-ray wireless

An account of the equipment used on March 31, by the I.T. and T. Laboratories for establishing straight-line two-way telephone communication across the straits of Dover, from St. Margaret's Bay to Blanc Nez, by 18 cm. (1,600,000 kc.) waves. A single short-wave generator tube is connected by a very short transmission line with the radiating system, a Hertzian doublet or dipole of 2 cm. length. The doublet is placed at the focus of a paraboloid reflector about 10 feet in diameter. To concentrate radiation still more in the direction desired, a small hemispherical reflector is placed on the side of the doublet opposite to the large reflector with the doublet at its center and the small tube off-center. As the radius is made a multiple of a half-wave, when the reflected radiations reach the focus again, they are practically in phase with those being radiated at that instant. The radiated power is of the order of 0.5 watt. The receiver is situated about 240 feet from the transmitter at each terminal station in order to avoid coupling; it contains a doublet and a short-wave tube. — *The Electrician, April, 1931.*

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Pentode vs. triode

[A. L. M. Sowerby.] The author compares the pentode and the triode on three bases:

(1) Efficiency as power conversion device, i.e., ratio of power handed to loud speaker to power drawn from battery or eliminator. The average pentode shows an efficiency of 21.5 per cent while the average triode shows an efficiency of 16.3 per cent. Pentodes range from 14.1 per cent to 29 per cent while triodes range from 11 to 24.8 per cent. Tubes with high filament voltages and high plate voltages show the highest efficiencies in each class.

(2) Sensitivity, i.e., milliwatts output divided by volts input. The average figure for triodes is 25.4 while that for pentodes is 66.2. The discrepancy is rather greater than that indicated because in each case the comparison was made with an input signal equal to the nominal bias of the tube, since with larger inputs grid current will flow, whereas it is an experimental fact that overloading with a pentode will often occur in the anode circuit before it takes place in the grid circuit.

(3) Fidelity, i.e., equal power should reach the speaker for each volt of signal on the grid, irrespective of frequency. Since the load on a triode is always much greater than the internal impedance of the tube the voltage developed across the tube tends to remain constant thus delivering smaller power as the frequency is raised. On the other hand, due to its high internal impedance, the pentode is essentially a constant current device. Cone type speakers are more sensitive at the higher frequencies and hence make better output devices for triodes; moving-coil speakers, which are essentially constant current devices, are better adapted to pentodes. Equalizers or pads may be used with either combination and the impedances should be properly matched by means of an output transformer or tapped impedance. —*Wireless World, November 26, 1930.*

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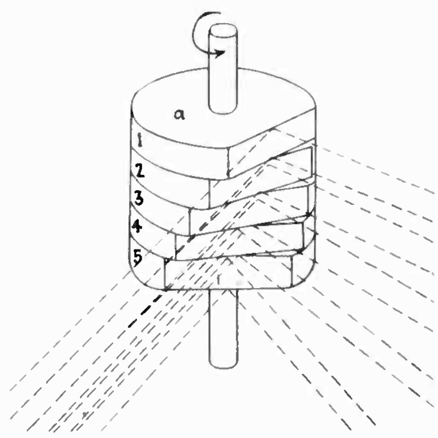
A new television system

[Noack] The "Telehor" Company has developed a new type of mirror-wheel for reception, replacing the normal (Weiller) type. In this several glass disks are mounted on a common axis so as to form a glass cylinder. One side of this cylinder is then ground flat and silvered, and the disks are then rotated on the axis relatively to one another so that the rotation of the assembly brings the mirrors successively into a given plane. They are then secured in place (see diagram). As the source of light a lamp producing a straight-line glow between two parallel electrodes is used, these being mounted parallel to the axis of the mirror-wheel, and the distances from the lamp to the mirrors and from these to the picture-window are so



chosen that each mirror begins to traverse the window with the reflection of the glow as the neighboring mirror ceases to do so. An image 30 times as brilliant as with a Nipkow disk is claimed. On the other hand, the new method is less economical of light than the Weiller wheel but has the advantage over this (especially for home use) that the image can be directly observed instead of having to be projected on a screen. The construction is also cheaper and lighter than that of the Weiller type. A further advantage is that practically any number of mirrors can be used, whereas with the Weiller wheel the diameter must be increased for the purpose.— *Radio B.F.f.A., Stuttgart, March, 1931.*

Progress in photo-cells

[Kr.] Report of a lecture by Schröter of the Telefunken Company, dealing especially with a cell in which a grid is inserted between the potassium cathode and the anode, enabling the modulation of the electrode stream by an applied alternating current, and thus simplifying the amplification or transmission of the resultant current. A further development is a screen-grid photo-cell, in which the anode is capacitatively screened as in the case of the corresponding triode, so that higher frequencies can be used. Mention was also made of recent improvements in the Lange-Schottky copper-oxide photo-cells (these Digests, October, December, 1930) in which a suitable choice of materials has allowed of much increased sensitivity.—*Radio B.F.f.A., Stuttgart, March, 1931.*

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Present ultra-short-wave developments for broadcasting

[Gerth] (Communication from the Lorenz Company Laboratories: amplification of article digested March. See also other digests February and March on this subject). Points more fully developed than in the previous article are: the limitation of range of these waves to the visible horizon (with exceptional results between France and Corsica, and in the U. S. A.); the priority of Esau in suggesting the use of these waves for city broadcasting; the extremely low field-strength obtained, necessitating critical regeneration setting. Results in Chemnitz gave some 5 kilometers range with good head-telephone strength on four-tube receiver (radio, regenerative detector, two audio) from 1 kw. sender on seven meters; in Berlin 7 to 10 kilometers under similar conditions, but with a two-tube receiver (regenerative detector and one audio). Interference was chiefly from automobile ignition, up to 50 meters distant. Difficulties in modulation were met with, a special grid-voltage modulation being developed. Double modulation (the modulation of the ultra-short wave with a wave of the normal broadcasting bands, this in turn modulated at radio frequency) was tried from 1929: compare the von Ardenne proposals. This method presents advantages (especially the possibility of using a special demodulator tuned to the ultra-short wave preceding a normal broadcast receiver) but also severe disadvantages (especially the reconciliation of quality and selectivity in view of the use of critical regeneration): experiments are being continued in Berlin by the Postal Department and the Lorenz Company. The development of suitable receivers is however regarded as the urgent matter for research at the moment. — *Funk, Berlin, March 27, 1931.*

NEWS
OF THE ELECTRON INDUSTRIES

Central Radio Laboratories, Milwaukee, Wis., announces the appointment of William B. Winslow, as its manager of West Coast sales. His headquarters will be located at the factory branch at 2149 E. Sacramento St., Los Angeles, Calif.

The Fairmont Aluminum Company Fairmont, W. Va., announces the appointment of Edgar T. Wards' Sons Company, with general offices at Pittsburgh, Pa., as eastern warehouse distributors for Fairmont aluminum sheets. These aluminum sheets may now be obtained in practically all principal cities of the United States, for immediate delivery.

Harry Holmes, former general sales manager of the Deforest Radio Company, has joined the Stevens Manufacturing Corporation, 42-48 Spring St., Newark, N. J., in the same capacity. The Stevens Manufacturing Corporation manufactures a wide line of products, including Burtex diaphragms for loudspeakers, complete loudspeakers, direct-coupled amplifiers, electric phonographs, and phonograph motors.

The Society of Motion Picture Engineers will have an exhibit of new motion picture equipment developed within the last year, at the Spring Meeting of the Society in Hollywood, May 24-29. Rules regulating the exhibits require that the equipment be new or developed within the last 12 months; no pamphlets or advertising literature will be permitted. Each exhibitor will be permitted to display a card giving the name of the manufacturing concern, and a technical expert, capable of explaining the technical pieces of the apparatus, will be present during the exhibition. Space provided will be free. Sylvan Harris, editor of the *S.M.P.E. Journal,* 33 West 42nd St., New York City, is in charge of arrangements.

The Capehart Corporation, Ft. Wayne, Ind., has announced the appointment of W. H. Hutter, formerly chief engineer of the Webster Electric Company, Racine, Wis., as its chief electrical engineer in charge of manufacturers' division sales. For the past 25 years Mr. Hutter has specialized in audio and acoustics, and during that time has served as consulting engineer in an advisory capacity for many companies engaged in radio production.

The Ceco Manufacturing Company, Inc., Providence, R. I., calls attention to the fact that the short-wave station mentioned in its January advertisement in *Electronics* was WIXAC, the equipment of which was used for test purposes on a dummy antenna. Station WIXAC is one of the many amateur stations which has reported the use of Ceco products.

Leon Brin has been appointed general sales manager of the Pilot Radio & Tube Corporation, and will make his headquartess at the company's plant at Lawrence, Mass. Mr. Brin was formerly connected with the RCA Victor Company at Camden, N. J.

The Kahle Engineering Company, a new organization, announces that it has opened offices and a warehouse at 548 39th St., Union City, N. J., to do business in machinery, equipment and raw materials used in the manufacture of radio tubes, incandescent lamps, Neon lamps and other vacuum products.

Shortwave & Television Corporation, Boston, Mass., has announced the appointment of William Dubilier as technical advisor, and Alexander Nyman, former assistant to the chief engineer of the Westinghouse Electric & Mfg. Co., has been retained as consulting engineer.

Arcturus Radio Tube Company announces election at the annual meeting held April 21, of officers and directors for the ensuing year as follows: Chester H. Braselton, president; George Lewis, vice-president; Charles E. Stahl, vice-president and general manager; Worcester Bouck, vice-president and treasurer; F. N. Norris, secretary; Frank L. Sparrow, assistant secretary; M. E. Dorn, assistant treasurer. The directors are: Chester H. Braselton, George Lewis, Charles E. Stahl, Worcester Bouck and A. E. MacFarland.

E. T. CUNNINGHAM

The new president RCA Radiotron Company who succeeds T. W. Frech, the latter returning to General Electric Company

The Rola Company is moving into new office and factory quarters at 2532-2570 Superior Ave., Cleveland, Ohio. This more than doubles its present production capacity. At the same time, all manufacturing activities are being consolidated at Cleveland, and the Oakland, Cal., plant is being dismantled. A new completely soundproof laboratory has been installed.

The DeJur-Amsco Corporation, 95 Morton St., New York City, has recently issued a circular describing in detail a new product called the Varitor, a small fixed variable capacitor, designed to meet the requirements of the semi-variable or fixed variable capacitor in modern radio frequency and super-hetrodyne circuits and will be glad to send a copy of this circular to anyone upon request.

The Daven Company, successors to the Daven Radio Corporation, manufacturers of Super-Davohm wire-wound precision resistors, located at 158-160 Summit St., Newark, N. J., has announced the purchase of the physical assets, patents and trademarks of the former Superior Resistor Corporation, located at 334 Badger Ave., Newark, N. J.

The Easton Coil Mfg. Company, formerly of Keplers, Pa., is moving its factory and executive offices to 22-17 41st Ave., Long Island City. Already part of the equipment has been set up, and all manufacturing operations of Easton will be located there after May 1.

Goat Radio Tube Parts, Inc., 33 35th St., Brooklyn, N. Y., has recently announced the addition of J. Grabosky to its sales engineering staff. Mr. Grabosky was formerly with the Westinghouse Lamp Company, and also has had a varied experience with other tube manufacturers.

Consolidated Wire & Associated Corporations, formerly at Green and Congress Sts., Chicago, Ill., has announced the removal of its offices, factory and warehouse, to 212 South Peoria St., Chicago, Ill. This company specializes in the needs of jobbers and manufacturers who are users of various types of electrical and radio wires and cordages.

The Central Radio Corporation, Beloit, Wis., announces that it has completed arrangements for the manufacture of radio sockets in the Dominion of Canada, for the Canadian trade. The sockets will be manufactured by Hale Brothers, Ltd., Montreal, Que. Hale Brothers' head office and factory are located at 6224 Chambord St., Montreal, Quebec.

The International Resistance Company, 2006 Chestnut St., Philadelphia, Pa., announces completion of its plant at 74 Wellington St. W., Toronto, Canada, for serving the Canadian trade. The International Resistance Company, Ltd., will manufacture all types of resistors produced by the parent company in Philadelphia.

The Grigsby-Grunow Company, Chicago, Ill., has announced the appointment of V. D. Landon, formerly of Radio Frequency Laboratories, to head up the development work on Majestic radio receivers. Mr. Landon was directly responsible for the major development work on the radio frequency and intermediate frequency end of Majestic models 20 and 60.

BOOKS ON ELECTRONIC SUBJECTS

Conduction of eletricity through gases

By K. G. Emeléus, New York, E. P. Dutton & Company, 94 pages. Price $1.10.

IN VIEW OF THE increasing importance of the subject of electrical conduction through gases and in low vacua, in the variety of modern applications of vacuum tubes, X-ray tubes, photo-electric cells, etc., this comprehensive review of the latest theories becomes of particular interest. The book is not intended as a popular work, but will be clear and readily intelligible to the physicist and electronics engineer who has a special concern with vacuum tube topics.

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Cases on the motion picture industry

Harvard Business Reports, Volume VIII., 687 Pages, published by McGraw-Hill Book Company. Price $7.50.

THIS VOLUME INCLUDES 66 cases on the business aspects of the motion picture industry. These cases were selected for publication by Prof. Howard T. Lewis from among the large number collected under his direction. The cases in the present volume represent a comprehensive survey of the leading business problems which the motion picture industry has to meet. The book takes up such problems as: The unsuccessful attempt to unionize motion picture players; regional exchanges expanded through purchase or organized national exchanges; copyright infringement; consolidation of competing companies to reduce production costs; survey to determine profitable theatre location; adoption of consumer advertising; change in theatre program caused by musicians' wage demands; sound equipment; failure of cooperative purchasing association; operating procedure of production department; basis changed from flat rental to percentage for superspecial picture; sound picture development coordinated with silent pictures; acceptance of percentage basis for motion picture rental.

While this volume is intended for executives, and managers in the motion picture industry, it will prove extremely valuable and instructive to engineers in this field. The reader will find the cases treated in a very interesting manner. Practically all producers of motion pictures in this country are represented. The significance of the motion picture cases is by no means limited to those whose chief interests lie within the industry; the cases should have meaning for all concerned with the general conduct of business enterprise.

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Telephone theory and practice

By Kempster B. Miller, M.E., Consulting Engineer; McGraw-Hill Book Company, New York; 471 pages. Price $5.00.

THE THEORY and elements of telephony are described in this volume, the first of a three-volume series which is intended to present a comprehensive picture of the art. The two volumes to follow will deal with the telephone exchange, and lines and transmission. The author, as consulting engineer, has had an unusual opportunity to observe and record the progress of the Bell system from its beginnings to the almost incredible complexity of its present organization. Following the introduction, which details in a very interesting manner the development from earliest times of communication at a distance, and outlines broadly the present system, the author enters into the discussion of the telephone art by a series of three chapters dealing with the fundamentals of sound, and a chapter on voice currents which includes the elements of electricity. In the succeeding chapters vacuum tube theory and magnetic materials are considered. The remainder of the book deals with the elements of apparatus: that is, the essentials which are component parts of many different kinds of apparatus. These include wires, coils, resistors, condensers, cords, and contacts, with a separate chapter devoted to each.

This work is mainly non-mathematical, intended, however, as the author says in the preface, "not only for the student and the beginner in telephone work, but also as a general reference text for the more advanced.

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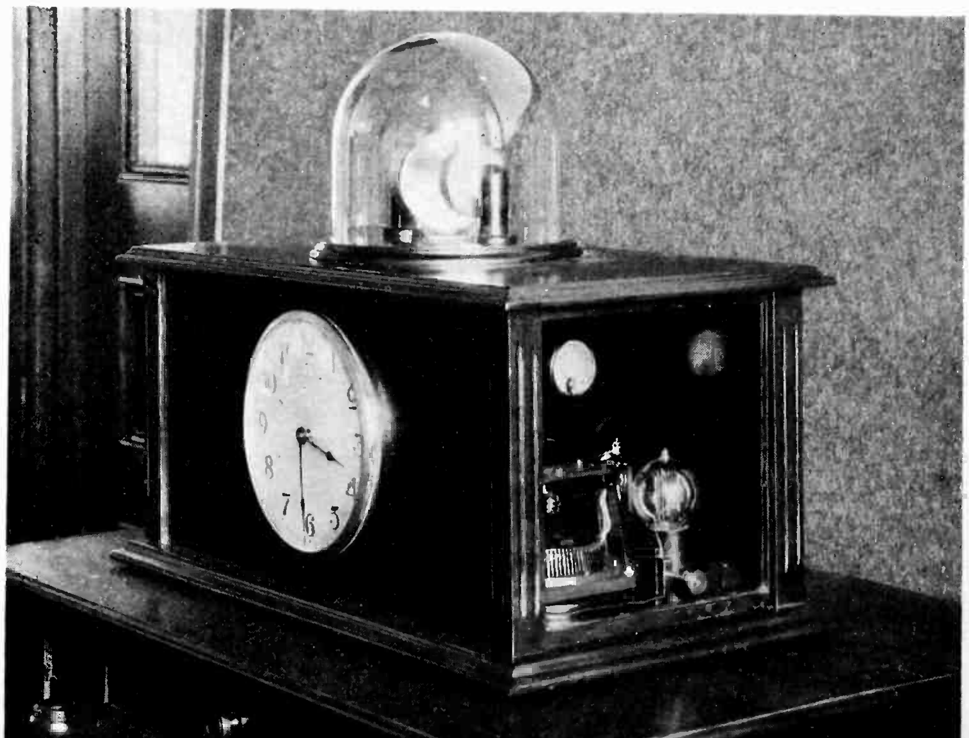
THE CRYSTAL ELECTRONIC CLOCK



Accuracy within one one-hundredth of a second per day is attained by this crystal-controlled mechanism, developed by Dr. W. A. Morrison, Bell Telephone Laboratories. The crystal oscillates at 100,000 cycles, and its impulses are delivered through a sub-multiple circuit to the synchronous clock motor

+ NEW PRODUCTS

THE MANUFACTURERS OFFER

Molded products in pastel colors

AFTER A CONTINUOUS SERIES of experiments, General Plastics, Inc., 1 Walck Road, N. Tonawanda, N. Y., has announced a line of Durez products in pastel colors. Twenty-two solid shades, and a wide range of mottled and striated effects gives the manufacturer an exceptionally large field to choose from. Durez pastel colors will be available in old ivory, light blue, gray, pink, green and yellow. Other colors will follow as demand warrants. While slightly slower in the molding process, Durez pastels can be molded under similar conditions and with the same equipment by which standard materials are handled. This material is resistant to acids, to moisture, gases and alkalies.—*Electronics, May, 1931.*

Voltage control for sound equipment

A MANUALLY OPERATED line-voltage control unit of convenient size has just been announced by the American Transformer Company, 178 Emmet St., Newark, N. J. It is designed to maintain the input power to the amplifier at a constant and its rated voltage. This unit is particularly necessary where line

voltages are subject to fluctuations. It consists of an adjustable auto-transformer with a meter for indicating the voltage supplied to the power circuits of the amplifier. The device will permit of maintaining the voltage at a constant value of 110, or 115 volts, as desired, and may be used where the existing supply is between 90 and 130 volts Adjustment is made by a special multipoint switch, which increases or decreases the potential in 5-volt steps.—*Electronics, May, 1931.*

Sound-picture amplifier

DESIGNED ESPECIALLY FOR use with sound-on-film equipment used in conjunction with a phototube of the caesium type, is the 408 amplifier made by Operadio Manufacturing Company, St. Charles, Ill. It is a portable type and is completely a.c. operated. This amplifier does not require an additional PEC amplifier, but takes its input energy direct from the phototube. It also furnishes

the necessary voltage for the phototube, as well as the filament for the exciter lamp. There are no batteries required in the operation of this amplifier. The dimensions are 19 in. wide by 21 in. high, by 8 in. deep. It may be put in a convenient carrying case; or it may be mounted on the wall of a projection booth between projectors.—*Electronics, May, 1931.*

Pentode for battery-operated receiver

THE RCA RADIOTRON COMPANY, Harrison, N. J., has just announced its power amplifier pentode for use in the power output stage of battery-operated receivers designed especially for it. This new tube (RCA-233) is capable of delivering to the loud-speaker a relatively large amount of power for small imput signal voltages. The filament employed is of the coated ribbon type, and consumes as little power as possible, consistent with satisfactory operating performance. The low filament current drain makes this tube particularly applicable for use in combination with the RCA-230, or the RCA-232 in sets where the economy of current consumed is an important factor. This tube is not interchangeable with any other existing type of RCA-Radiotrons.—*Electronics, May, 1931.*

Red sensitive photoelectric cells

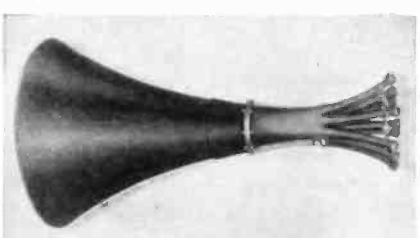
THE CABLE RADIO & TUBE CORP., 84 N. 9th St., Brooklyn, N. Y., has recently announced a series of photoelectric cells of caesium and silver-oxide highly sensitive in the red region of the photoelectric spectrum. By a special treating process, sensitivity of these cells has been increased to a value in excess of 100 microamperes per lumen. Uniformly high sensitivity has made it possible to supply these cells with a somewhat higher ionizing voltage than heretofore. This allows greater latitude in pick-up adjustment, as well as minimizing damage to cell from accidental ionization during adjustment. Vacuum cells are also manufactured to special order, if desired. The new cells are available in a variety of sizes and shapes to fit any sound film equipment. —*Electronics, May, 1931.*

Automobile pentode tube

SYLVANIA PRODUCTS COMPANY, Emporium, Pa., has announced the SY-238 automobile pentode tube, which is an output pentode designed to give increased output over that obtainable by use of the 171-C tube, made by this company. The same heater cathode construction is employed, as used in the other tubes of this series—*Electronics, May, 1931.*

Nine unit aeroplane horn

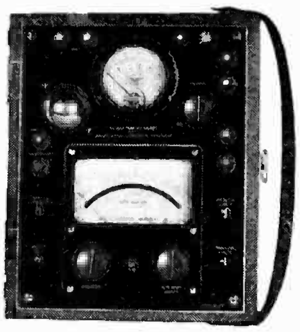
A SUPER-POWERFUL loudspeaker, designed to operate with nine receiver units, has been announced by Racon Electric Company, Inc., 18 Washington Place, N. Y. The bell is 30 in. round,



with an overall length of 54 in. This horn is especially designed for aviation fields, and public address equipment for extreme long range projection. Three miles audibility is claimed. The horn is storm-proofed, and has a metal-beaded edge and heavy aluminum throat section, with loose couplings for individual units. It is demountable, and weighs 48 lbs.—*Electronics, May, 1931.*

Vacuum tube voltmeter

A PORTABLE VACUUM tube voltmeter that meets the need for a permanently connected instrument of this type, is manufactured by the Jewell Electrical Instrument Company, 1642-U Walnut St., Chicago, Ill. It is arranged to measure a wide range of potentials, and



is especially suited for application where potential measurements must be made without any current drain. Either an 01A, a '12 or a '40 type tube may be used in this device. The unit consists essentially of a d.c. voltmeter with scale ranges for measuring A, B and C voltages, and a 0-200 microampere instrument for indicating changes in plate current.—*Electronics, May, 1931.*

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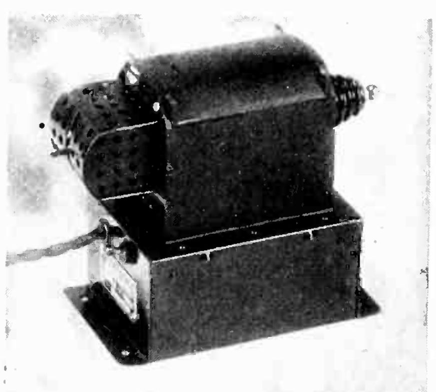
Short-wave oscillator

MODEL "E" OSCILLATOR, announced by Lepel High Frequency Laboratories, 39 W. 60th St., New York City, is of the quenched gap type, having tuned and loosely coupled primary and secondary high frequency circuits. It consists of a 60-cycle step-up transformer, two common lever adjustable tungsten gaps, two mica condensers, a high frequency transformer, and the necessary switching and housing mechanism. It is designed for continuous operation. Input: 60 cycles, 110 volts, .35 amperes. Output: approximately 2500 kc., E-maximum—1 in. spark, I-maximum—100



m.a. It can be adjusted from 10 per cent to maximum output. As gas or leak indicator in conjunction with lamp or radio tube production on automatic exhaust, the short-wave output of this oscillator makes possible keener gas indication, and reduces puncturing of glass.—*Electronics, May, 1931.*

Mercury vapor rectifier

AUDION, 575 MERCURY VAPOR RECTIFIER, announced by the DeForest Radio Company, Passaic, N. J., is an intermediate power half-wave mercury vapor rectifier designed especially for use in circuits when the inverse peak voltage is greater than Type 572 will normally handle. As indicated under its rating, there are two fundamental limitations on the operation of Audion 575. These are the maximum peak inverse voltage of 15,000 volts, and the maximum peak plate current of 2.5 amperes. A standard "50"-watt base is employed, and the approximate diameter of the bulb is 4 in. and overall height 9 in. Net price, $30.—*Electronics, May, 1931.*

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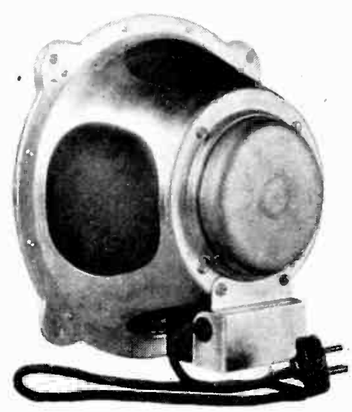
Midget dynamic reproducer

THE PETER SMITH STAMPING COMPANY, Fordson, Detroit, Mich., has announced a dynamic speaker, especially designed for midget receivers. The cone is clamped to the cone bracket with a one-piece, U-shaped clamp, and spe-



cial gasket, to eliminate possibility of rattles. A sufficient number of rivets is used to give further guarantee of clamping of the cone edge. The cone of this reproducer is one-piece, molded of special fiber which is extremely light. The voice coil construction is rigid, and a special method of manufacture is used to keep it concentric. The transformer is mounted on a special bracket, and the terminal board is mounted on the transformer itself.—*Electronics, May, 1931.*

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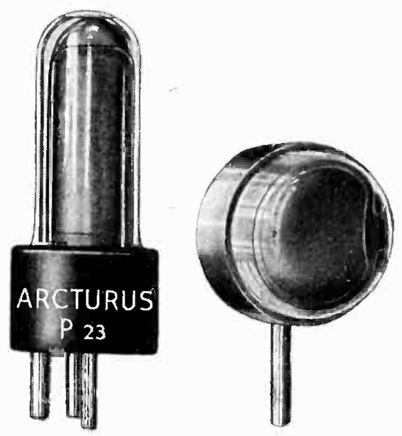
Potentiometer for sound systems

A LINE OF RHEOSTATS especially designed for sound picture, public address and other units requiring especially heavy duty use has been developed by De Jur-Amsco Corporation, 95 Morton St., New York City. These units are designed for ratings as high as 75 watts in single units, and 150 watts in tandem units. Practically any ohmic range can be furnished for this line of rheostats.—*Electronics, May, 1931.*

Photolytic cells

IN ADDITION TO THE Type P-4-A Photolytic cell, the Arcturus Radio Tube Company, Newark, N. J., has recently announced a Type-P23, and a Type P27 Photolytic cells, of special design. These cells can be most efficiently operated into impedances between 500



and 1,000 ohms for talking motion pictures or dynamic circuits. This permits the use of a high gain transformer for coupling to the first tube. These cells claim lack of microphonicness, background noise, and photo-cell hiss.—*Electronics, May, 1931.*

✦

Tube component parts

KEEPING IN STEP with the latest trends in types of radio tubes, Goat Radio Tube Parts, Inc., Brooklyn, N. Y., is turning out elements for the variable-mu., 6-volt and pentode tubes, the 235, 236, 237, 238 and 247 tubes. This company recently prepared a loose-leaf catalog for listing all component parts required in tube construction, copies of which will be furnished responsible engineers.—*Electronics, May, 1931.*

✦

Caesium photoelectric cell

AN IMPROVED TYPE of photoelectric cell is announced by Western Electric Company, 50 Church St., New York City. This cell replaces previous types, and uses a caesium compound as the photoactive element, instead of a preparation of potassium, as used in two earlier cells. The caesium oxide is coated on a half cylindrical electrode and a small vertical rod forms the positive electrode. This cell is highly sensitive to radiation within the spectrum range produced most abundantly by the exciting lamp—namely, yellow, red, and infra-red. The average output claimed for this cell is 20 db. higher than for the 1A or 2A cell previously furnished. The response from the cell being greater, the amplifiers can be operated with reduced gain, thus reducing the volume level of any noise-producing elements within the system.—*Electronics, May, 1931.*

Sound-on-film for home movies

[*continued from 622*]

draws the film over the slit block past the optical image *C* of the physical slit in the optical system, and thence feeds it to reel *E*. The light passes through the film and the aperture in the slit block to phototube *F*. The electric vibrations of the phototube pass through a suitable amplifier *G*, the output of which is fed to glow lamp *H*. The resulting light intensity variations pass through the optical system *I*, and are focused on the 20 mm. film at *J*. The 20 mm. film is drawn from reel *K* by the pull-down sprocket *L*. Sound sprocket *M* draws the film past the optical image of the physical slit in the recorder optical system which results in exposure of the sound track on this film and it is then fed to take up reel *N*. Thus the sound track of the 35 mm. film is re-recorded on the 20 mm. film. Assuming that the starting points have been properly marked, both films are placed in an optical reduction printer with the sound tracks masked o from the light source. These films are then run through so that the 20 mm. film may be exposed to the picture also.

After proper development we have a 20 mm. negative duplicate of the 35 mm. positive print. In order to obtain positive prints from this negative, it is necessary to place the negative and unexposed positive film in direct contact, emulsion to emulsion, in a continuous contact printer with the negative film between the unexposed positive and the light source. Under these conditions they are run through twice. The first time the picture is masked off and the sound track exposed. The second time the sound track is masked off and the picture exposed. This is the usual practice in 35 mm. production. The technique of exposure, volume compensation, and development is similar to standard 35 mm. work and requires no special treatment.

Designing projection equipment

Having a satisfactory positive print, the difficulties involved in projection have to be considered. The most serious of these is variation in speed of the film, due first to motor speed variations, and second to eccentricities of gears and sprockets. Any periodic variation in the angular velocity of the sprocket or even small rollers over which the film is made to ride after passing the slit block will cause a serious waver in the tones and produce a very unpleasant effect. To make matters worse, the limits of mechanical accuracy are again encountered in these mechanisms. For a given error in a sprocket or gear, the absolute value of the error is the same for both the 35 mm. and 20 mm. films. This means that the effect would be increased two and one-half times for the latter over the former. With certain precautions, however, these errors can be brought to the point where they are apparently ineffective. Another point to be considered is the elimination of the usual pull-down sprocket. This is essential and consistent with the desire to adhere closely to present manufacturing standards. The top sprocket of the projector must serve a double purpose in this case. The usual difficulties are transient loads suddenly applied at this point when the inertia of the film and reel has unwound the film sufficiently to provide slack. When the slack is taken up there is present a sudden pull on the reel; in other words, the instantaneous acceleration is very great. This force is supplied by the sprocket through the film as a medium and presents a heavy load to the motor and a severe strain on the film. To help offset this condition a source of inertia in the form of a small fly wheel interposed between the sprocket and the upper film reel and driven by the film can be utilized. Mechanism designed for this purpose is shown in Fig. 3. The slack

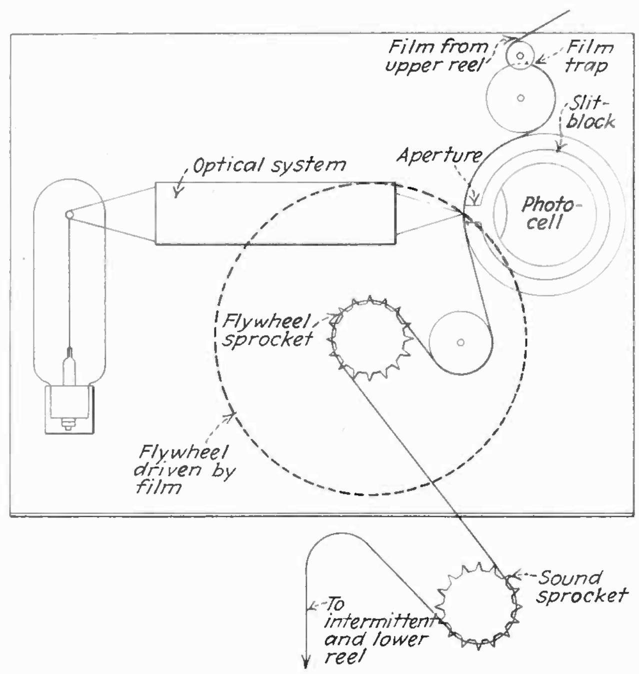


Fig. 3—Projection equipment used for sound-on-film reproduction with film driven flywheel to maintain constant velocity

in the film as described, would also have a tendency to push that part of the film close to the slit image out of focus. To overcome this we have merely to insert a form of trap between the film reel and the slit block.

Concerning the electrical system, both the gas and liquid type of phototube have been used. Each has its advantages and disadvantages, relatively speaking, but one outstanding feature of the liquid type is the complete elimination of tube "hiss" and the absence of microphonicness due to the physical vibration of the projector. The latter is particularly difficult to overcome in small home projectors.

A very neat compact and efficient amplifier has been used utilizing two '24-type tubes for voltage amplifiers in cascade feeding into a single '45-type tube. With this arrangement a gain of about 70 db. can be easily realized and the resultant volume should be more than sufficient for average home use.

▼

EIGHT or nine companies already have sound-on-disk equipment on the market for home use and seven film companies have made available hundreds of educational and entertainment pictures. Successful production of sound-on-film equipment will give the home movie market a great impetus. ***—The Editors.***

▲

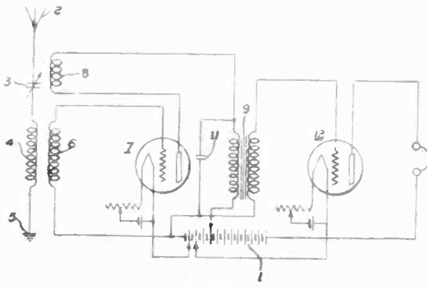
PATENTS

IN THE FIELD OF ELECTRONICS

A list of patents (April 28) granted by the United States Patent Office, chosen by the editors of *Electronics* for their interest to workers in the fields of the radio, visio, audio and industrial applications of the vacuum tube

Modulation, Detection, Generation, Etc.

Grid bias battery. A patent filed in 1923, and granted to William E. Brindley, assigned to Westinghouse E. & M. Co., showing a tapped battery, one end of which supplies positive potential to the plate of two tubes, the other end of which supplies the negative grid bias and intermediate points of which are attached to the respective cathodes. No. 1,801,843.



Coupling system. A transformer used to couple the input of one tube to the output of another, a means being provided for controlling the ratio of energy transfer at a given frequency, without affecting the tuning of the coupling method. This means is a resistance in series with the tuned circuit in the output of the first tube. F. A. Kolster, assigned to Federal Tel. Co. No. 1,801,352.

Neutralized r.f. amplifier. A high-frequency amplifier having an intermediate divided anode circuit, including a pair of spaced coupling coils to neutralize the overall regeneration of the amplifier. W. L. Carlson and K. A. Chittick, assigned to G. E. Co. No. 1,801,138.

Harmonic suppressor. Signalling system consisting of a high frequency generator connected to an antenna system through a series of acceptor and rejector circuits, eliminating objectionable side frequency harmonics, etc. F. Gerth and Fritz Gutzman, Berlin, Germany. No. 1,800,996.

Inter-stage coupling system. A method connecting two tubes together through a common impedance which includes a liquid cell. W. L. Edison, assigned to W. L. Edison Mfg. Corp., Wilmington, Del. No. 1,800,821.

Three-phase wired radio. A method of receiving a 3-phase wired-radio program by effectively adding vectorially the current components in the 3-phase system upon the rectifying device. R. D. Duncan, Jr. Assigned to Federal Tel. Co. No. 1,800,820.

Piezo crystal circuit. The grids of two tubes are connected in parallel across the piezo crystal. The plates of the tubes, however, are supplied with alternating current of opposite phase relation. F. B. Monar, Washington, D. C. No. 1,795,343.

Frequency adjuster. Mechanical methods of adjusting the frequency in a high frequency signalling system. C. L. Davis, assigned to Wired Radio, Inc. No. 1,796,863.

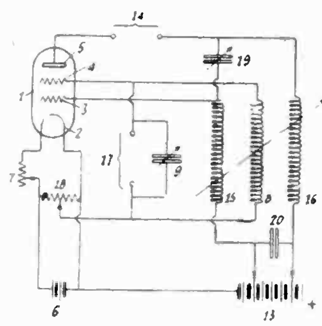
Piezo-electric crystal apparatus. A mechanical method of mounting crystals for exciting them electrically. J. R. Harrison, assigned to RCA. No. 1,796,650.

Rectifying system. A relay circuit for use with double wave rectifier. A. Weaver, assigned to A. T. & T. Co. No. 1,796,497.

Signalling system. Two antennas adjacent, connected to two sources of high frequency energy of different frequencies. One antenna system is connected to the other with sufficient inductance to substantially neutralize the mutual capacity existing between antennas. E. F. W. Alexanderson, assigned to G. E. Co. No. 1,797,039.

Frequency eliminator. A combination of a wave filter having a flat transmission characteristic for frequencies above some value, and variable attenuation characteristics for frequencies below combined with a piezo electric device having a natural frequency adjacent to the determined frequency. E. I. Green, assigned to A. T. & T. Co. No. 1,794,847.

Four-electrode tube signalling system. A space-charge grid with high potential, connected to the anode supplied through an impedance, the usual grid being connected to the cathode through a second impedance coupled to the first impedance. A. F. Nozieres, Paris, France. Filed September 11, 1924. No. 1,794,708.



Amplifier. Conventional circuit in which the operating potentials on the input and output electrodes are so proportioned for a given peak amplitude of input wave to control the ratio of output modulation component to output fundamental component, both magnitudes being proportioned with respect to the external output resistance to control the output of useful component. Eugene Peterson and H. P. Evans, assigned to B. T. L., Inc. No. 1,800,901.

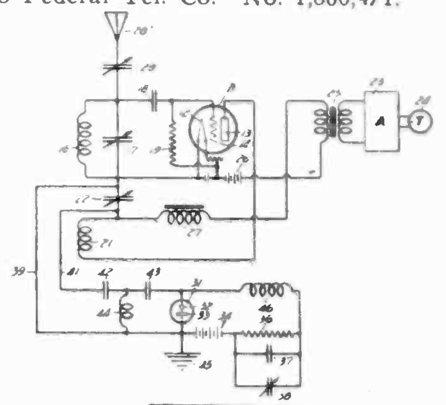
Wave trap. Circuit for eliminating a current of interfering frequency comprising a Wheatstone bridge circuit. Wilhelm Stappmann, assigned to C. Lorenz, Berlin, Germany. No. 1,800,962.

Oscillator-modulator system. One tube supplies modulation for the grid of the power tube, and another tube supplies deficiencies in the grid current. Gunther Jobst, assigned to Gesellschaft für Drahtlosie Telegraphie, Berlin. No. 1,800,536.

Frequency translating circuit. Push-pull modulation system in which the output common portion has a high impedance to the frequency of one of the waves. H. S. Black, assigned to B. T. L., Inc. No. 1,800,372.

Radio-frequency amplifier. A triode tube circuit in which is a series impedance common to both input and output, resonant at a frequency at the lower limit of the desired band of frequencies to be transmitted. E. O. Farnham and Raymond Asserson, assigned to R. F. L. No. 1,799,093.

Modulating system. A method involving a cold gas tube which has its resistance varied. A. T. Overacker, assigned to Federal Tel. Co. No. 1,800,471.



Volume control. A double volume control means for a tuned r.f. amplifier which simultaneously varies the voltage applied to the input of the receiver, and the resistance of a tuned section so that the selectivity remains substantially constant. Burke Bradbury, assigned to G. E. Co. No. 1,799,000.

Transmission system. An attenuation equalizer and circuit constants which produces a transmission delay on any frequency in the transmitter band less than a predetermined value. H. Whittle, and L. B. Hilton, assigned to B. T. L., Inc. No. 1,798,243.

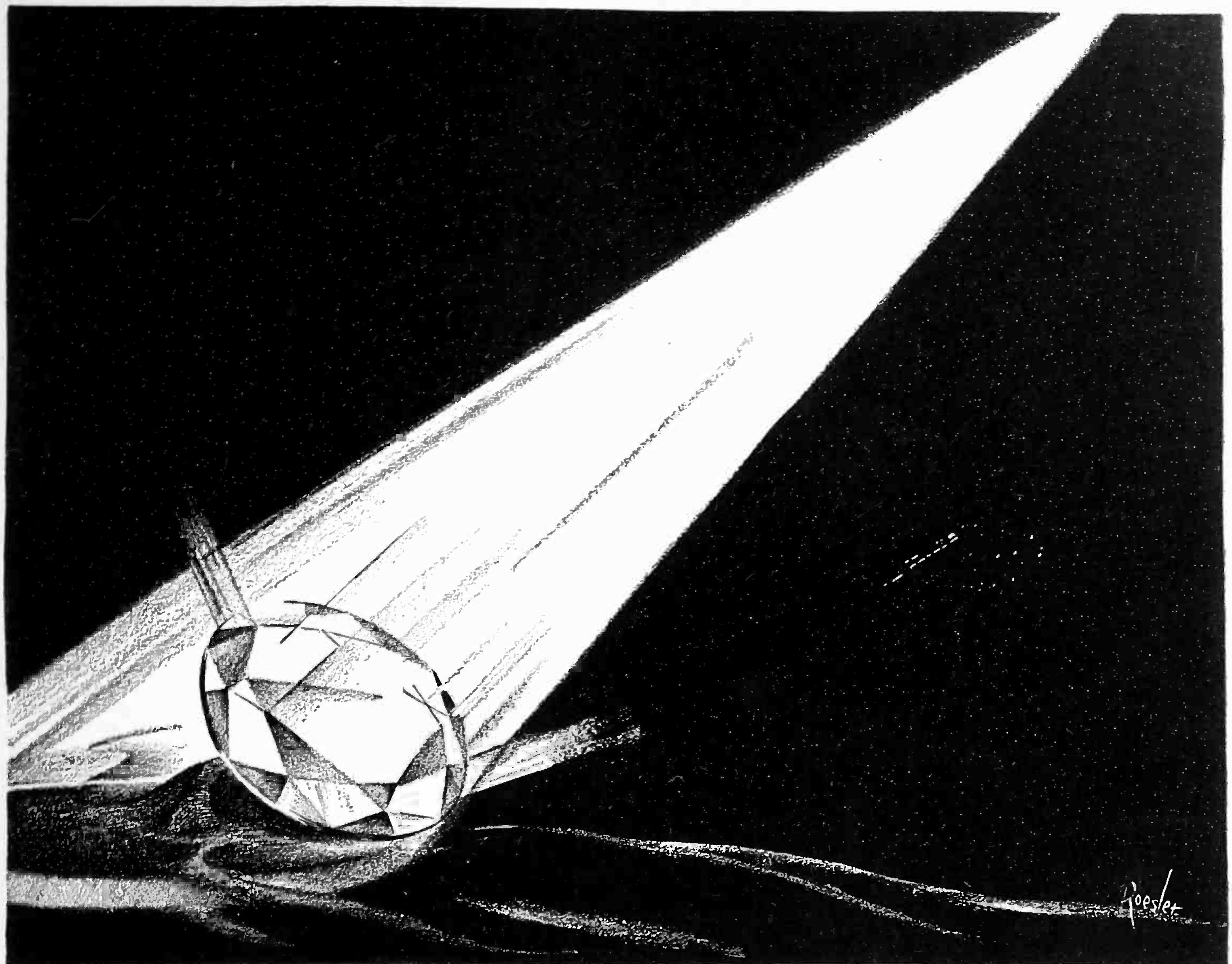
A method of observing objects in motion. A method by which the radiations from a transmitter are varied in accordance with one or more characteristics of a motion. At the receiving station these variations are analyzed to determine their characteristics. C. B. Townsend, New York, N. Y. No. 1,801,466.

Modulation system. Using a modulator having a variable amplification factor, and a variable internal resistance. The amplification factor is varied in accordance with modulations, and further modulation is prevented due to the variable internal resistance. F. B. Llewellyn, assigned to B. T. L., Inc. No. 1,802,118.

Transmitting system. A master-oscillator drives a number of intermediate power amplifiers which are connected to a common antenna. D. G. Little, assigned to Westinghouse E. & M. Co. No. 1,801,870.

Relay circuit. A circuit employing tetrodes and a pentode controlling relays whereby operation of one relay affects the circuit so that another relay is blocked. Anton Buyko, Berkeley, Calif. No. 1,801,657.

[continued on page 658]



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Electronics

Patents—

[*continued from page 658*]

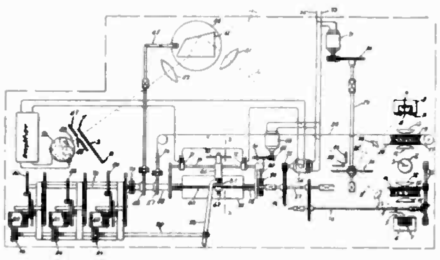
Facsimile transmission. A method of illuminating the picture surface, separating it into units and transmitting it. R. H. Ranger, assigned to RCA. No. 1,789,687.

Electronic Applications

Remote control system. A patent filed on April 11, 1929, involving 32 claims, the first of which involves "in combination a means for executing a sequence of movements so as to produce a continuous sequence of audio impulses of successive frequencies corresponding thereto, and a means actuated by said audio impulses for producing similar graphic recording movements." M. B. Sleeper, assigned to Sleeper Research Laboratory, Inc. No. 1,800,760.

Testing magnetizable objects. A circuit not involving electronic tubes, but of interest to workers in this field. C. W. Burrows and E. S. Dimes, assigned to Magnetic Analysis Corp., Long Island City. No. 1,800,676.

Mechanical integrating device. A photo-electric method of determining the spectral composition of a source of radiant energy. A. C. Hardy, assigned to G. E. Co. No. 1,799,134.



Radio direction finder. An oscillating circuit direction-finder. Fred Woods, assigned to R.C.A. No. 1,798,714.

Vacuum Tubes, X-Rays, Photo-Cells, Etc.

Electron tube. Potential difference is supplied to the internal electrodes of a tube and an electrostatic force to the exterior terminals, so that one of the interior electrodes emits electrons. W. J. Winninghoff, assigned to G. E. Vapor Lamp Co. No. 1,799,345.

Neon lamp stroboscope. S. A. Staege, assigned to Westinghouse E. & M. Co. No. 1,799,993.

Filament substitution system. In an exciter lamp, two filaments are provided, and a means for throwing one into the circuit when the other fails. E. G. Ramsey, assigned to W. E. Co., Inc. No. 1,800,903.

Facsimile system. A means for changing the path traced by a scanning system from parallel scanning to cross screen scanning, and vice versa. R. H. Ranger, assigned to RCA. No. 1,800,357.

Photo controlling arrangement. A method involving vacuum tubes for controlling the motion of a motor. R. H. Lindsay, assigned to A. T. & T. Co. No. 1,800,303.

Inductively-heated cathode-triode. A method of heating a cathode by an inductor coil. J. Slepian, assigned to Westinghouse E. & M. Co. No. 1,799,992.

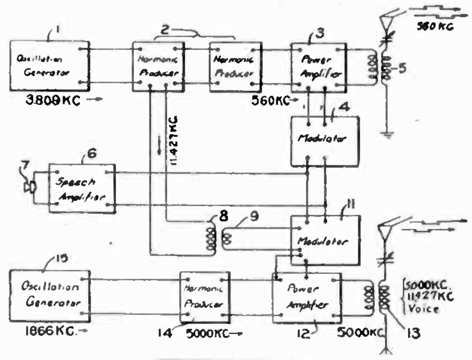
Electron emission elements. A cathode containing a mixture of ferrosoferric oxide, chromic oxide and strontium oxide fused and in an electrical device of low pressure. Samuel Ruben, assigned to Ruben Patents Co. No. 1,799,645.

Radio Circuits

A.C.-D.C. system. A method of switching a radio receiver and power supply from an a.c. to a d.c. circuit. Alexis Poncel, Long Island. Assigned 49 per cent to Paul DesFosse, Brooklyn. No. 1,801,022.

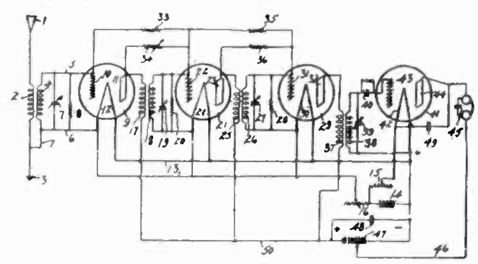
Direction finder. F. A. Kolster, assigned to Federal Tel. Co. No. 1,800,455.

Remote control system. A modulated wave is transmitted to a radio station whose output is to be varied. A control frequency transmitted to the distant station governs the radiation frequency and the signal modulations determine the amplitude of the radiated frequencies. F. B. Falknor, assigned to Westinghouse E. & M. Co. No. 1,799,976.



Multiple broadcasting system. Simultaneous transmission of news throughout a given area by means of short waves of different frequencies, so chosen that the sum of their zones of incidence will cover the total area to be supplied. Walter Hahnemann, assigned to C. Lorenz. No. 1,798,415.

Radio circuits. In a radio frequency amplifier, the grids of adjacent tubes are connected together by resistances, and the plate of one tube is coupled to the grid of the following tube through its normal inter-stage circuit, as well as by resistances. Wolff Kaufman, assigned to Samuel Darby, Jr. No. 1,799,169.



Acoustic treatment for sound-picture theaters

[*continued from page 627*]

32 feet was very unsatisfactory to the ear as the trace indicates to the eye.

Careful study of this condition revealed the fact that the low frequency components were shifted along the time axis by a different amount than that of the high frequency components. This undesirable distortion can be traced eventually to the variation of the diffraction of sound with change in frequency. Further research is now in progress along this line which will prove to be very important.

Another oscillogram is shown in Fig. 5. The lower trace represents the speech as it came out of the horn of a talking picture theater. At the eleventh row in the orchestra the sound was somewhat changed as indicated in the upper trace. Distinct echoes are in evidence as well as the usual reverberation. Here, again, the low frequency reverberation predominates.

A multiplicity of echoes is often caused by large domes. A record of such a condition is reproduced in Fig. 6. In addition to a dome-to-floor system there is superposed a lateral wall-to-wall system. The latter type of echo is often encountered in auditoriums which have large flat and parallel walls, with and without the domes.

It becomes evident that, if the next big advance in acoustics is to be entirely successful, it must be made with the aid of adequate testing equipment which will make an accurate diagnosis possible. Having determined the existing acoustic condition it is a much simpler task to make an effective cure by not only adjusting the reverberation at 512 cycles per second but also by adjusting the balance at other frequencies over the range important to speech, according to the requirements of the particular auditorium which is to be improved.

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