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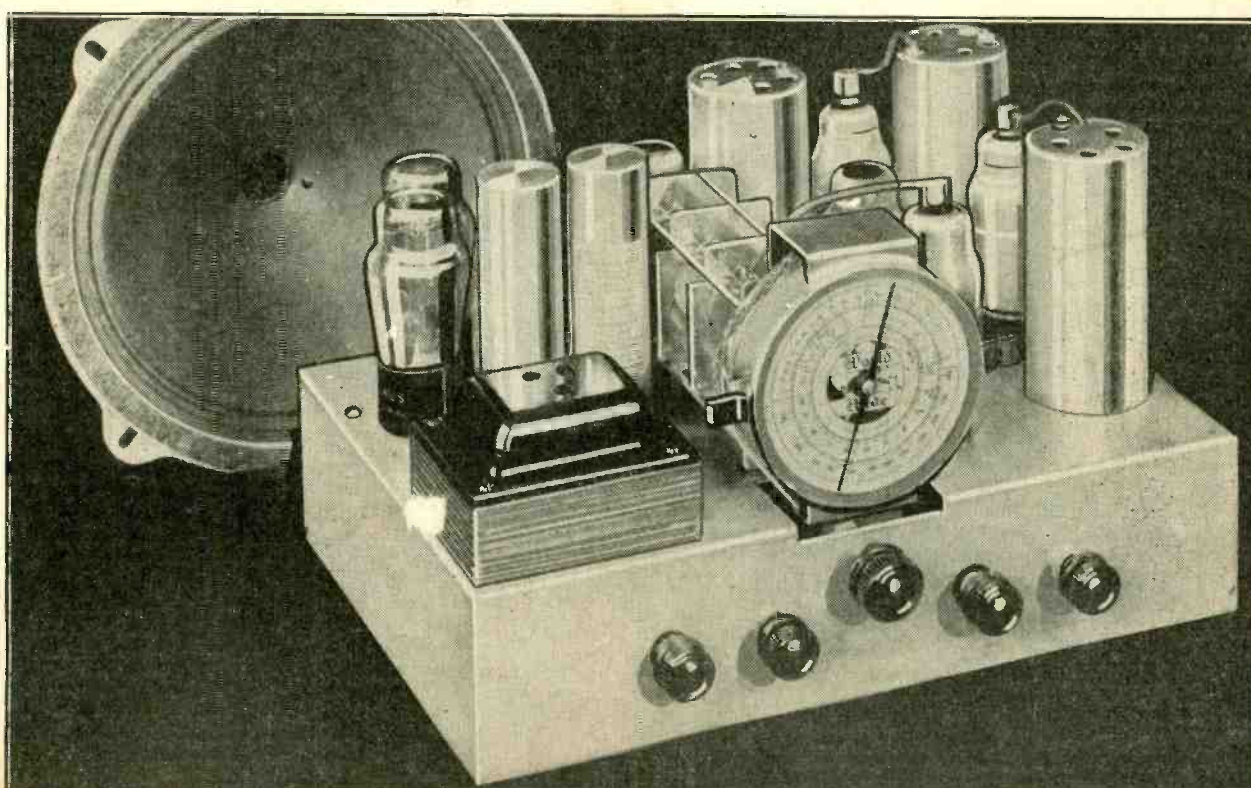

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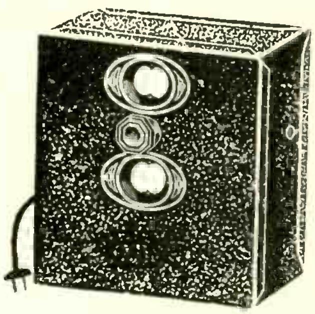

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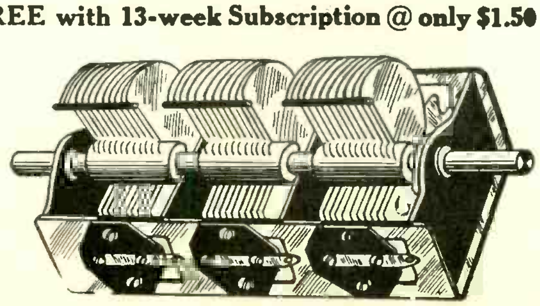

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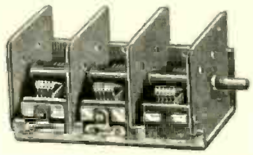

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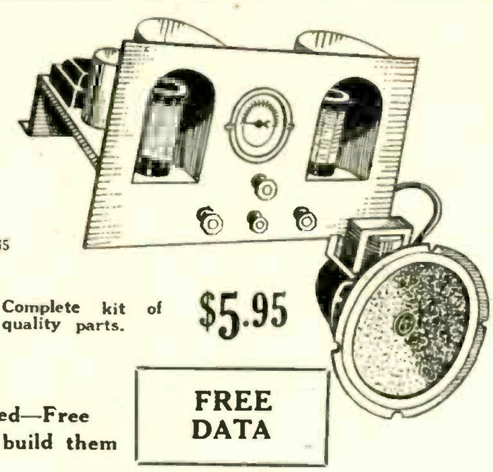

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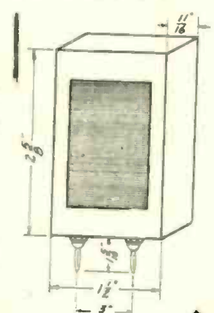

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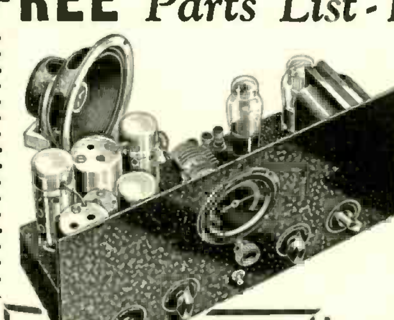

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Cathode Ray Television

A Primer of Some of the Considerations in Tube Use

By M. K. Kunins

THE facility of the use of the cathode ray tube for television purposes compared to mechanical television systems using discs or drums is obvious to those experimenters that have considered the tube for the purpose of television. To newcomers in this field it seems strange that the tube has not been more generally adopted for this purpose since it is free from inertial effects, is readily controlled, and is not cumbersome. Were these the sole considerations, the mechanical systems would indeed have been discarded. However, the cathode ray tube that is available on the market at this date has some very bad shortcomings. Nevertheless these may not be quite as bad as they seem, since the tubes are not especially designed for television purposes. By that is meant that these tubes have been marketed for the oscillograph trade where brilliancy of the image, coupled with large image size, is not as important as in television.

Here we have indicated a bad feature of the contemporary cathode ray tube. The image on the screen is not bright enough for television purposes. This statement should not be misunderstood, since the image is bright enough if a small picture, limited by the size of the tube's screen, is satisfactory. However, practically everybody desires a picture that can be projected on a movie type screen. And when this is done with the cathode ray tube image, it is found that the projected picture is very weak.

Man-Sized Tube

Of course we might construct a cathode ray tube with a screen that is large enough for our desire but that tube would certainly be unwieldy, higher than the normal height of a man, not to mention its exorbitant cost and thousands of volts. We are therefore forced to produce a brighter image upon a small tube to establish the practicability of the cathode ray tube.

Another shortcoming of the modern cathode ray tube is the green fluorescence of the screen material. Quite a few persons remark that everybody is accustomed to see pictures in black and white and so television pictures should also meet this requirement. That there is or is not merit to this argument will not be debated here. At any rate, the best plan is to attempt to satisfy these objectors. And so, these two points need consideration.

It will be noted that rectification of these shortcomings can be attained by the discovery of some substance or combination of substances that when bound together to form the cathode ray tube screen will produce a very brilliant black and white image that is capable of enlargement to a reasonable degree despite reduced illumination. This, of course, is a chemist's problem although some layman may be lucky enough to discover the formula and so found his fortune. Here is indeed a needed discovery that is worth much to the public. And so we await the suitable screen to convert the contemporary cathode ray oscillograph tube to the cathode ray television tube. But that inability of the modern tube need not prevent us from understanding the fundamental considerations involved in the use of such a tube for television purposes.

The Screen Material

Fundamentally, the cathode ray tube is applicable in television because of the electron gun (Fig. 6), which shoots a beam of electrons upon a screen that is composed of some chemical or combination of chemicals that fluoresce under an electronic bombardment and which lose this brilliance about as soon as the electronic influence is removed. The cathode ray tube screens that have been applied to oscillographs are composed of a mixture of calcium tungstate and zinc silicate, bound together by transparent water glass. This combination of electron gun and screen is productive of a good fluorescent spot upon the screen. To afford control of this spot over the expanse of the screen and thus build up a television picture, two sets of coils or plates are also included in the tube whereby either electrostatic or electromagnetic deflection of the beam in both horizontal and vertical directions on the screen is obtained. The fluorescent spot may be caused to move to any point on the screen by applying suitable voltages to the deflecting electrodes. For the sake of uniformity and simplicity, it shall be understood that electrostatic means (two sets of plates at right angles to each other) are used for deflection purposes and the diagrams are shown on that basis although the analysis is the same when electromagnetic deflection means is utilized.

Fig. 1 (next page) indicates, on the top, the screen of a cathode ray tube with the two sets of deflection plates indicated, one set for the "X" axis and one set for the "Y" axis. With no voltages on these plates the fluorescent spot on the screen will assume a position in the center as indicated in that sketch, provided there are no other stray potentials upon the bulb, etc., of the tube.

Moving the Beam

Now, suppose we apply an alternating sinusoidal voltage upon the X plates of the wave form shown in the second sketch of Fig. 1. Then at the different instances, labelled by the numerals, the spot will be deflected one way or the other from the rest position on a horizontal line depending upon the voltage and the polarity of the potential. Thus, the third sketch should be coupled with the second and it is found that at position 1 on the wave shape of the voltage, the potential is zero which is ineffectual in deflecting the spot so that the spot remains in the unenergized position. However at point 2, the right hand plate of the X plates becomes more positive than the left hand side so that the right-hand one attracts the negatively charged electron beam by an amount that is proportional to its potential difference. We have assumed that in this case this point is half the maximum voltage that will deflect the beam to either end of the screen so that the spot falls at a point that is half way between this maximum position and neutral position. Likewise in position 3, the spot will be deflected all the way to the right. In a similar manner, deflection of the spot to the left of the neutral position occurs during the negative portion of the cycle.

If the frequency of this alternating voltage is on the order of about 10 cycles per second or less, this spot will be clearly seen to move in the fashion indicated by these spots in a straight horizontal line at a speed proportionate to the frequency. Due to the slow speed with which this motion occurs, the individual spot will be readily visible. However, should the frequency of the alternating voltage be increased to 24 cycles per second or more, a defect in the eye known as "persistence of vision" will cause these individual spots to blend into one continuous line indicated in the fourth sketch of Fig. 1. Upon this defect in the eye is the gigantic industry of the motion pictures dependant as well as the new industry of television.

Two Directions

If the sinusoidal voltage shown in the sketch were applied to the Y plates alone, leaving the X plates unenergized in this instance, then a similar action will cause the spot to move in a vertical line as shown in the last two sketches of Fig. 1. The frequency considerations mentioned in connection with the X plates also hold for the Y plates so that it is desirable to have the frequency of the impressed voltage higher than 24 cycles per second if a line is desired rather than a clearly defined moving spot.

However, a moving spot in one straight line is not sufficient to reproduce a television image no matter what its frequency since a line is a one dimensional figure whereas a picture requires motion in two dimensions. Accordingly, we have to impress voltage on both sets of plates simultaneously, in order that a two dimensional picture may be produced. The kind of voltages that we impress on these plates are of extreme importance in order that the picture be most effectively produced so that we shall have to study the effect on the screen of the different types of voltages that might be used.

Suppose this sinusoidal voltage shown in Fig. 1 was applied to both sets of plates of the oscillograph tube. What would the image on the screen look like? If we refer to Fig. 2, it will be noted that the top sketch concerns such a set of conditions. These drawings show the cathode ray tube screen as a heavy circle with four heavy lines that are mutually perpendicular representing the deflector plates.

Within these lines, there is represented the image on the screen that results from the application of the voltage wave shapes depicted on the respective X and Y deflectors.

Frequency Doubled

The first sketch of Fig. 2 concerns the case just mentioned. It will be noted that the image is an inclined straight line. The angle that this line makes with the horizontal will depend upon the ratio between the voltages on the plates. When the voltages are equal, as is the case here, the line is inclined at a 45° angle. Of course, an inclined straight line is just as useless as a vertical or horizontal line obtained from one voltage for television purposes. So this combination of voltages is not to be considered.

Suppose we double the frequency of the voltage on the Y plates, then the image becomes a figure 8 if the X plates are supplied with the original voltage as before. Following this procedure through, of doubling the frequency of the Y voltage, it is seen that it is possible to cover the screen fairly well with the lines. However, it might be preferable to obtain an image that does not zig-zag back and forth in this manner. Also, with the

(*Continued on next page*)

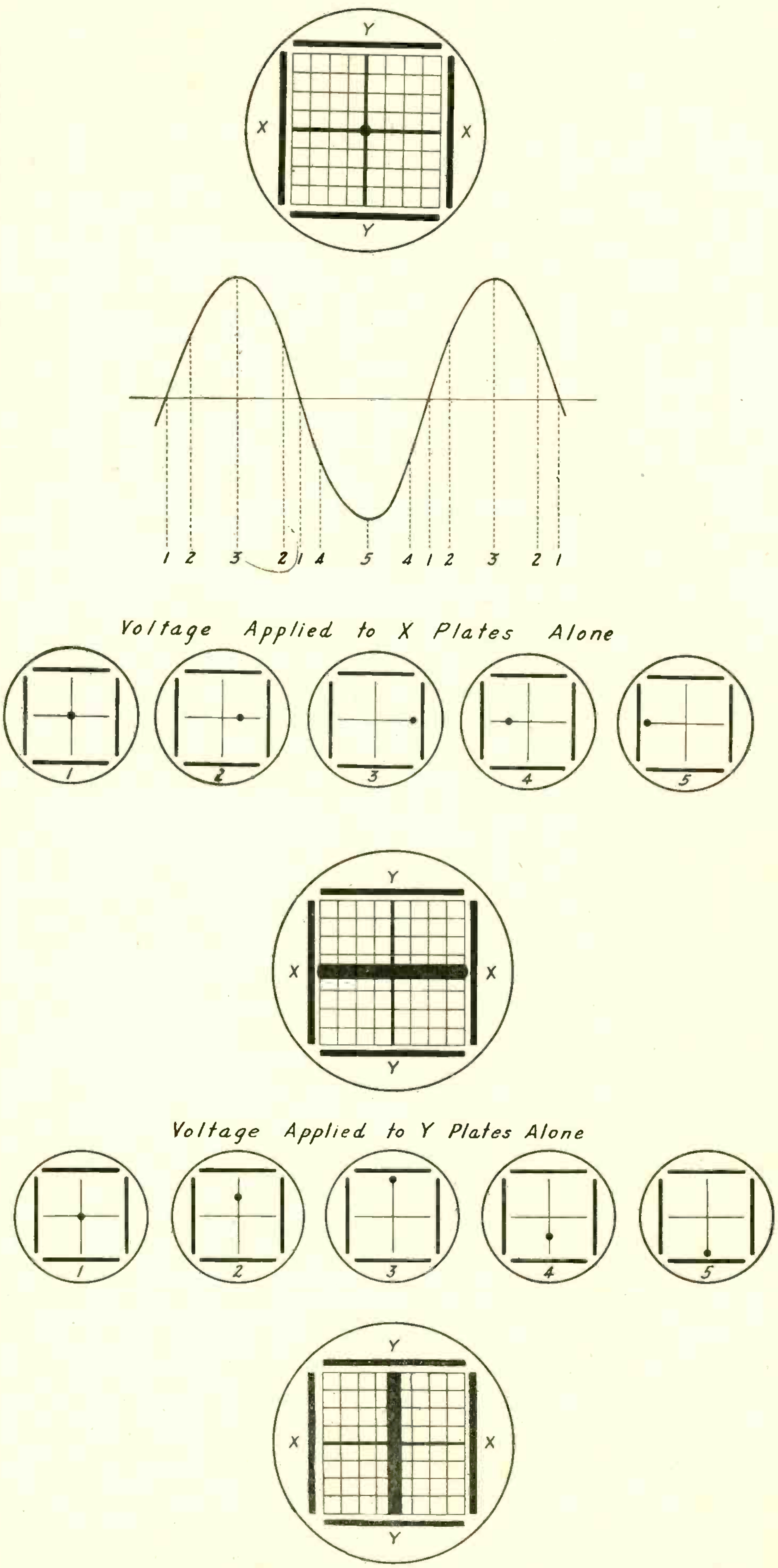


FIG. 1

The application of suitable voltages upon the deflector plates of a cathode ray tube causes the fluorescent spot upon the tube's screen to move in suitable directions.

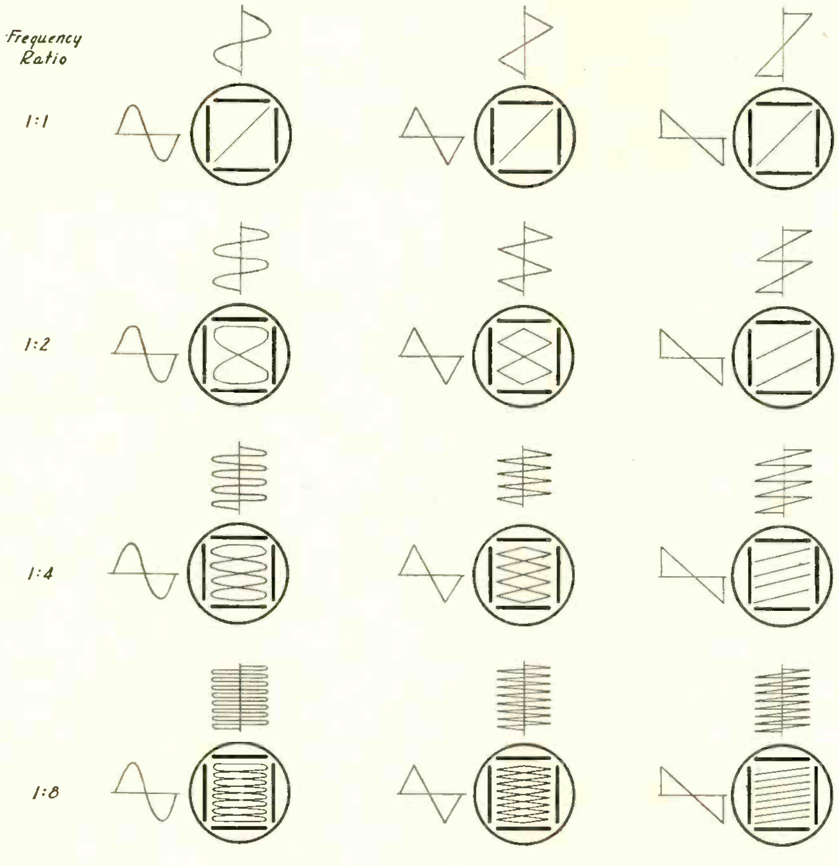


FIG. 2 FIG. 3 FIG. 4

The screen of a cathode ray tube is best scanned by using a saw tooth voltage upon the X deflector plates and a multiple of that voltage's frequency upon the Y deflector plates.

(*Continued from preceding page*)

sinusoidal voltages on the plates, the image brilliance is not uniform since the beam moves slower at the ends and thus affects the screen a longer length of time. This results in an image that is brighter at the ends. So it would be wise to consider a voltage that varies linearly in order to secure an image of uniform brilliance when unmodulated. In this connection we shall consider a "V" shaped saw tooth voltage in Fig. 3.

It will be seen that if the frequency ratio between the two voltages is 1:1, we again get a diagonal line for the image. Obviously, we shall have to consider higher multiple frequencies. Following this procedure through as was done with the sinusoidal voltages it is found that though the brilliancy of the image is uniform as contrasted with the images of Fig. 2, the image is still formed by a zig-zag motion back and forth. This motion is quite complicated and for the purpose of explanation to the beginner is not the best means for producing an understanding of the television process. Fig. 4 concerns itself with a wave that is more easily understood.

Producing an Image

When the frequency ratio with these waves is 1:1, it is seen that we still get an inclined straight line. Obviously, regardless of the characteristics of the wave shape, so long as the frequency ratio is 1:1, the image that appears upon the screen will be an inclined straight line. We therefore have to take recourse to the lowest persistance of vision frequency on the horizontal plates and a multiple thereof on the vertical plates. Studying through Fig. 4, it is seen that the beam is deflected across the screen at a uniform rate which is conducive of an image of uniform brightness. And, the entire area of the screen is swept by the beam progressively. The number of sweeps across the screen is obviously dependant upon the number of times that the frequency of the vertical plate voltage is greater than the frequency of the voltage upon the horizontal plates. Thus, in the last sketch of Fig. 4, where the frequency ratio is 1:8, there appears upon the screen eight lines that are equally spaced and cover the screen completely.

Following this procedure through to higher frequency ratios, say 1:100, it is clear that a greater number of lines that are equally spaced will appear upon the screen. In the instance mentioned, there will be 100 lines that are almost horizontal. It can therefore be readily postulated that the number of lines that appears upon the screen is exactly the same as the frequency of the voltage applied to the vertical plates when the frequency of the horizontal plates voltage has been reduced to one (mathematically speaking).

A little consideration will reveal that the actual frequency of the voltage impressed across the horizontal plates will determine the rapidity with which the beam will traverse the entire screen. In other words, if the frequency of the horizontal voltage is one cycle per second, the beam will take one second to traverse the entire screen. For practical television purposes this frequency is of course useless, since the frequency should at least be the minimum at which the persistence of vision effect in the eye occurs.

Number of Pictures per Second

It has been said that this frequency was about 24 cycles per second, therefore the horizontal timing frequency should be at least 24 cycles per second. This means that the beam will traverse the entire screen 24 times per second. Thus, in order that there be 100 lines on the screen with this 24 cycle frequency on the horizontal plates, the vertical plates require a frequency of 100 times that amount or 2400 cycles per second.

The importance of the number of lines that appears upon the screen is apparent from Fig. 5. Here we have represented an original picture of the first three letters of the alphabet to be televised by three different scanning frequencies. In the first case, the vertical plate frequency is 240 cycles per second to give ten lines on the screen. The second case gives twenty lines upon the screen due to the vertical plate frequency of 480 cycles per second, while the last case gives 40 scanning lines because of the vertical timing frequency of 960 cycles per second. The difference in clarity of the picture reproduction is obvious. It can be seen that the closer these scanning lines are, the more detail that can be obtained in the picture. It is apparent that 10 lines produce an image that is just barely representative of the original whereas the 20 line image is better and the 40 line image still further an improvement.

Another thought that is a corollary of

Crystal Tower Likely Site of British Vision Plant

Experiments with television on microwaves have been conducted by John Logie Baird, Scotchman, from Crystal Palace tower, London, Eng., for many months. Demonstrations have been given at distances up to 30 miles and the results pronounced satisfactory. It is believed the first regular television will be sent from this high tower. The projected pictures were of two sizes, 8 inches wide by 6 inches high, and 12 inches wide by 9 inches high. The cost of a television receiver for the small sized picture is estimated to be £50 and that for the larger sized picture £95 to £100.

Baird has used a system of movie-sound pickup and put the film before the sender's scanning system and photo all sound detector 30 seconds after the last shot was filmed. This method is looked upon as being one that will prove popular for a while at least and is of the same general nature as a method used by the television station in Berlin, Germany, which gave some demonstrations at the radio fair last spring. At the present moment live pick up is not being used much, despite estimated popular interest in that method, because of time and money needed for perfecting it. This consists of telecising the persons and scenes directly, without the intermediation of film. However, the film method is handy and satisfies a need, especially as day events can be recorded both visually and acoustically, and put on the air at night when workers can view the reproductions of afternoon events they otherwise would miss. This method is being discussed also for use in the United States and Canada.

"The Financial News," London, concerning the report of an official committee favoring television now, said:

"The television report by the committee is believed in Parliamentary quarters to spell the death of the cinema industry."

In Britain much of the television experimenting has been financed by movie money, evidently with the expectation that if the movies suffer it is profitable to play both horses, to insure victory.

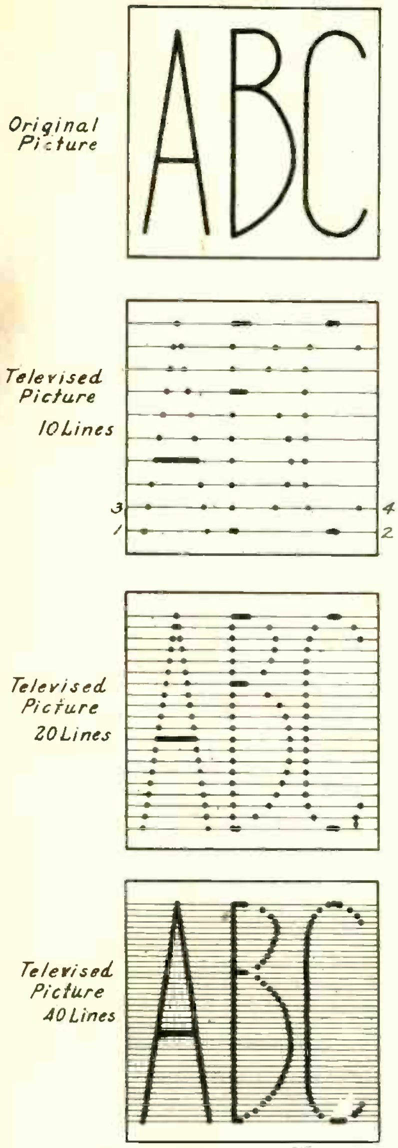


FIG. 5

The original picture in the top sketch is televised by three vertical scanning frequencies so that one gives a picture of ten lines, another gives a picture of twenty lines, a third gives a picture of forty lines. The clarity of each picture is readily contrasted.

this consideration is that the image becomes more concrete the farther the observer is from the image. This consideration of eye resolutions was treated by William Hoyt Peck in the February 16th, 1935, issue of RADIO WORLD. It is the angle that two adjacent television scanning lines form at the eye that will determine the illusion of continuity, or wiping out of the lines. Mr. Peck states that this resolution point occurs when the angle at the eye is 3 minutes.

It is thus seen that the number of lines that will afford picture concreteness is governed by the distance of the observer from the screen and the size of the picture on the screen. Assume that ten lines per inch of vertical screen height gives a satisfactory picture based upon the fact that the observer shall not be closer to the screen than 9 feet, 2 inches.

Introducing Modulation

But, we have jumped ahead of our story. We have not considered how we are to produce these necessary changes in light intensity of the spot on the screen. This is essential if we are to produce a picture rather than a solid area of light that is unintelligible. In other words, we have to modulate the electron beam so that the screen image will contain the modulation of light intensity as existent in the original picture. This is done by impressing the modulated television signal upon one of the elements of the electron gun. This will cause the beam of electrons to vary in intensity in direct proportion with the modulations of the signal.

Thus referring to Fig. 5 again for the case of the 10 line television, we can see that if the spot moves from left to right and progressively upwards in ten equally spaced parallel lines, it will move along line 1 to 2, then practically instanteously move to 3 so that a return line is not visible upon the screen. When the television transmitter scanned the original picture the intensity of current was a minimum (or maximum according to the system used) until modulated. The lowest scanning line 1-2 will contain dark spots for the points that correspond to the original picture. These dark spots on the receiving system's screen are achieved by impressing the incoming television signal upon any of the grids of the electron gun which will control the beam's intensity at the proper moment with respect to the scanning frequencies, so that a reproduction of the original picture is achieved with the detail determined by the scanning frequencies.

Marconi Is Trying to Extend Micro Waves

Guglielmo Marconi is experimenting with micro-waves for possible use in television and wit hthe hope that he can span the Atlantic with them. At present others have used micro-waves up to 200 miles or so, and he himself has accomplished two-way results at 170 kilometers. The 60-centimeter wave is about 23.5 inches long and represents a frequency or wave-length that can be handled for reception with the 955 acorn tube.

TWISTED CORD O.K.

The amateurs have been shocked to realize that after so many years of careful measurement of feeders, etc., that ordinary twisted telephone wire when correctly terminated at both ends provides an efficient means of energy transfer despite the proximity of the adjacent wires to each other.

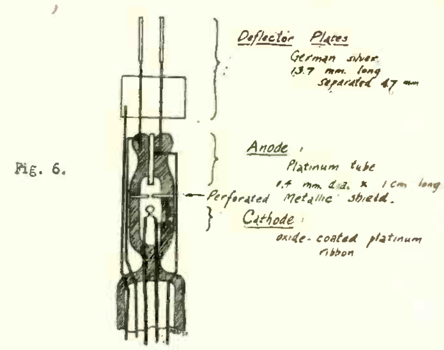


FIG. 6

The "electron gun" assembly of a cathode ray tube that was commercially available a few years ago.

A THOUGHT FOR THE WEEK

THE ADVERTISING AGENCIES HANDLING RADIO ACCOUNTS are trying to figure out some programs that will arouse new public interest and perhaps startle some of our many millions of listeners. Those who represent the artistic and business sides of sponsorship are perfectly aware of the fact that radio has been accustomed to so many ambitious attempts to build up a reawakened public interest that wide-range treatment and an almost utter disregard for cost must figure in all these efforts to win and hold a modern audience of the air.

If what we hear is correct, one agency alone will be authorized to spend not far from a million dollars for one big sponsor before the Christmas holidays of 1935 have come and gone.

Harmonic Suppression

WHAT IS THE best way to suppress harmonics?—J. L. O.

Harmonics are generated when tubes are operated on any portion of their characteristics that is not linear. In other words, when the output wave is not the same as the input wave, harmonics have been generated. Obviously, the best remedy to refrain from operating tubes on the curved portion of their characteristics. This is scarcely practical, however. A helpful means is to have loose coupling. Also push-pull will squelch even harmonics and filters will remove output odd harmonics.

Vast Employment Seen As Television Adjunct

The possible effects of television on show business in all its aspects has been a matter of concern in all countries. In the United States it has been pointed out that the world leadership in talkie production would be periled by television, because many would stay at home to see pictures, rather than go to the movies, thus causing economic dislocation in many branches of specialized activity, including motion picture operators, directors, actors and actresses, booking agencies, film and talkie patent owners, theatre owners, etc. Also, the sale of sound receivers, it is believed, would be affected, thus perhaps reducing employment here, too. Moreover, the recording of sound on film is a license proposition from which RCA reaps a large revenue that might be adversely affected. It is even said that the possible effect on recovery of now introducing television in this country has been called to the attention of President Roosevelt.

On the other side are those advocates of television that point out that while some dislocations may result, just as they did when radio itself started, and show business was hostile to radio and treated it as a menace, radio grew up to take the place of a disappearing legitimate stage, and the movies survived the competition. Meanwhile new avenues of employment were opened by radio, and particularly to persons who were very closely a part of show business and who themselves at first treated radio as ruinous. So it is expected that television will grow to afford new opportunities and in fact increase the total amount of employment.

Besides, when television reaches a grand scale, the employment of directors, operators, actors, actresses, electricians, authors, musicians, decorators, scene painters, carpenters, etc., would rise to enormous proportions, due to the short-distance transmission, and the problem will be rather where all the manpower is coming from, vision and with the hope that he can span where jobs are to be found for some millions of unemployed.

The Mechanical Television

Scanning Method Contrasted by Two Engineers with the Electrical System

By J. Francis Dusek

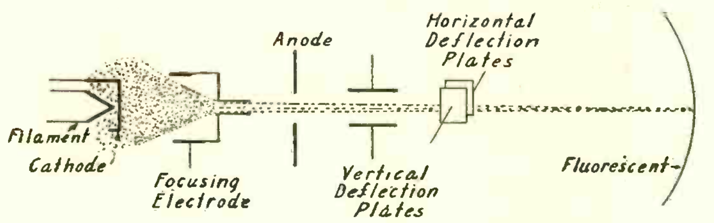


FIG. 1

System of cathode ray operation. The emission from the cathode is focused in a beam and the beam actuated in two directions by a-c voltages applied to pairs of deflecting plates. The ray illuminates the coated end of the bulb.

[*Herewith are presented two articles by engineers of the Peck Television Corporation giving reasons why they favor the mechanical system of scanning and stating what they consider serious shortcomings of the electrical (cathode ray) method. The mechanical system they particularly discuss is one including an optical invention of William Hoyt Peck, president of the corporation.*—EDITOR.]

ONE of the most versatile tubes developed in the vacuum tube industry is the cathode ray or Braun tube. It lends itself to such a variety of uses that a number of video engineers is looking to it as the long-sought "missing link" in the solution of all television problems.

When one examines this theory on the surface it really would seem as if the cathode ray tube should be the answer. It is purely an electrical device, a modern version of an Aladdin's lamp, having no moving parts and requiring very little attention after all the circuits associated with it are once adjusted. But let us delve in a little further and examine its short comings or disadvantages.

Let us first briefly review how the cathode ray tube operates.

A cathode, either of the filament or indirectly heated type, is caused to emit a copious flow of electrons, which is focused by a negatively charged cylinder into a very narrow beam. The next electrode having a high positive charge accelerates or speeds up this electronic beam to such a velocity that when the beam strikes the fluorescent screen it sets up secondary motions in the atomic structure of the chemically coated screen manifesting itself to the eye as a glow.

The beam is deflected up or down and left and right by being passed between four plates or four electromagnetic poles, with a potential applied from two oscillators to each set of plates or poles.

The wave form applied to the deflection plates for the purpose of scanning a field would appear as a saw tooth. The voltage would build up at a definite rate of speed and drop to zero almost instantly. Thus scanning one line and returning to its original position to start scanning the second line are accomplished. This would occur at the rate of 180 times per 1/24 of a second for a 180 line picture while the second set of plates would deflect the beam up and down at rate of 24 times per second which would be the repetition rate of standard motion pictures.

In addition to this scanning we must cause this beam to go on and out corresponding to the lights and shadows of a picture for each line scanned. This modulation of the beam is usually accomplished by bringing it to focus ahead of the screen for the brilliant "whites" and in back of the screen for the blacks of the picture by varying the focus.

The D-C Voltages

You will notice that as the "whites" are the elements that make up the picture, they are no longer the proper size but actually four times as large in area as they should be, thus reducing our detail from 180 lines to 90.

The voltage applied to the anodes of cathode ray tubes vary from 1500 for a 3 inch tube to 10,000 for a 9 inch tube. When we use such high voltages on a cathode beam we approach a stage where the voltages may be harmful not only from actual physical contact but also from soft X-ray radiations.

The "whites" referred to in the preceding paragraph are actually not "white" but green, blue or pink, depending upon the chemical used for the fluorescent screen, while pictures we are accustomed to see are black and white.

The cost of these tubes today ranges from $18 for a 3-inch to $140 for a 9-inch tube. Tests have shown that the life is usually about 200 hours. A 3-inch tube will reproduce a picture 1½ inches square and on a 9-inch tube we can enlarge it to about seven inches square without introducing too much distortion from the curved edges of the screens. At the present cost of tubes this would represent an operating cost for tube alone of 70 cents per hour for this 7-inch picture.

Intensity Modulation

According to the data furnished with a 9-inch tube, 903, using 8,000 volts on the anode, the measured brilliancy of a spot is 2.5 foot candles. When this intensity is distributed over a scanned field the brilliancy obviously drops to a very small fraction of this value.

In the mechanical optical system of the 180 line scanning under construction in the Peck Television Corporation's laboratory we find a novel system using a new lens principle, namely, the Peck reflecting lens. A new 1440 rpm 60 cycle synchronous motor drives a series of these Peck lenses and each lens focuses a spot, sharply defined, upon a screen. Light collected optically from an automobile headlight lamp is modulated by a highly developed electro optical light valve which is focused upon the aforementioned lenses. The focused spot on the screen is made to scan each of the 180 lines at a repetition rate of 24 per second. The spot of light does not change in size when modulated, but only in its intensity from zero to an extremely brilliant one, scanning a field measuring 15 by 18 inches, which may be diminished or enlarged at will.

In a survey conducted for the past

EDITORIAL

WHILE the United States, with television technique not to be rated as backward, is holding off attempts to establish quality television on a dependable basis, other countries are going ahead. The latest announcement is that the British Government is aiding the establishment of television stations, using the systems of John Logie Baird and the Marconi Company. Canada is about to introduce quality television, while Germany has a station going.

Foreign activity should act as a spur to American efforts. At present one of the retarding influences is the ruling of the Federal Communications Commission that no television licenses will be granted to concerns that sell television stock. Another deterrent is that the largest institutions, termed most conservative, believe no real start could be made by less than a national chain, and would rather let some independents explore the more limited field, then step in when things are going well, or hold off if consequences are not as fruitful as expected.

Nevertheless the elementary fact should be recognized that first there must be at least one excellent station, otherwise there will be no television. Further, that no chain so elaborate that heaping millions of dollars would be necessary to finance television on a "proper scale" is needed. Nobody knows what would be the result of introduction of television by independents, or by any of the broadcasting combines. There is no law requiring that the television stations at once dot the landscape of the country far and wide, even though merely short-distance penetration on the intended high frequencies may be taken for granted. Acoustic broadcasting started with one station. Quality television could start the same way, and acquire such natural growth and stature as public reaction decrees.

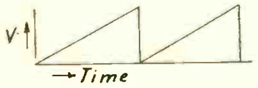


FIG. 2
Saw tooth scanning means the wave form looks like this, with slow ascent and very rapid descent, return or recovery.

year The Peck Television Corporation feels that a picture of this size and brilliance would be the most acceptable for a home by the public.

Trial measurements of the scanning spot show a brilliance of 12 beam foot candles. The picture is black and white. Dangerously high voltages are unnecessary.

Will Public Accept?

Video engineers working with cathode ray tube systems claim that a moving mechanism such as a motor would not be tolerated by the public for television reception, yet, in the same organizations another group of engineers sing high praises of why the public should buy their vacuum cleaners, electric fans and electric refrigerators, which depend upon electric motors for mechanical power. Thus we can conclude whether cathode ray or mechanical-optical scanning is the solution for present day television reception. What is your opinion?

* * *

By J. Lawrence Cassell

NOW that it is an actual fact that we will have high definition television in 1935 as evidenced by the activities of the German and English Governments in this field it is quite pertinent that something be said about mechanical scanning as against cathode ray methods.

To begin with, the word television is made of two words *tele* meaning distant and *vision* meaning sight. If we go back over the history of television we will see that the pioneers in this development have almost all been communication men, that is, either wire or radio engineers. As an example we shall take the father of television, Paul Nipkow (who by the way is still alive), an engineer in the German telephone company. Wire lines and radio systems have been developed to a surprising point at this writing and though the engineers will never be finished 1935 sees the *tele* part of television in a well developed form.

Optical Expertness

When we take the *vision* part of this improved development it is found that the number of men who actually could be called optical experts were few and far between, since Paul Nipkow's conception of the pinhole scanner in 1884 to the present time. Nipkow was not an optical expert; neither is Marconi, Baird, Jenkins nor Zworykin.

As practical television on the horizon we find that there are only two men in the world who can be called television optical experts and at the present time only one of them is actively engaged in television in a constructive capacity.

It is not necessary at this time to name either one of these men, both of whom are well known to RADIO WORLD readers but the situation brings us to the purpose of this article.

If we assume that we have a television signal receiver or an antenna in our home, that it has been rectified and been given to the optical expert, then we have the problem that faces Canada, England, Germany and the United States to-day.

In a mechanical system such as the Peck Television Corporation of Canada is installing in Montreal we have a light source (an automobile head light bulb) the light from which is polarized—modulated by a special form of Kerr cell, and then projected onto a screen in the black and white shadings we are accustomed to looking at in a movie theater.

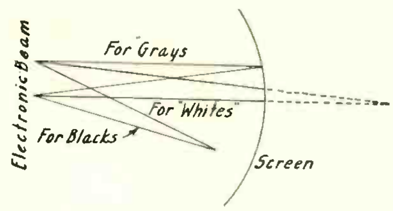


FIG. 3
The charge on the focusing electrode. The distribution for grays, blacks and whites is shown, in reference to the object scanned. Actually the image is green, blue or red.

One Spot at a Time

As in all television systems we have the breaking down of the picture into elements. This means that one spot of light is on the screen at a time. It is the size, shape, focus, color and brilliance of this tiny spot that gives us *high definition television*. In the Peck system, which has been judged the outstanding achievement in mechanical methods, we find a spot of light so bright that as it speeds across the screen it is actually scintillating. If we stop the scanning disc we find a spot that is about twice as high as it is wide, a very pertinent point. Any system that can have a spot of that proportion proves that that method has a sharp focus.

We all know how important it is to adjust our snapshot cameras to a proper focus. The amount of sunlight, the distance we are from the image that we are trying to photograph, the length of time we expose our film, all go to make a sharp focus for the picture.

When we find that we have made a very fine picture of some scene that is dear to our heart and we have a desire to have a much larger picture we find that it takes just a few dollars more and a real enlargement is made. With this enlargement we notice a certain fuzziness when we examine the picture closely. This loss of detail can be well explained by the exposition in last week's issue of RADIO WORLD by William Hoyt Peck in visual acuity.

Stage Must Be Set

The lookers-in must realize the sharpness of vision and set their own stage for television. Everybody's eyes are different. In the next few years it will be very interesting to see the different ideas that will come up as a result of the strides of television and the test of acuity of vision.

After a complete analysis of Mr. Peck's very able discussion of visual acuity of the normal eye we can put down the fact that home television must be about 18 to 24 inches square for motion picture detail with 180 lines. On the assumption that the Canadian public will not accept anything less, we find a very good basis to compare mechanical versus cathode ray television.

When we stop and analyze the words cathode ray we find the work of the communication engineers who knows very little about optics which is related to vision, the second part of the new wonder. When we get down to cold facts we find that the largest television picture on a cathode ray tube has been 6x8 inches and it has been necessary to use as many as twice the number of lines to produce the same results obtained by mechanical systems. After making a careful survey of the opinions of men who have had the privilege of seeing some of the cathode ray pictures we find the only comment is that television is five years off. We find that the pictures though 240 and 320 even 500 lines are still not sharp and clear. They have a soft focus. We all know what a soft focus of a movie close-up is, so when we hear about cathode ray soft focus it seems safe to conclude that a good sharp picture is not reproduced.

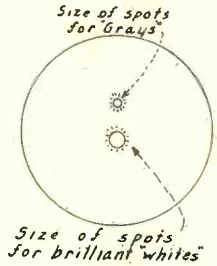


FIG. 4
The spot sizes are dissimilar for different color values. For brilliant whites in the object the spot size may be four times that for grays.

Focal Change for Modulation

When we examine the structure and operation of a cathode ray tube we see why this is true. To begin with, the modulation of a cathode ray beam is by changing its focus. This means that at only one time from maximum to minimum brilliance do we find the spot sharp; also the fluorescent effect gives bad tails. It is not hard to realize the reason for the fuzzy effect in all cathode ray pictures.

It is a well known fact in mechanical systems that much care must be used when short focus wide angle projection is resorted to in reproducing a large picture in a short throw. Comets with tails of three and four times the height of the spot are present at the extremities of the picture with all the colors of the rainbow. In the Peck system these troubles are all corrected for but the communication engineers who have computed the optics of their cathode ray beams have not yet been able to correct for this trouble which shows up on a cathode ray picture as an even more blurred picture at the extremities of the bulb.

As the tramp, tramp, tramp of the television giant is heard marching through Germany and England the Peck Television Corporation of Canada is prepared to give the public the very best in high definition television.

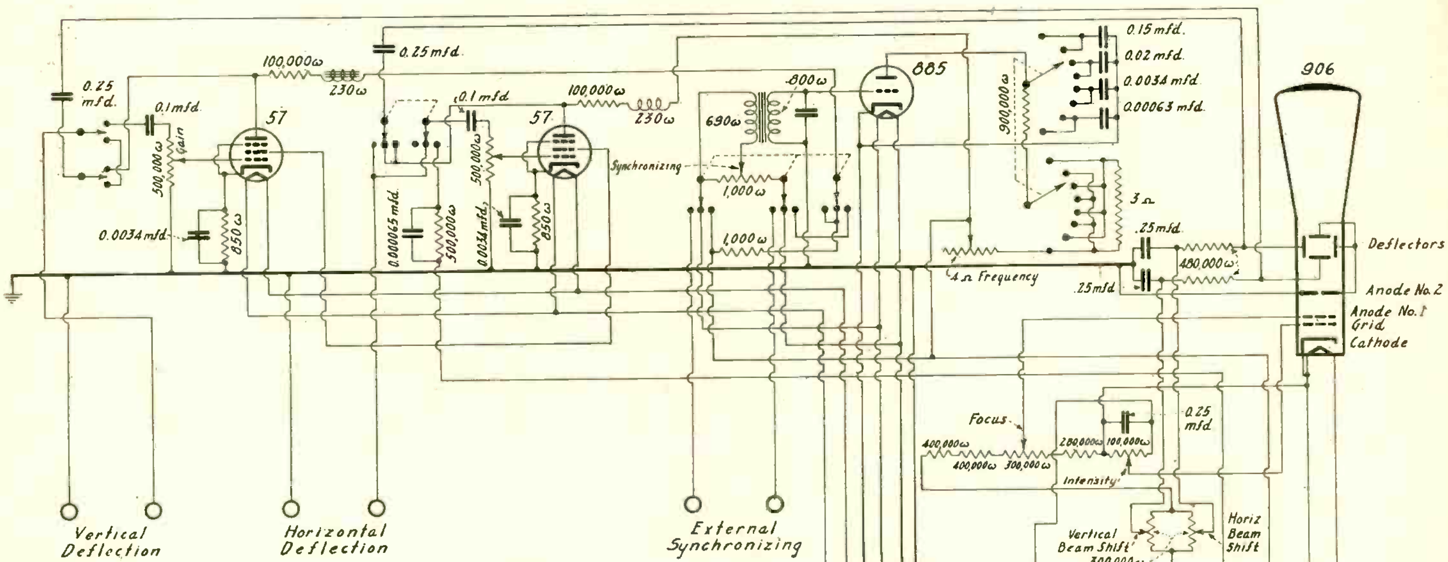
NOISE OF ELECTRONS LIMITS SENSITIVITY

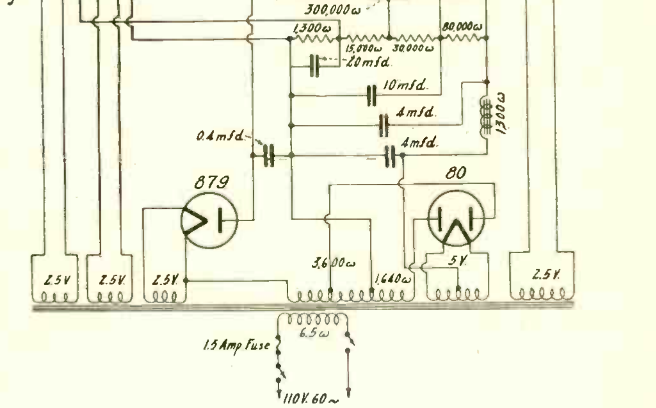
One of the applications of radio involves listening to the noise made by electrons in their mad rush through the conducting media. Now we are advised by Drs. Johnson and Llewellyn, of the Bell Telephone Laboratories, this noise of rushing electrons sets up a natural limit to the noiselessness of radio circuits. In other words, we have been imposed with a natural limit to which amplifiers may be built since electronic noise that is amplified also becomes so great as to prove troublesome.

Construction of Oscillograph

New Instrument Simplifies Measurement of Complex Values—Excellent for Servicing

By A. J. Bannister





ONLY the short time of ten years separates us from the days when the research electrical engineer engaged on a study of currents and potentials resorted to oscillographs that were nothing more than very light and sensitive d'Arsonval movements that utilized tiny mirrors to deflect a light beam rather than a moving needle over a scale.

The introduction of the Braun tube oscillograph served to open the eyes of many to the advantages of cathode rays for oscillographic purposes and so a persistent endeavor to improve this new gadget was entered upon. The newly announced RCA cathode ray oscillograph is the first moderately-priced offering of such an instrument.

The new RCA oscillograph is complete within itself and is a very handy tool to the radio experimenter, operator, service man and engineer.

One new feature of the new oscillograph is the vertical and horizontal amplifiers having a flat frequency range of from twenty to 90,000 cycles with an amplifier gain of 40. This is a feature without which the high sensitivity of two volts per inch could not be obtained.

Another important feature is the linear variable timing-frequency oscillator which has a wide frequency range from 20 to 15,000 cycles. This permits the close observation of extremely high frequencies.

Although the many controls demanded by the completeness of the instrument make for a control panel that would bewilder a layman, the operation of the oscillograph is easily understood by any competent radio service man after a few minutes actual operation.

Operation Controls

1. "Intensity" control (upper left), is a potentiometer in low side of 1,200-volt bleeder. Its position controls the bias on the grid of the cathode-ray tube, which in turn determines the quantity of electrons emanating from the "gun," thus controlling spot size. The power switch is located on this potentiometer. Initial clockwise rotation of this control turns on switch, additional rotation increases spot size.

2. "Focus" control (upper right), is a potentiometer in the 1,200-volt bleeder. Its position controls the anode No. 1 voltage, which (with constant A_2 voltage) determines the distance at which the electron beam focuses. In general, for a given "Intensity" setting, the "Focus" control should be set for maximum distinctness of spot or image.

3. "Ampl. A" switch (middle left), connects the "Vertical" binding posts either straight through to the vertical deflecting plates on the cathode-ray tube or through an amplifier to these deflecting plates. In either case there is a condenser in the input circuit.

4. "Ampl. B" switch (middle right), has 3 positions: "Timing," "On," and "Off." On "Timing" the "sawtooth" or timing axis oscillator feeds through an amplifier to the horizontal deflecting plates on the cathode-ray tube. When "On" the "Horizontal" binding posts are connected through an amplifier to these deflecting plates. When "Off" the binding posts are connected straight through to the deflecting plates. In either of the latter two cases there is a condenser in the input circuit.

5. "Ampl. A Gain" control (vertical) (lower left), is a potentiometer on the input circuit of the vertical amplifier. With "Amplifier A" switch "On," this potentiometer controls the vertical deflection.

6. "Ampl. B Gain" control (horizontal) (lower right), is a potentiometer on the input circuit of the horizontal amplifier. With "Amplifier B" switch on "Timing" or "On" this potentiometer controls the horizontal deflection.

7. "Range" switch (upper central), selects one of four timing capacitors and on alternate positions it places a Resistor, R_{11}, in and out of the circuit. It thus changes the timing axis oscillator frequency in steps, giving 8 ranges as follows: No. 1, 20-37; No. 2, 37-120; No. 3, 120-205; No. 4, 205-700; No. 5, 700-1,100; No. 6, 1,100-3,700; No. 7, 3,700-5,700, and No. 8, 5,700-15,000 cycles.

8. "Freq." control (right central), is a rheostat in series with the timing condenser. It changes the timing axis oscillator frequency gradually as it is rotated, and in conjunction with "Range" switch above gives continuous range between the extremes of frequency (20-15,000 cycles).

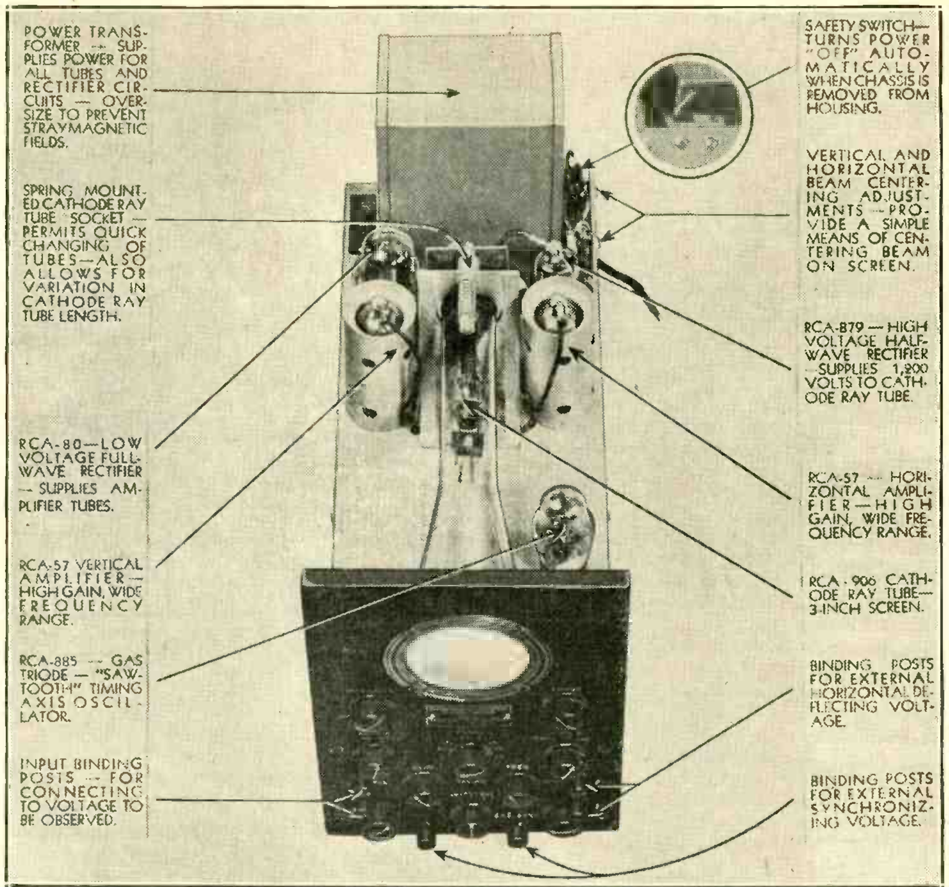
9. "Sync." control (left central), is a potentiometer controlling the amount of synchronizing voltage fed to the grid of the RCA-885 tube. In general it should be set as far counter-clockwise as is consistent with a locked image, as over-synchronization causes poor wave-form from the timing axis oscillator.

10. "Synchronizing" switch (lower central), has three positions, "Int.," "60 Cycle," and "Ext." On "Int." the voltage drop across the resistor in the plate

circuit of the vertical amplifier is fed through the "Sync." control and input transformer to the grid of the 885 tube. Thus the timing axis oscillator can be synchronized with the signal on the vertical axis at fundamental frequency or any small sub-multiple, such as ½, 1/3. . . . Synchronization is not effective if it is attempted to operate the timing axis oscillator at a higher frequency than that of the synchronizing voltage. On "60 Cycle," a 2.5 V. 60 cycle source is impressed across the "Sync." control, and can be used for locking the timing axis oscillator at 60, 30, or 20 cycles. On "Ext." the "Ext. Sync." binding posts are connected across the "Sync." control. This allows the use of an external source for synchronizing.

11. On the right-hand side of the cabinet, toward the rear, there are two potentiometers slotted for screw-driver control. These potentiometers control the amount of d-c potential between the two deflecting plates of each pair, and thereby allow adjustment of the position of the spot or image. The rear potentiometer controls the horizontal deflection and the front one controls the vertical deflection.

12. There are three pairs of binding posts on the unit. Voltage impressed on the "Vertical" posts will give deflection vertically. Voltage impressed on the "Horizontal" posts will give deflection horizontally. The "Ext. Sync." posts are used when it is desired to synchronize the timing axis oscillator with some external source. (See [10] above.) The binding posts marked "O" are all common ground and the ones marked "HIGH" are insulated from ground, which is the chassis.



The "works" slid out of the cabinet, with parts identified. The safety switch is in inset.

Circuit Description

An amplifier consisting of a single 57 constitutes the means of obtaining "gain" for the signal applied to the vertical deflecting system. The input to this stage is a high-resistance potentiometer connected to provide "gain" control. An isolation capacitor is made a part of the input circuit to exclude any DC which may be associated with the circuit being observed. The plate, or output circuit of the 57 is composed of two elements in series, a resistor and an inductance whose values are so designed as to effect a broad and uniform frequency response in the amplifier stage. Coupling from the amplifier plate to the cathode-ray tube is made through a capacitor.

The amplifier for the signal applied to the horizontal deflecting plates is identical to that described above. Switches are provided to disconnect either or both amplifiers, thereby applying the voltage to be studied directly to the deflecting plates. Extra contacts are used on the input switch to the horizontal amplifier for feeding in the timing or "Saw-tooth" oscillator signal.

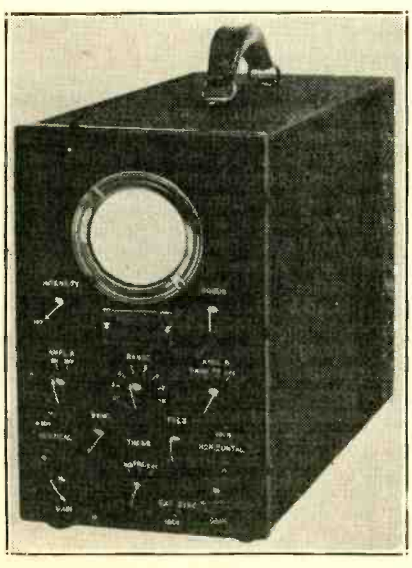
Saw-Tooth Explained

A synchronization system is included, as shown in the input circuit of the 885. The timing axis oscillator stage, using the 885, is designed to have a frequency range of 20 to 15,000 cycles, controlled through the "Range" switch and "Frequency" control.

The signal from this oscillator has a "saw-tooth" wave shape, obtained as follows:

A d-c potential is applied across a capacitor and resistor in series in the plate circuit of the 885 tube. This voltage charges the capacitor until the ionization potential (plate voltage at which the gas in the 885 ionizes) is reached. When the 885 ionizes the capacitor is short-cir-

(Continued on next page)



Positions stated in directions apply to this cabinet.

Electrical Specifications

Power Supply Rating	Voltage	110-120 volts a.c.
	Frequency	50-60 cycles
	Wattage Consumption	50 watts
	Fuse Protection	1.5 amps.

Operating Limits:
- Deflection sensitivity at amplifier inputs 2 peak volts per inch (max. "gain").
- Deflection sensitivity at cathode ray tube inputs 75 peak volts per inch
- Input Characteristics:
  - (1) Through either amplifier 500,000 ohms, approximately 20 mmfd.
  - (2) Without either amplifier 400,000 ohms, approximately 10 mmfd.
- Frequency response range of amplifiers....20-90,000 cycles
- Maximum signal input (with amplifier)..700 volts (RMS)
- Frequency range of timing axis or "saw tooth" oscillator 20-15,000 cycles
- Maximum d-c voltage across input binding posts..300 volts

Tubes and Functions	57	Signal amplifier for vertical deflection
	57	Signal amplifier for horizontal deflection
	885	"Saw tooth" oscillator
	906	Cathode ray tube (3-inch)
	879	High voltage rectifier
	80	Low voltage rectifier

Physical Specifications

Overall Dimensions	Height	14 inches
	Width	7¼ inches
	Depth	17¾ inches

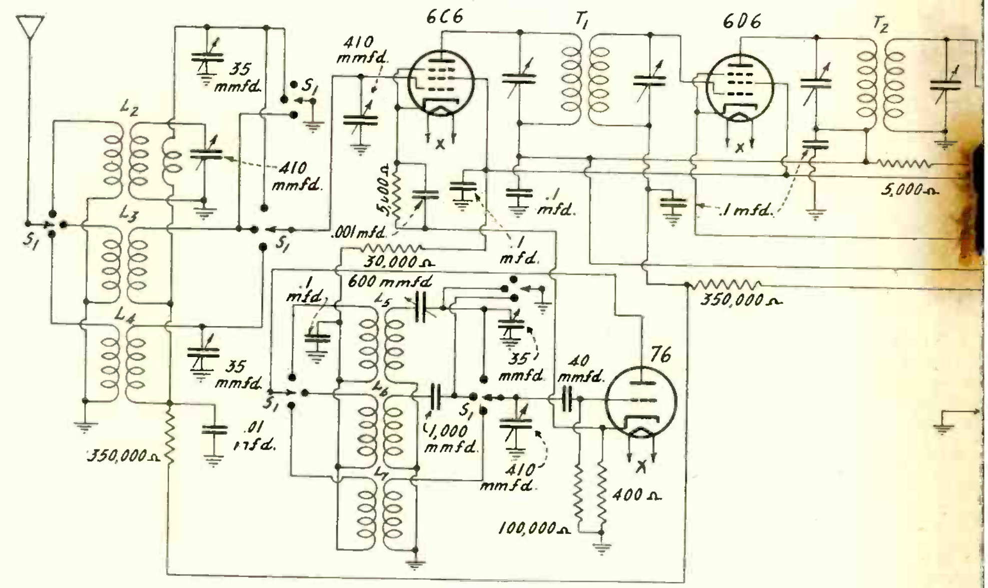
POSTAL'S NEW S

Full A.V.C., Precision Coils, Non-

By Samue
Chief Engineer, Post

CHARACTERIZED by its usual neatness and efficiency, the new Postal all wave superheterodyne makes its bow. It has 8 tubes that comprise one 6C6 for r-f preselection and first detection, two 6D6's for the i-f stages, one 76 for the oscillator, one 76 diode detector, one 76 a-f stage and one 42 power stage and the 80 rectifier. This combination of tubes results in a very useful arrangement for receiving the all wave range covered by the band between 14 meters to 550 meters for the all wave model and the range between 14 meters to 2,000 meters for the all wave and long wave model.

The diagram shows that the different wave bands are chosen by means of a 6 circuit 3 point switch that controls the three ranges: 14 to 50 meters, 50 to 180 meters, and 180 to 550 meters. This tuning arrangement is obtained by means of a three ganged 0.00041 mfd. condenser across the preselector, first detector and oscillator coils. In the short wave model, all the coils are wound on 1¼ inch bakelite tubing.



'Round World Reception

All together, the selectivity aided by the preselection, the absence of serious fading due to automatic volume control, the noise minimizing afforded by a tone control, the linearity of a diode detector of the non-overloadable type, and the large audio power capabilities afforded by a power a-f stage tend to furnish the operator of the new Postal receiver with all the ease and ability that is necessary for 'round the world reception.

It will serve for the purposes of description of this receiver's functioning if we will trace the path of a signal from the antenna to the loudspeaker. In this undertaking we shall assume that the wave band switch has been set on position 1, the highest frequency point. Then the signal that has been induced into the antenna will activate coils L_2. The 0.00041 mfd. condenser in conjunction with the 0.000035 trimmer will then tune in this signal and impress it upon the first grid of the 6C6 r-f and first detector tube.

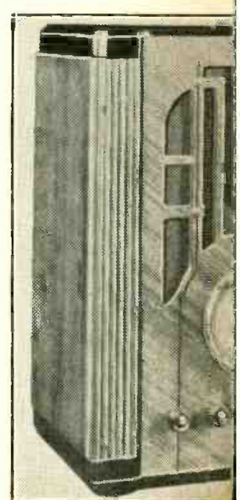
Care with the Coils

With the L_5 circuit of the oscillator stage active through the position of the wave switch, the locally generated oscillation is caused to heterodyne the incoming signal in the second and third grids of the 6C6. This combination of the local oscillations with the incoming carrier produces the 456 kc intermediate frequency carrier that progresses through the two 6D6 i-f stages to the point where the automatic volume control, the tone control and the sensitivity control perform their functions. Here, the intermediate frequency signal is suitably pruned, groomed and preserved for introduction into the diode detector where it is rectified to an audio frequency which is free from overloading distortion because of the 100-volt capabilities of the diode constituted triode. This detected signal then is amplified at audio frequencies to a point that is suitable for introduction into the speaker.

This action of the equipment is of course dependent on the correct functioning of the set's components and it is therefore extremely important that these parts be well made. With this thought in mind, the coils have been wound on seasoned bakelite tubing and the inductances held very close. The number of turns of these coils has been worked out carefully by Postal so that the requisite lining up properties were present to allow for the greatest amount of gain.

These coils have further been carefully shielded so that stray external effects will not be induced into the circuit to undo the good functioning of the other parts. Despite the large number of coils and condensers that are necessary for this all wave coverage, it is surprisingly apparent that compactness has not been lost. The i-f transformers have also been taken into

A well designed 3 tube all wave superheterodyne with all the trimmings. The use of switches for wave changing provides a facility in changing from band to band. The complete circuit diagram is shown above.



Oscillograph Circuit for Regu

(*Continued from preceding page*)

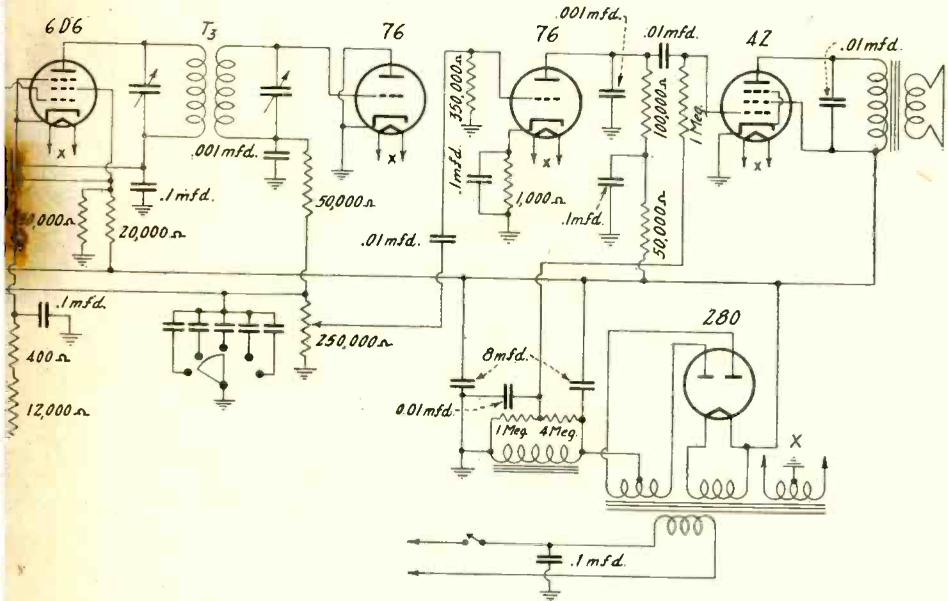
cuited and the voltage across it drops nearly to zero. The 885 immediately deionizes and allows the capacitor to start charging again. In this manner, the voltage across the capacitor has a "sawtooth" characteristic. The capacitor referred to above is selected by the position of the "Range" switch. With "Ampl. B" switch on "Timing," the voltage across this capacitor passes through the horizontal amplifier to the plates of the 906.

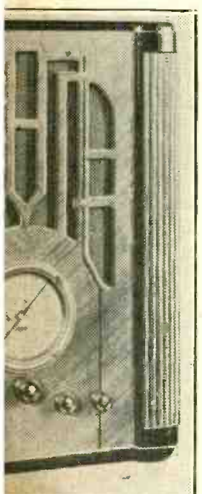
Power required for operation of the instrument is obtained through the power unit from a 110-120-volt, 60-cycle supply. Voltage rectification is accomplished by an 80 and an 879 connected in the secondary windings of the power transformer. The 80 supplies plate voltages for the amplifier stages and sweep oscillator, filtered through a reactor-capacitor combination. The 879 supplies the high voltage to the cathode-ray tube for polarization purposes.

WITCH TYPE SET

Overloadable Detector Featured

el Miller
al Radio Company





The front view of the finished product shows beauty. The airplane dial coupled with a fancy matching of wood veneers is productive of a set augmented in aesthetic flavor by the addition of modernistic columns.

account in an effort to minimize any leaks. In this effort, use has been made of i-f transformers that are wound with Litz wire so that losses due to skin effects in these stages are minimized. And, the general use of a high quality fixed resistors and condensers also serve this purpose of quality.

In external appearance the new receiver is beyond adverse criticism, for it has a handsome table cabinet, an airplane type dial of the most advanced design together with a well-balanced array of knobs which control, from left to right, the combination volume control and power switch, the wave band selector, the tuning control, the tone control, and the sensitivity control.

A. V. C. Removable

A novel aspect of this sensitivity control is that when it is rotated to its extreme counter-clockwise position, it kills the automatic volume control action while when it is in full clockwise rotation, the full automatic volume control is available.

The modernistic charm of the cabinet serves further to augment the beauty of this convenient means of 'round the world traveling. And the care with which veneer of the wood cabinet has been matched serves to admit this set into the most fastidious home.

That this aesthetic charm is more than skin deep is observable from this issue's front cover which reveals the appearance of the chassis unadorned. Inspection of this reproduction of a photograph shows that careful design attaches to the parts layout of this equipment too and that one does not have to feel that the external beauty hides an internal shame.

All this serves to produce a real job that works well, looks well, and lives well.

LIST OF PARTS

Coils

Three 465 kc i-f transformers.
One band pass coil.
Three detector coils for the 3 wave ranges.
Three oscillator coils for the 3 ranges.
One power transformer.
One B supply choke.

Condensers

One 3 gang 0.00041 mfd. variable condenser.
Three 0.000035 mfd. trimmer condensers.
One 0.0006 mfd. trimmer condenser.
Four 0.001 mfd. fixed condensers.
Four 0.01 mfd. fixed condensers.
Ten 0.1 mfd. fixed condensers.
One 0.00004 mfd. fixed condensers.
Two 8 mfd. fixed condensers.

Resistors

One 4 megohm resistor.
Two 1 megohm resistors.
Three 350,000 ohm resistors.
One 250,000 ohm resistor (variable).
Two 100,000 ohm resistors.
Two 50,000 ohm resistors.
Two 30,000 ohm resistors.
One 20,000 ohm resistor.
One 12,000 ohm resistor (variable).
Two 5,000 ohm resistors.
One 1,000 ohm resistor.
Two 400 ohm resistors.

Other Requirements

One speaker.
One power transformer.
One 6 circuit 3 point wave switch.
One volume control and switch.
Tubes: One 6C6, two 6D6, three 76, one 42, one 80.
Sockets, hardware, chassis.

lar Use in Service Work

Visual alignment of tuned circuits, "flat-topping" I. F. circuits, measuring hum and checking distortion in audio amplifiers are few of the problems which are easily solved through the use of the oscillograph. A visual presentation of practically all alternating current circuit functions may be quickly and easily made.

The oscillograph enables the amateur to monitor percentage modulation, to check modulated waveform for distortion and examine the phase shift in audio amplifiers.

Schools may easily give students the benefit of visual presentation of alternating current phenomena. Studies of alternating current wave shapes and demonstrations of the effects of changing constants in circuits may be quickly and easily made.

The oscillograph gives the radio dealer an instrument for comparison of receiver characteristics and for making extremely effective window displays.

Working Padding Formulas

Mathematics Simplified in Solution of Tracking

By George V. Webster

RECENT articles on padding have elicited requests for a more simple mathematical treatment of the subject. This subject has been treated more technically in past issues of RADIO WORLD and it would probably be useful to refer to the issues dated July 7th, 1934, and October 27th, 1934.

The whole problem of padding has been incurred by the justifiable demand that our radio receivers be tunable by only one dial. The old sets with their multiplicity of dials are no more desirable as when the value of a set was gauged somewhat by the number of controls that appeared on the front panel. The old time superheterodyne in this fashion would contain a separate dial control for each intermediate stage. There would be the first and second detector controls in addition to the oscillator and perhaps two stages of radio frequency.

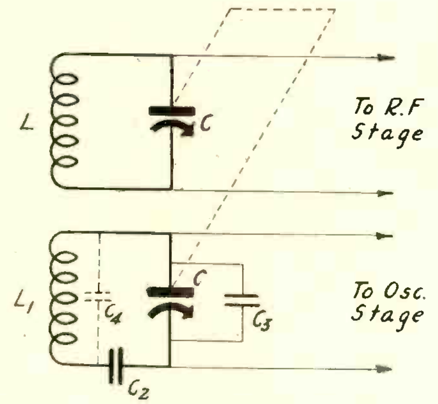
Simpler Nowadays

So far this would entail a total of nine dials, to say nothing of the separate filament rheostats that usually were included. In a set like the one indicated there would be probably eleven tubes, which would entail eleven filament rheostats in addition. Such a multiplicity of controls in the old days was considered the heighth of efficiency though not especially easy to operate. And so, now that we have arrived at the stage of common sense, we insist upon one dial tuning control which involves the complications of mathematics that is associated with such an effort. Therefore, in an explanation of this subject we might just as well set ourself for a siege of mathematics and weird symbols. Our efforts to simplify this subject will therefore be restricted to a simplification and elaboration of the mathematical processes involved rather than to an avoidance of mathematics which would denude the subject of its basic explanation.

Nowadays, the intermediate stages of the superheterodyne sets on the market are fixed at one frequency so that we needn't concern ourselves with variations in this part of the circuit. The modern superheterodyne has evolved into a set that requires tuning only in the r-f or first detector and the oscillator stages so that this discussion involves the problem of padding only with respect to the controls to be ganged into one shaft. In cases where there are more than one r-f stage, no additional complication is incurred since all r-f stages are similar to one another which will therefore be satisfied by the treatment of one stage.

Simple Methods

The modern practice in this connection is to utilize fixed inductances in conjunction with variable capacities as depicted in the diagram showing the fundamental tuning circuit. Here we utilize a main tuning condenser which is shunted by a trimming condenser that serves the function of lining up the various component condensers of a ganged arrangement. And, in the case of the oscillator, an additional trimmer known as the padding condenser is placed in series with the oscillator tuning control. The distributed capacity of the coils themselves do not amount to



In order to establish tracking in a superheterodyne it is necessary to pad the oscillator circuit with a series and sometimes a shunt capacity.

a sufficiently large item at frequencies that are higher than the intermediate frequency and so may be neglected from the consideration in those instances.

A simple method of design promulgated by the RCA Manufacturing Company, Inc., requires no charts or graphs or other tools except a pencil and paper. Those adept in the use of the slide rule will probably utilize that instrument for their calculations, but it is unnecessary to go to such lengths if inconvenient. The flexibility of this method of calculation to cover any intermediate frequency and any frequency range renders it quite handy in this endeavor. Its accuracy is reasonably valid to provide the required circuit values and greatly reduces the necessity for the cut and try method.

The diagram illustrates the essentials of a modern superheterodyne circuit that concerns us in the design of the apparatus. The upper section leads to the r-f stages on the right and the antenna on the left, either inductively, conductively or capacitively coupled, the exact method of which concerns us little here. The lower portion of the diagram shows the essentials of the oscillator part of the circuit which leads on the right to the oscillator tube or oscillator section of the converter tube.

How to Get Value of L

In the r-f circut, **L** represents the inductance of the r-f coil, while **C** represents a variable capacity that consists of the tuning capacitance and the capacity of the wiring and the tube. In solving the problem involved in this consideration, it is necessary to know either the value of **L** or the value of **C** at some particular frequency. If the value of **C** at a frequency that we might designate as f_o is expressed as C_o, the corresponding value of **L** is obtained from the formula:

$$L = \frac{25{,}330}{f_o^2\ C_o}$$

in which **L** is expressed in microhenries, **f** in megacycles, and **C** in micromicrofarads.

This formula has been derived from the standard formula given in all radio texts involving the frequency that is resonant to the fundamental of an inductance-capacity circuit arrangement:

$$f_o = \frac{1}{2\pi\sqrt{L\,C_o}}$$

to get rid of the radical, square both sides of the equation:

$$f_o^2 = \frac{1}{4\pi^2\ \ L\,C_o}$$

to solve for **L**, exchange f^2 and **L**:

$$L = \frac{1}{4\pi^2 f_o^2\ C_o}$$

Evaluating $\pi = 3.1416$:

$$L = \frac{1}{39.6\ f_o^2\ C_o}$$

which number when brought to the numerator becomes:

$$L = \frac{.02533}{f_o^2\ C_o}$$

Conversion of Units

But the first formula contains the parameters in terms of henries, cycles per second and farads which units are unwieldly for radio purposes. Therefore, to convert the units to those that are common to high frequencies, we have to make the following operation: we desire **L** to be in microhenries, of which unit there are a million in a Henry, therefore **L** is to be multiplied by one million. We desire **f** in megacycles per second and so we have to divide **f** in cycles per second by one million. Also we want **C** in micromicrofarads of which there are a million million (trillion) in one farad; which means that **C** in this formula must be multiplied by a trillion. We sum this up as follows:

$$L\ (10^6) \neq \frac{0.02533}{\left(\frac{f_o}{10^6}\right)^2 \times C_o\ (10^{12})}$$

$$L\ (10^6) \neq \frac{0.02533}{f_o^2\ C}$$

It will be seen that the left side of the equation is one million times greater than the right side (compare with the first equation given above) and so the state of equality is destroyed. In order to regain the state of equality, it will of course be necessary to multiply the right side of the equation by one million also. This then takes the following form:

$$L\ (\text{in microhenries}) = \frac{0.02533}{f_o^2\ C_o}\ (1{,}000{,}000)$$

$$L\ (\text{in microhenries}) = \frac{25330}{f_o^2\ C_o} \quad \ldots\ldots(1)$$

Thus it is inferred that in order that the units of the equation be in terms of microhenries, micromicrofarads and megacycles, it is necessary that the equation take the form of (1).

The Oscillator

In the oscillator portion of the circuit the variable capacity **C** is supposed to vary simultaneously with **C** of the r-f portion of the circuit. The rate of variation of **C** with condenser setting is not so important as long as the r-f and oscillator tuning condensers change at the same time. This means that though the tuning control is varied the difference between the natural frequency of the r-f circuit and the natural frequency of the oscillator circuit should always remain constant all over the dial. This is usually accomplished by inserting in series with the oscillator tuning control of a small padding condenser which is the reason for all this talk.

The desired relation between the r-f and oscillator circuits is given by:

$f_1 = f + f_o$ ....(2)

where f_1 is the resonant frequency of the oscillator, f the resonant frequency of the r-f circuit, and f_o is the intermediate frequency.

It is unfortunate that this equation is not satisfied at all frequencies; but rather that there are, in general, usually three frequencies that satisfy it exactly. The regions between and just beyond these frequencies depart from conformity with this equation and thus introduce a defect in the theory that cannot be avoided.

Tie-down Frequencies

The three signal frequencies that do exactly conform with this equation are termed the "tracking frequencies" and are designated as **F_1, F_2 and F_3**. These frequencies should be chosen in advance of any construction and should be at such points that F_2 is in the center of the band and F_1 and F_3 are near the limits of the band. Examples of such values for the broadcast band are $F_1 = 600$ kc., $F_2 = 1{,}000$ kc., and $F_3 = 1{,}450$ kc. The usual intermediate frequency that has been associated with broadcast band superheterolynes has been 465 kc. and so we can, for this example in the broadcast band, consider that $f_o = 465$ kc. Applying this information to equation (2) together with the three values of signal tracking frequencies, F_1, F_2 and F_3, it is found that the resonant frequency of the oscillator circuit for the three tracking frequencies should be:

$f_1 = 600 + 465 = 1065$ kc. $= 1.065$ mc.
$f_1 = 1000 + 465 = 1465$ kc. $= 1.465$ mc.
$f_1 = 1450 + 465 = 1915$ kc. $= 1.915$ mc.

The summarized tabulation of formulas that appears on this page indicates the formulas that are applicable to the design computations involved in the superheterodyne. For practical use in design problems, this tabulation gives all the information that is necessary in the computation of L_1, C_2, and C_3. It is assumed that the following data is known:

(1) Intermediate frequency.
(2) Tracking frequencies.
(3) **L** or C_o at the frequency f_o (obtainable from **(1)**.
(4) The capacities C_3 or C_4.

Three Cases

In the use of the final formulas shown under Case 1, 2, 3 and 4, the letters **a, b, c, d, l, m, n, A** and **B** are used which represent complicated functions of the various inductances and capacitances in the circuit. By their use, it is possible to render formulas (10) to (23) inclusive seem less formidable. It will be seen that Case 1 concerns the instance when the distributed capacity of the coil and associated wiring is equal to zero or at any rate very much less than the series padding condenser, which is the usual case. In Case 2, C_3 which represents the difference between the capacities of the respective minimum settings of the r-f and oscillator tuning condensers, is equal to zero. In Case 3, the computations take into account the distributed capacity of the coil and associated wiring while in the last case the value of C_3 is represented by a particular known magnitude. The final four formulas (24, 25, 26, and 27) may be used in the checking of results obtained from the other formulas.

To illustrate the working of this method, an example of the manner of computing the data under Case 1 will be shown. We have decided upon 465 kc. as the intermediate frequency, also our tracking frequencies have been set at 600, 1,000 and 1,450 kc. We then determine **L** from formula (1) at the end of the band which is 1,965 kc. as far as the oscillator is concerned at maximum condenser setting (from $f_1 = 1{,}500 + 465 = 1{,}965$ kc.). A condenser with a maximum capacity of 0.00014 mfd. shall be used (140 micromicrofarads). From equation (1) then, we find:

$$L = \frac{25330}{140\,(1.55)^2} = 75 \text{ microhenries}$$

Reference to "The Inductance Authority," a book of charts that dispenses with coil calculations, reveals that this coil should contain 54 turns of No. 26 enamelled wire on a 1¼-inch form. Then in order to determine the values represented by formulas (10), (11) and (12), it is necessary to evaluate:

$a = 0.6 + 1.0 + 1.45 = 3.05$
$b^2 = 0.6 + 0.87 + 1.45 = 2.92$
$c^3 = 0.87$
$d = 3.05 + 0.93 = 3.98$

$$l^2 = \frac{(2.92)\,(3.98) - 0.87}{0.93} = 11.55$$

$m^2 = 11.55 + 0.93 + 12.15 - 2.92 = 21.71$

$$n^2 = \frac{[(0.87)\ (3.98) + (0.216)\ (21.55)]}{21.71} = 0.373$$

Now that we have evaluated all the basic relations, we can apply them to the formulas of Case 1 and determine the sizes of the condensers and inductance of the oscillator circuit.

$C_2 = (140)\ (.3025)\ (2.68 - 0.0865 = 11\mu\mu f.$
$C_3 = (140)\ (.3024)\ /\ 11.55 = 3.65\ \mu\mu f.$
$L_1 = 75\ (11.55/21.71)\ (14.65/11) = 53.1\ \mu H.$

Basic Considerations and Relations

f_o = Intermediate frequency
F_1, F_2, F_3 = Frequencies at which exact tracking is to be obtained.

$a = F_1 + F_2 + F_3$ (3)
$b^2 = F_1F_2 + F_1F_3 + F_2F_3$ (4)
$c^3 = F_1F_2F_3$ (5)
$d = a + 2f_o$ (6)
$l^2 = (b^2d - c^3)/2f_o$ (7)
$m^2 = l^2 + f_o^2 + ad - b^2$ (8)
$n^2 = (c^3d + f_o^2l^2)/m^2$ (9)
C_o = Tuning capacitance at frequency F_o
$L = 25330/C_oF_o^2$, or if L is known, then $C_oF_o^2 = 25330/L$ (1)
$A = C_oF_o^2(1/n^2 - 1/l^2)$ Required only for Case 3 (16)
$B = (C_oF_o^2/l^2) - C_3$ Required only for Case 4 (20)

Case 1: When $C_4 = 0$, or $C_4 \ll C_2$ (the usual case).

$C_2 = C_oF_o^2(1/n^2 - 1/l^2)$ (10)
$C_3 = C_oF_o^2/l^2$ (11)
$L_1 = L(l^2/m^2)(C_2 + C_3)/C_2$ (12)

Case 2: When $C_3 = 0$.

$C_2 = C_oF_o^2/n^2$ (13)
$C_4 = C_oF_o^2/(l^2 - n^2)$ (14)
$L_1 = L(l^2/m^2)C_2/(C_2 + C_4)$ (15)

Case 3: When C_4 is known.

$C_2 = A\ (1/2 + \sqrt{1/4 + C_4/A}\ )$ (17)
$C_3 = (C_oF_o^2/l^2) - C_2C_4/(C_2 + C_4)$ (18)
$L_1 = L(l^2/m^2)(C_2 + C_3)/(C_2 + C_4)$ (19)

Case 4: When C_3 is known.

$C_2 = (C_oF_o^2/n^2) - C_3$ (21)
$C_4 = C_2B/(C_2 - B)$ (22)
$L_1 = L(l^2/m^2)(C_2 + C_3)/(C_2 + C_4)$ (23)

* *

Check Formulas

Equation for oscillator frequency:

$$f_1 = m\sqrt{(f^2 + n^2)/(f^2 + l^2)} \quad (24)$$

Equations for l^2, m^2, and n^2, in terms of oscillator constants:

$$l^2 = C_oF_o^2/(C_3 + \frac{C_2C_4}{C_2 + C_4}) \quad (25)$$

$$m^2 = C_oF_o^2/(L_1/L)(C_4 + \frac{C_2C_3}{C_2 + C_3}) \quad (26)$$

$$n^2 = C_oF_o^2/(C_2 + C_3) \quad (27)$$

The Electrolytic Condenser

Its Historic Development, Constitution, Manufacture and Use

By Paul McKnight Deeley

THE electrolytic capacitor is in reality a comparatively ancient piece of electrical apparatus, as old in fact as the discovery of the decomposition of water in the electric cell.

In the early seventeenth century it was found that platinum electrodes, when immersed into solutions of sulphuric acid, gave capacity indications of as high as ten microfarads per square centimeter of anode surface at voltages of the order of two volts. It was also soon discovered that tantalum, magnesium and aluminum showed the same characteristics.

Commercial electrolytic capacitors seem to have found application and use as early as 1892 and were used at that time, in connection with split phase alternating current motors, for starting purposes.

Electrolytic capacitors began to be used commercially in large quantities about ten years ago and have been used in increasing quantities ever since, until at the present time they have almost completely replaced the use of the paper dielectric type of capacitor in the fields of filter and by-pass work, in the radio and allied industries. In the last three years electrolytic capacitors have also found a large field of application in connection with fractional horse power capacitor motors for single phase alternating current.

What the Condenser Is

There are two outstanding reasons why the electrolytic capacitor has replaced the paper dielectric capacitor: first, cost and second, size. On an average, the cost of an electrolytic capacitor is one fourth that of a corresponding paper dielectric capacitor and the size of an electrolytic capacitor is one eighth, or less, the size of a corresponding paper dielectric capacitor. This is particularly true of capacitors rated at voltages of from four hundred to five hundred volts.

Fundamentally, an electrolytic capacitor is similar to any other type of capacitor in that it consists of two conducting surfaces separated by an insulating or dielectric medium. Likewise, the capacity of an electrolytic capacitor is determined by the same factors that determine the capacity of any other type of capacitor. That is, the capacity varies directly in proportion to the areo of the conducting surfaces, inversely in proportion to the thickness of the insulation or dielectric medium and directly in proportion to the dielectric constant of the dielectric medium.

Considerable knowledge has been accumulated on the subject of "anodic" *films* but the greater portion of this knowledge consists of empirical data and few actual facts are known about the fundamental theory behind the asymmetric nature of such "anodic" films.

Two Theories Liked

From among the great number of theries put forth in explanation of the asymmetric behavior of the anodically formed film only two theories seem to have been experimentally substantiated to any degree. These two theories are the gas film theory and the solid film theory. It may be well to point out that neither theory has been experimentally verified to fit all conditions. A consideration may be also given to the application of a combination of both theories.

The Gas Film Theory

Aluminum, when made an anode in an electrolytic bath, tends to plate into solution. By electrolysis of the water, oxygen is formed and tends to collect on the surface of the anode. Aluminum, having a great affinity for oxygen, combines with the oxygen collected on the anode surface and a film of aluminum oxide is formed.

Microscopically small gas bubbles tend to remain on the anode surface and prevent complete film formation at the points where they exist. This results in a film structure of a porous nature, full of minutely small gas pockets which serve to insulate the anode surface at these points where the film does not cover over.

A reversal of polarity repels the gas bubbles and leaves the unfilmed points of raw aluminum exposed to contact with the electrolyte for unimpeded conduction of current.

In other words, during the formation of the anodic film there are produced simultaneously two films. One, an inactive filf of aluminum oxide and two, an active gas film of oxygen. The oxide film is not responsible for the asymmetric properties of the anode but seems to hold in position the oxygen gas film, which has the properties of a dielectric medium. It is considered that the pores of the oxide layer, insofar as they are not occupied by gas, are filled with electrolyte and that electrons from the aluminum can cross the gas film but that electrolytic ions from the electrolyte can not cross.

The Solid Film Theory

The gas film theory has been held to be untenable because of some of the following advanced reasons. A gas film has a low dielectric constant and so it has been difficult to account for a sufficient lowering of the work function to permit electron emission from a metal surface at ordinary temperature and furthermore the work functions for the escape of electrolytic ions from aqueous solutions should be less than in the case of electrons escaping from a metal surface.

Because of these and many other reasons it has been held that the entire anode surface is covered with a solid film of aluminum oxide or dehydration product of aluminum hydroxide. It has been stated that this film of oxide has insulating properties in consequence of the almost complete lack of free electrons, exactly as in the case of a vacuum. Electron emission from the metal anode into the insulating film of oxide is controlled by a work function as in the case of from a metal to a vacuum. As a result of the definite time required for the electrons to traverse the film from one electrode to the other, space charge effects arise and thereby reduce the current flow to a very small value. This is based on the assumption that there is a uniform distribution of the dielectric film over the entire anode surface but it is possible that the film is discontinuous and that the work function is suppressed at some points and operative at others.

Still another viewpoint of the solid film theory is one which more readily seems to fit all conditions. In this theory the anodic film is thought of as being a solid film of aluminum oxide which possesses almost infinite resistance and in which there is an almost total lack of free electrons. This film of aluminum oxide is likened to a vacuum in its function and the asymmetric nature of a polarized junction consisting of anode plate, film and electrolyte is explained by the analogy of a vacuum tube type rectifier.

Leakage Current

With the anode plate positive and the electrolyte negative no electrolyte ions can cross the film from the electrolyte to the anode. If any electrolyte ions do cross over the result is the formation of additional film at that point. If the polarity of the junction is reversed, electrons are discharged from the surface of the anode and a path is thus afforded for current passage through the film.

Direct current leakage is accounted for by the fact that the film of aluminum oxide is not always complete and therefore there are always minute areas where current flow is not completely blocked.

With inactive age or shelf life the completeness of the film is lessened and there are an increased number of areas where the current is allowed to pass, but when the juncture is again polarized the electrolyte ions which do pass quickly replace the breaks in the film with newly formed aluminum oxide.

Leakage current therefore is a function solely of completeness of film coverage and film thickness. Film thickness is a function of voltage applied and therefore capacity is a direct function of voltage.

The reason that film thickness is a function of voltage is that after any film formation takes place no electrolyte ions will pass to afford additional formation unless the voltage is increased. The passage of electrolyte ions are therefore actually dependent upon increased electrostatic pressure due to increased voltage.

By combining such a favorably polarizable junction surface with one which is not polarizable or is polarizable only in the reverse direction an asymmetric arrangement is obtained which will possess the uni-directional current flow characteristics upon which the production of electrolytic capacitors is dependent.

Polarization

If the voltage of an electrode immersed in an electrolyte is altered by some cause from its equilibrium value it is said to be polarized. It is said to be polarized anodically if it is made more positive than its equilibrium value and cathodically if it is made more negative than its equilibrium value. Such polarization may be produced by impressing an external voltage on the electrode, it may result from changes in the concentration of the electrolyte or from some interference caused by a reaction of the electrode with the electrolyte, as for example, the formation of a non-conductive film upon the surface of the electrode.

When a metal dissolves anodically into an electrolyte, thus producing metal ions capable of combining with the ions of the electrolyte, further dissolving of the metal may be hindered as a result of the formation of a film upon the surface of the metal electrode. The presence of this film reduces the area of the electrode which is in contact with the electrolyte and as a result increases the current density upon the parts not affected. If the entire surface of the electrode is covered by such a film the polarization must be increased to maintain a given current and as this process is followed through exceedingly high polarizations may result.

The physical characteristics of the film such as its porosity, thickness, electrical conductivity and stability may vary in different cases but it is upon the formation of poorly conductive films at the surface of a metal anode, permitting the maintenance of high voltages between the electrode and the electrolyte, and preventing the discharge of anions, and the relative stability of the anode film when made a cathode that the production of electrolytic capacitors is made commercially possible.

The characteristic property, of the "anodic" film, of poor conductivity, is only apparent when the electrode is positive in relation to the electrolyte. On reversing the polarity the conduction of current is of course possible. In other words the "anodic" film has an asymmetric nature.

Aluminum Is Favorite

Although, as has been previously mentioned, tantalum, magnesium and other metals have been used in various devices on account of possessing this asymmetric characteristic, it has remained for aluminum alone to become universally and exclusively used in the construction of electrolytic capacitors. This has been the natural result of lower cost, abundant supply and the ease of manufacture into thin foils or sheets as well as other important factors. Only aluminum will be considered as an anodic material in connection with electrolytic capacitors.

Aluminum was discovered first in 1827 and then again in 1854. Ever since the discovery of the first practical electrical method for its extraction, in 1885, aluminum was found to possess a very high affinity for oxygen and this is one of the important characteristics of the metal.

Whenever aluminum is exposed to air and moisture there is immediately formed a film of aluminum oxide. Normally this film is invisible and its thickness is of the order of molecular dimensions. Aluminum owes its stability and resistance to corrosion to this fact. Aluminum oxide Al_2O_3 occurs naturally in such forms as ruby, sapphire, corundum and emery and is extremely hard, ranking in hardness next to the diamond.

The aluminum oxide film occuring naturally, although impermeable to gases, has practically no insulating value and offers little or no resistance to the flow of current in either direction.

Synthetic Filming

When, however, the oxide film is artificially produced by making the aluminum the anode in any one of various electrolytes, it takes on a definitely asymmetric character and becomes not only an insulator capable of withstanding high voltages, but an excellent dielectric medium. Due to the fact that this dielectric has a thickness in the order of molecular dimensions, extremely large capacities can be obtained with the use of relatively small plate areas. In an electrolytic capacitor this oxide film is a dielectric medium only however when the aluminum plate is made the anode with respect to the electrolyte.

Very heavy or thick oxide films when washed, dried and impregnated with waxes, oils, varnishes or other insulating compounds do serve as excellent and stable insulating mediums for aluminum wires, etc. Under such conditions the films serve merely as insulation and show no asymmetric characteristics. Heat does not materially affect such films and some use has been made of such material in the form of motor and coil windings where weight is an important item of consideration.

Anodic Film Formation

As has been mentioned before, aluminum has become the metal that is used exclusively for anodes in electrolytic capacitors and any information which follows refers only to aluminum.

When aluminum is made the anode in an electrolyte, the voltage necessary to maintain a given current density increases almost in direct proportion to the time of voltage application. At a certain voltage a partial breakdown of the film occurs and minute sparking between the anode and the electrolyte occurs. This point is called, for want of a better classification, the sparking or scintillating voltage of the capacitor.

This period of polarization during which the oxide film is formed is called the formation period.

The formation of the anodic film can take place on direct current or an alternating current and both are used in commercial practice. In most cases direct current only is used but in some instances both direct and alternating current are used, either separately or in combination.

The anodic film which first appears on aluminum is both transparent and colorless, but as the thickness of the film increases, interference colors become visible. If the thickness of the film is further increased it becomes greyish in color.

Time Required for Formation

With the use of direct current, the time required to form the anodic film depends upon the current density at a given voltage, the type and concentration of the electrolyte and the temperature of the electrolyte. The greater the current density for a given electrolyte the more rapid the formation of the film.

With the use of alternating current the same factors apply which have been mentioned in the preceding paragraph with the additional factor of frequency having considerable influence. Obviously, the higher the frequency the slower the formation. The time required for formation of the film with alternating current is much greater than the time required with direct current, assuming the same electrolyte and current density are used in both cases.

In the formation of anodic films there are two general classes of methods employed. These two classes are "still" formation and "continuous" formation.

Still Formation

In the process termed still formation, the anode is placed into the electrolyte and voltage applied until the leaage current decreases to a certain desired value. In the application of voltage in this case the full desired voltage is applied through a current limiting device, or a lower voltage is first applied then gradually increased to the desired value and left at that value until the current has decreased to the desired minimum value.

In the process termed continuous formation, the anode material is passed through the electrolyte at a fixed rate of travel. While the anode material travels through the electrolyte full desired voltage is applied and the current as well as the voltage remains constant. The current density on the surface of the anode material however changes from maximum value at the point of entrance of the anode material into the electrolyte, to minimum value at the point of exit of the anode material from the electrolyte.

Due to the voltage (IR) drop in the electrolyte the actual voltage between anode material and electrolyte at point of entrance is of a very low order and this voltage increases in proportion to the decrease in current density until the full voltage is applied at the point of exit of the anode material from the electrolyte.

Anodic Material

The chemical purity of the aluminum used as an anode in the electrolytic capacitor has considerable influence on the efficiency and life of the capacitor. Impurities affect:

(a) The time of formation of the anodic film.

(b) The direct current leakage of the film.

(c) The amount of corrosion of the anode in service.

The higher the purity of the aluminum the more rapid the formation of the film and the lower the direct current leakage. It has been observed, for example, that the time required for formation of an anodic film on aluminum of 99.8 purity to a given current density at a given voltage was 1/60 of the time required for aluminum of 99.1 purity.

By experiment, it has been determined that the maximum allowable impurities in aluminum intended for use as anodes should conform to the following analysis:

Silicon (Si)	.05%
Iron (Fe)	.1%
Copper (Cu)	.005%
Total others	.045%
	.2%

Corrosion Apparent

In other words, anodic aluminum should show a minimum aluminum content of 99.8%.

The corrosion that occurs in electrolytic capacitors makes itself apparent by pitting of the anode, the development of growths on the anode surface and the deposition of sludge. There is no definite time at which corrosion may occur, it may start soon after a capacitor has been placed in service. In many cases, when corrosion has actually started, the capacitor may continue to function in a satisfactory manner for long periods of time. In fact there is evidence that in some cases corrosion starts then later stops due to electrolytic action and the anoic film forms over the corroded area. In any event great care must always be exercised to eliminate from the entire structure of the electrolytic capacitor any impurity or contaminating influence which might result in any corrosive action. Further mention will be made later to the matter of corrosion and its causes.

Electrolytes for Anodic Film

The formation of the anodic film can take place in either an acid or an alkaline electrolyte. The presence of acid ions in the electrolyte favors the formation of the anodic film on aluminum whereas in some cases the alkaline ions favor the removal of the anodic film especially if the aluminum is made the cathode.

Essentially, the results obtained with different electrolytes are the same, provided similar reactions occur at the anode surface, but the resulting characteristics of the completed electrolytic capacitor may be subject to a wide range of variations in resistance, power factor, direct current leakage and voltage factors.

Photo Cell and Relay

Experiments Simplified For Beginners

By Samuel Wein

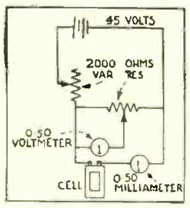


FIG. 1

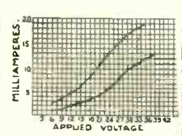


FIG. 2

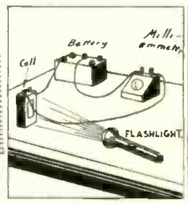


FIG. 3

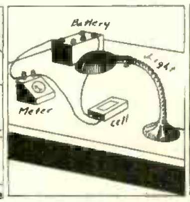


FIG. 4

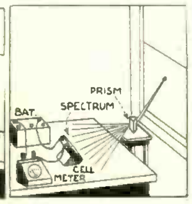


FIG. 5

EXPERIMENT NO. 1

The effect of a change in the applied voltage on the current flowing through a cell

Apparatus: Cell under test; 45 volt B battery; 0-50 d-c voltmeter; 0-50 d-c milliammeter; 50 watt frosted incandescent lamp; switch; and a sheet of graph paper.

Procedure: Connect the apparatus as shown in Fig. 1, arranging the light source so that it will be one foot from the cell. A conveniently reached switch should be connected in series with the lamp.

Since readings of the call should be taken in the dark, it is preferable that the lamp and cell be mounted inside a light tight box, so that the light in the room where the experiment is being performed will not interfere with the results obtained. Even subdued daylight will interfere with proper readings on the meter. Graph paper may be obtained from any large stationery store, or lines may be ruled on a sheet of white paper to simulate a sheet of graph paper. The vertical left edge of the graph sheet is now numbered every five lines with increasing values of current readings representative of cell current. The horizontal lower edge is now numbered every two lines with increasing values of voltage that is applied to the cell. See Fig. 2. It will be noted that the vertical scale is in terms of milliamperes of current whereas the horizontal scale is in terms of voltage.

With the cell in complete darkness, apply as low a voltage as possible to the cell and increase this voltage in small steps until a reading is obtained on the milliammeter. Referring to the curve in the illustration, it will be seen from the curve recorded from a previous test on such a cell that a reading of one milliampere of current was obtained from the cell when the applied voltage was 6 volts.

The method of recording each reading upon the graph sheet is to look along the lower horizontal scale until a voltage corresponding to that value of voltage that exists across the cell is reached. In the case of the test indicated above, this point is 6. Now follow this 6 line vertically upwards until a horizontal line is reached that represents the value of the current flowing under the conditions. In the case of this test it was one milliampere. Therefore, to record this condition on the graph, a dot is placed at the intersection of these two lines.

Now, with the same value of voltage still applied, switch the lamp on and note the milliammeter reading. It will be noted that it reads a higher value, which is also recorded on the graph on the same voltage line but higher up vertically at a point that represents this new value of current. In the case that is illustrated in the graph, it will be seen that this new current was 2½ milliamperes. This process is repeated increasing the voltage gradually in 3 volt steps and recording both light and dark currents obtained at each voltage used. Readings are taken until the maximum voltage is reached or until the current values are too high to be read on the meter available.

At the end of the test, a series of dots will be obtained on the chart which should be connected by a smooth line to form a curve. The lower curve on the chart gives what is termed the current-voltage characteristic of the cell in the dark, while the upper curve gives the current voltage characteristic in the light. It is well that the experimenter plot such a curve in as neat a manner as possible and keep it handy, since such a curve will be useful in future work.

EXPERIMENT NO. 2

How to Show That Current Varies with the Intensity of Light Falling on the Cell

With the cell, meter and battery connected as in the previous experiment, it is possible to show that the change in resistance of the cell and consequently the current through it depends upon the intensity of the light falling on the cell.

To perform this experiment, stand the cell on its end near one side of a table in a dimly lit room, see Fig. 3. Hold the flashlight two feet from the cell and throw the beam of light on the face of the cell. A slight change in the meter reading will be noted. Now bring the flashlight six inches nearer and a higher reading will be obtained. In this manner the light can be brought closer to the cell in short steps and each time a slightly higher meter reading will be noted, indicating that the resistance of the cell decreases as the light on the cell increases, thus permitting more current to flow.

The following variation of this experiment is also of interest. Take the cell in one hand and carry the meter and battery in the other. With the apparatus all connected, hold the face of the cell about 6 inches from a 100 watt electric light or other strong artificial light source, and note the meter reading obtained. Then carry the cell where sun-light can fall on it and note the tremendous increase of current obtained in the latter case. This demonstrates clearly the relative intensities of sun-light and artificial light.

EXPERIMENT NO. 3

How to Determine the Ratio of the "AM" Cell

Connect the cell, meter and battery in series as shown in Fig. 4 and arrange a 100 watt lamp one foot away from the cell. One method of mounting the light is to use a desk lamp, but any other convenient arrangement will serve as well. Lay a piece of heavy cardboard or light metal over the face of the cell. Adjust the voltage at the battery till the meter indicates a dark current of 3 or 4 milliamperes.

Switch on the 100 watt bulb. After making a note of the dark current, remove the cardboard from the face of the cell to admit light and make a note of the meter reading then obtained. The ratio of the cell is then calculated by dividing the light current reading by the dark current reading. For illustration, if the dark current is 3 milliamperes (mills. or milliamps. abbreviated) and the currents is 7 milliamps., dividing the latter by the former we obtain 2 1/3 and the ratio of the cell is 2 1/3 to 1. This means that the resistance in the dark is 2 1/3 times as great as the resistance in the light.

This is one way of rating light sensitive cells, but it is rather crude, for we have seen from Experiment 1 that the resistance of the cell will vary much more if sunlight is used on the cell and the ratio would then be much higher. It is customary therefore to state the conditions under which the ratio was determined, in order that conditions may be duplicated when the ratio is checked again. So we would say the cell under test has a ratio of 2 1/3 to 1 with a 100 watt light at 1 foot.

EXPERIMENT NO. 4

How to Determine the Color Sensitivity of the "AM" Cell

The purpose of this experiment is to show the effect of colored lights on the "AM" cell. This experiment is known as determining the spectral sensitivity of the cell. It is well to plot a curve to show this characteristic and the training will help in the plotting of more complicated curves.

The connections for the appartus are as previously used and shown. The best source of light for the experiment is sunlight and if the apparatus can be arranged as shown, conditions will be ideal. A window is darkened by a large sheet of

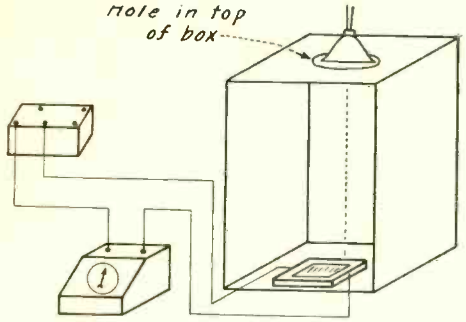


FIG. 6

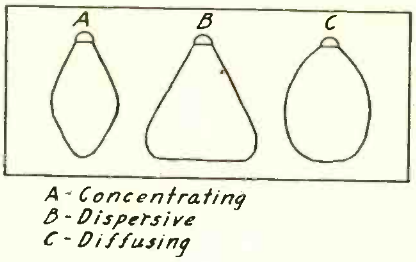


FIG. 7

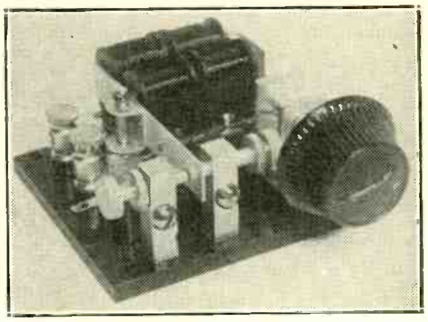


FIG. 8

cardboard and a hole one inch in diameter permits a beam of light to strike the cell in a dimly lit room. A set of colored gelatin filters is required and the lined chart with the illustration used to record the findings.

Set the apparatus up and regulate the voltage till a reading of 2 milliamps. is obtained on the meter.

EXPERIMENT NO. 5

How to Determine the Color Sensitivity of the "AM" Cell Using the Prism

In the absence of suitable color filters, the color sensitivity of the "AM" cell can be determined by the use of a prism. The same set up is used as in the previous experiments, except that a glass prism will be required. See Fig. 5.

With the apparatus connected up and a small dark current reading on the meter, the prism is held in front of the hole in the window screen till a spectrum is thrown on the table. The cell is placed so that the proper end of the spectrum falls on the face of the cell at right angles to prevent any reflection from the glass. This can be done by tilting the cell slightly and placing a wood block under it as shown in the illustration.

The reading with the cell in the violet is noted on the chart in the illustration and as the cell is moved along the spectrum, the readings are taken as each color falls on the cell in turn. The readings are noted on the vertical lines as described in the previous experiment and the dots connected by a smooth curved line. It is interesting to compare the curve obtained in this experiment with that obtained by the use of the colored filters. It may be found the spectrum is too narrow to obtain single colors on the cell window, in this case cover the face of the cell with a piece of cardboard in which a slot has been cut the same width as one of the color bands in the spectrum.

EXPERIMENT NO. 6

How to Compare the Intensity of Light from Two Different Sources by the Zero Method

From this experiment there will be required in addition to the cell, battery and meter, a yardstick, a candle and a 10 watt incandescent lamp connected by means of a flexible cord to the house lighting circuit. The apparatus is set up as shown previously with the cell raised three inches above the table top by means of a block of wood and the yard-stick lying at right angles to the face of the cell.

The voltage is adjusted till a small dark current of about 3 milliamps. is obtained on the meter. The 10 watt bulb is held near the far end of the yard-stick, it is then gradually brought towards the cell until some definite reading is obtained on the meter, say 5 milliamps. Note the distance between the cell and the lamp by means of the graduations on the yard-stick.

The same procedure is now followed using the lighted candles again, when a reading of 5 milliamps. is obtained, note the distance between the candle and the cell.

We can now calculate the relative intensities of the two sources of light, for example, let us assume that when the 10 watt bulb was 8 inches from the cell and the candle was only 3 inches from the cell, the same meter readings were obtained.

Since the same intensity of light was obtained at the cell in both cases and from the laws of illumination, we learn that the light carries as the square of the distance.

EXPERIMENT NO. 7

Plotting the Distribution of Light from a Reflector

The purpose of this experiment is to show how light is distributed by a reflector. There will be required in addition to the cell, meter and battery a large sheet of cardboard about 3 feet square. If cardboard is not available, a sheet of wrapping paper may be used if the top and bottom edges are stiffened by gluing to a thin strip of wood. This sheet has a line drawn down the center and then fastened under the reflector to be tested as shown in the illustration with the center line coinciding with the center of the lamp. The cell is connected to the meter and battery by long flexible leads.

With cell darkened apply sufficient voltage to obtain a dark current of two mills. Switch on the light in the reflector under test and holding the cell at the lower edge of the sheet slowly raise it along the center line till some definite deflection is obtained on the meter, say 4 mills. At this point on the center line place a dot at the top edge of the cell. Now move the cell to the right a few inches and again move it up and down till a 4 mill. reading is obtained and place another dot on the sheet. Move a few inches further to the right and again raise and lower the cell until a 4 mill. reading is obtained on the meter and place another dot. After progressing to the right and in this manner, then go back to the center and repeat the same process on the left. See Figs. 6 and 7.

After covering the right hand half of the sheet in this manner return to the center line and cover the left hand half of the sheet in the same manner.

At the completion of the test there will be a number of dots on the sheet which is then taken down from the lamp and laid on the table. Connect the dots with a smooth line and you will have the distribution curve of that particular reflector. Other reflectors may be tested in the same manner and various sizes of bulbs can be tried to see the effect upon the reflection of light.

In the illustration will be found small insert curves of the three general types of reflectors to guide the experimenter in classifying the one under test.

EXPERIMENT NO. 8

Group of Tests for Relays

Now that we have discussed the various types of selenium cells, their characteristics, and experiments with meters in their circuits, we shall now discuss experiments where the meter is no longer in the circuit and a relay is substituted for this.

The number of experiments possible with a cell and a relay are so large in number that it would take pages upon pages to outline all of them, and since space does not permit these, we shall discuss only those types of experiments which are headed as instructive and amusing, keeping in mind the popular

(*Continued on next page*)

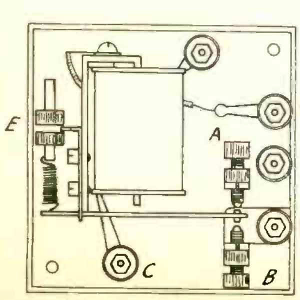


FIG. 9

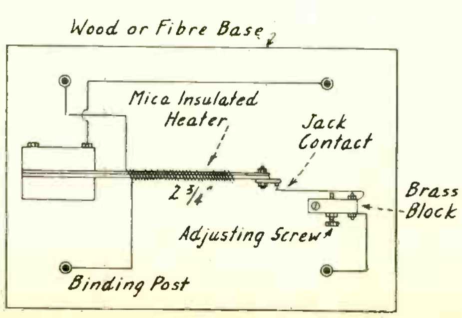


FIG. 10

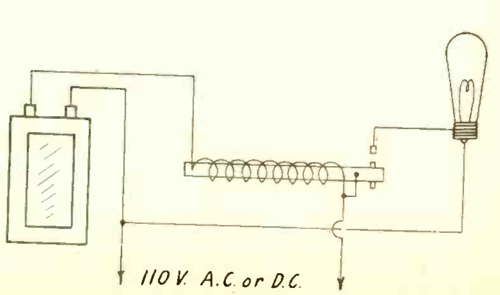


FIG. 11

Thor Introduces New Low-Priced Amplifier

By Robert G. Herzog, E.E.

THOR Radio Corporation offers to the experimenter a very low priced amplifier kit to enable him to enter the field of inter-office communication, store window demonstration, and similar profitable installations, with which he might not have been previously able to compete.

If the amplifier, Model 3F, is purchased in kit form the parts are already mounted on the black crackle chassis and all the necessary holes are drilled. Should any additional holes be required it is advisable to drill these before mounting the parts on the chassis.

The circuit is simple and while conservative embodies the latest in tube circuit design. No feataure has been overlooked that would make the amplifier an outstanding product.

In wiring the amplifier, while all leads should be as short as possible it is advisable to run them along the chassis instead of across in space. The resistors are mounted on small racks and located near to the tubes to which they are connected. This also helps produce a neater amplifier.

When the amplifier is completely wired check carefully, making sure all connections are soldered firmly and that no splashes of solder are permitted to remain. After having checked the wiring, plug in the tubes and speaker, connect the a-c line and some input, from a tuner, pickup or microphone input stage, turn on the juice and the amplifier should give high volume for even a moderate dance hall.

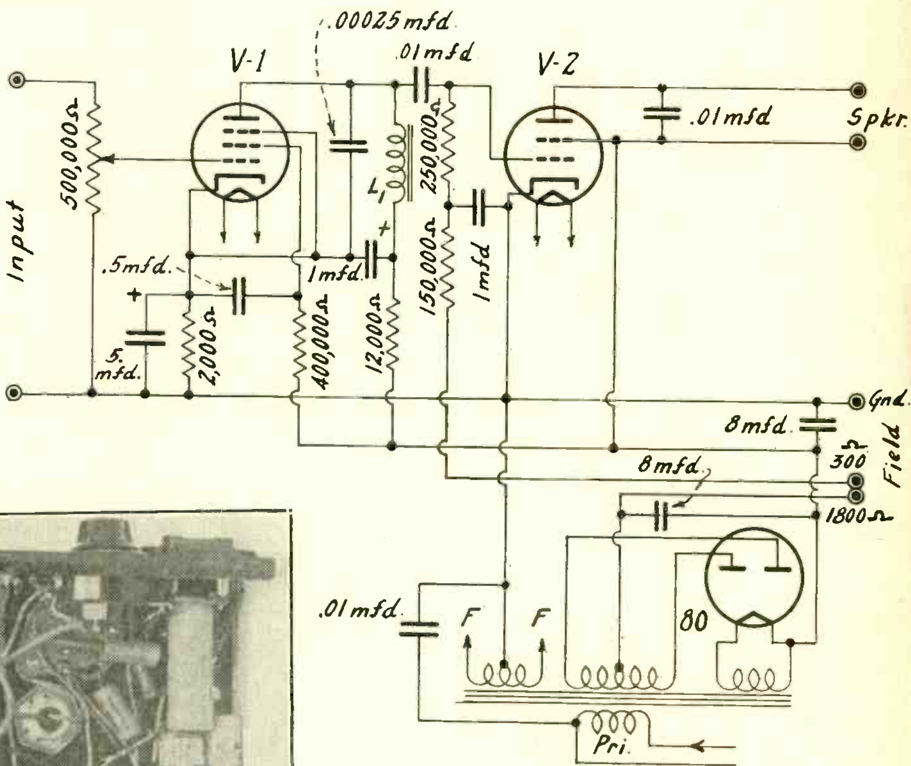
The chassis layout is such that even the novice should find no difficulty in wiring.

The amplifier may be fed directly from any high impedance pickup, or a low impedance one with a suitable matching transformer. Should the experimenter desire to use a microphone, an input stage, consisting of a microphone battery and microphone input transformer, must be used.

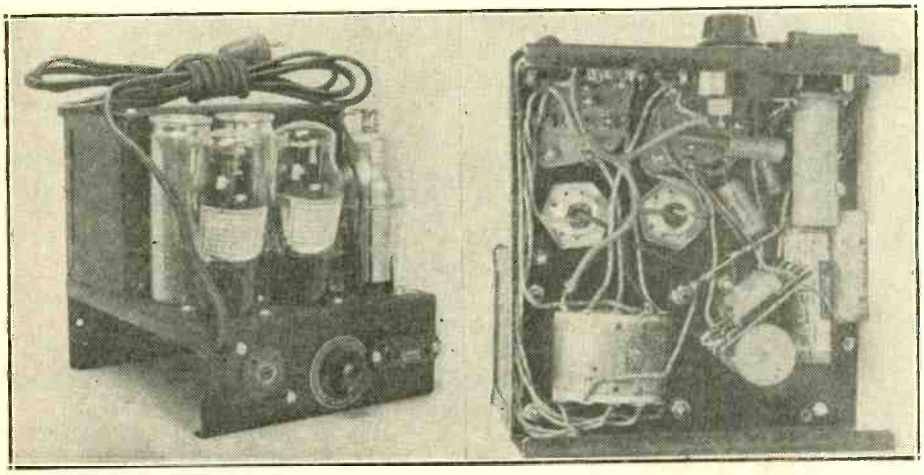
Caution: Do not connect amplifier to the current if speaker is not plugged in.

The circuit is that of the conventional two-stage, impedance coupled audio, using the latest pentode tubes in properly matched circuits. For its compactness it is truly a giant in performance, giving more volume than some large radio receivers and clear, full tone.

A radio tuner may be coupled through a .02 mfd. 400 volt condenser to the input provided the tuner's output tube has a suitable load resistor or choke.



V1 may be a 57 or 6C6, V2 a 2A5 or 42, depending on whether a 2.5 or 6.3 volt secondary is used. Output is 4 watts.



Photographs by Herbert E. Hayden

The circuit used in the Thor amplifier, Model 3F, for inter-office communication, window demonstration talks, and public address to small assemblages generally. Immediately above, views of wired product.

'PLANE OVER PERSIA PICKS UP U. S. A.

The wide range of possibilities that radio opens up when it is utilized in aviation was vividly shown recently when a British mail plane flying over Persia greeted the operator on duty at the Chatham, Mass., station of the Radio Corporation of America. The separation was 8,900 miles.

(*Continued from preceding page*)

appeal with which these experiments were set out to accomplish.

It is obvious of course that hundreds of other experiments will soon suggest itself to the reader, and it is hoped that the text will be the direct cause for this, and the readers write to me with a view of further investigation along these lines.

Before we discuss these experiments in detail, it is necessary that we have a better understanding of the common forms of relays that are available and which may also be made by the experimenter.

The R-4 type relay is seen in the photograph, Fig. 8, in which four head phone type bobbins are each wound to 250 ohms, and these are connected in series to form 1000 ohms. The coils are now placed on a nickel-iron core. The armature of the relay is made of silicon iron (annealed) with ample coin silver contacts to handle a maximum of 1½ amps. non inductive load without undue arcing.

Provision is made for adjusting the space between silver contacts on the armature. Tension is also provided for armature as by means of a phosphor bronze spring through a silk thread and held by means of the Bakelite knob.

This relay will operate at or about 1½ milliamps. with dependability at all times.

The R-1 type relay (Fig. 9) is a modified form of that seen in Fig. 8, where we use in the present case a single coil of 1000 ohms, and the tension of the armature is held as by means of phosphor bronze spring through two knurled adjustable nuts.

This relay, like the foregoing one, will operate as little as 1½ milliamps.

The thermal relay. This is simple, although slow in action. A thin air of thermo-static metal (sometimes known as bi-metal) has a resistance wire wound on it aggregating 8000 to 10,000 ohms, either 38 or 40 B & S guage Nichrome is recommended for this purpose. Details of the relay is seen in Fig. 10. The relay should be operated away from sudden air drafts which will affect its proper functioning. The relay will operate direct with the cell on a.c. or d.c. It is interesting to note here that this relay was used to operate a sign for over a period of months with a change in daylight.

Fig. 11 shows the circuit used with the thermal type of relay.

Radio University

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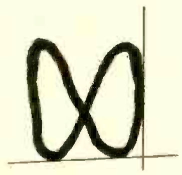
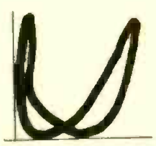
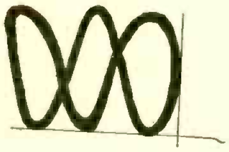
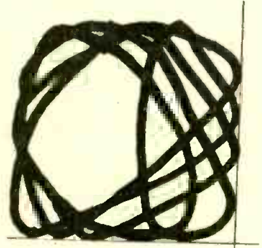
LISSAJOUS FIGURES.

2:1  Fig. 9a

2:1  Fig. 9b

3:1  Fig. 9c

4:5  Fig. 9d

Lissajous Figures

WHAT ARE LISSAJOUS figures and what do they represent?—J. M. L.

The diagram on this page, which illustrates Lissajous figures, will give an idea of what these figures look like in four different instances. These figures appear on the screen of a cathode ray oscillograph tube when two voltages of different frequencies are impressed upon the two sets of deflecting electrodes. In Fig. 9a, the ratio between the two frequencies is 2 to 1 and if one of the frequencies is known, the other is quickly obtainable from this ratio. Similarly, Fig. 9c represents two frequencies that are related to each other by a 3 to 1 ratio. In Fig. 9d, the relation is 4 to 5. Obviously, the method of obtaining these ratios is to draw two straight lines that are about 90° apart and tangent to the figure. The number of tangent points on each axis gives the ratio between the two frequencies.

* * *

Vibrator B Supply

REGARDING THE ARTICLE in RADIO WORLD of January 19 on a vibrator B supply, please advise what size core the transformer is to have. Also, how are the coils wound? On top of each other? Would it be necessary to change the filament coil for different tubes like 01A, 12A, and 71A?—A. B.

The cross sectional area of the transformer core may be one square inch and the laminations should be of such length that the external periphery of the core forms a square three inches on a side. The coils are wound so that the high voltage winding fills the space available first, then the primary winding is installed and finally the low voltage filament winding is placed on top. All these coils may be wound on one leg of the core or the windings may be divided in two between two opposite sides of the core. Should you divide the windings in this fashion, it is important that you wind the coils in the additive direction so that the induced voltages do not buck each other to result in a lack of output results. The 01A, 12A and 71A, are interchangeable because of their similar filament ratings. However each tube will not give the same output power.

* * *

Treasure Seeker

IN THE TREASURE SEEKER circuits outlined in RADIO WORLD for December 1, 1934, please advise whether the two drawings on page 5 are of one or two machines.—M. J. N.

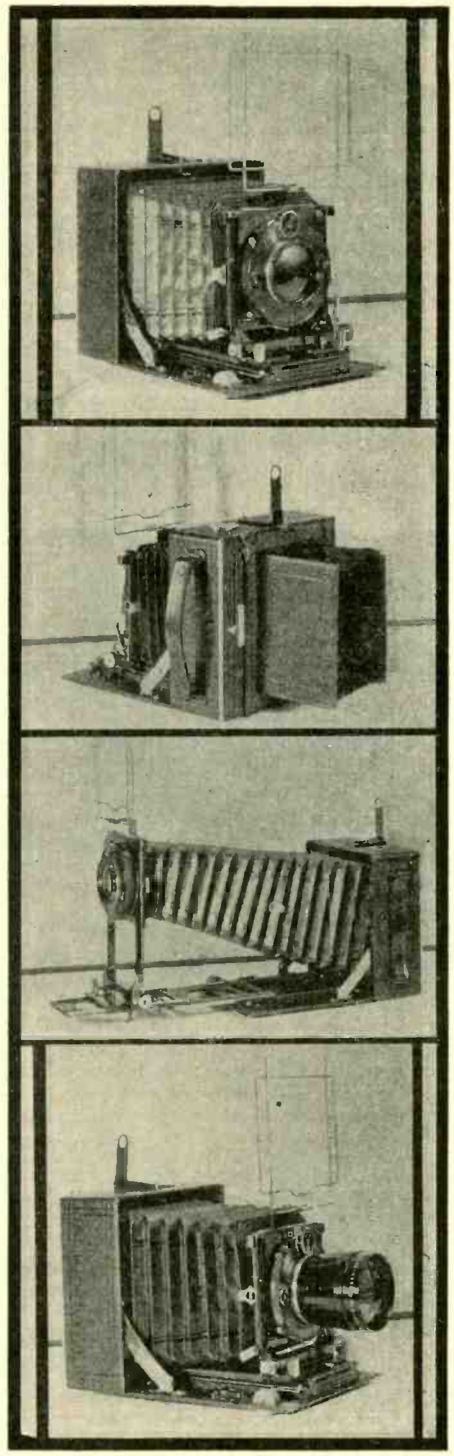
Either sketch may be used to build either the transmitter or the receiver of this equipment. The two drawings are of two machines.

Wide Utility Camera Suits Radio Purposes

So extensive is the photography connected with radio and audio work that many require a camera of great utility, including very short focus work and telescopic photography. On some occasions the object to be photographed is to be shown in individual, intimate detail, and close focus is necessary, so that a lens system that permits taking pictures only a few inches from the object is necessary. One example is cathode-ray oscilloscope photography, another close-up of sections of sets. At other times a medium distance stretches between the object and the lens, as where a console picture is to be taken, also on some occasions an aerial array is to be photographed, and this requires telescopic treatment.

Such a wide extent of purposes naturally requires a camera of the precision type. Since the angle between the ground and the camera will likely be zero degrees, the bellows should be adjustable vertically, while for the different focal lengths of course the bellows must be widely adjustable as to distance from the plane of the emulsion. The lens front tilts backward 15 degrees from vertical, lever locking at any point.

Pictured is a camera that meets such requirements as well as other conditions. It is an extraordinary view type and is known as the Linhof Precision Camera. The model shown takes 3¼ x 4¼ inch (9 x 12 centimeter) pictures, but there are four other models to 5 x 7 inches.



Top to bottom, the wire view finder on the camera is set for outdoor use; the focusing ground glass used for precise work; bellows extended almost to maximum and 15-degree tilt; a special telephoto lens is replacing the normal lens so that objects at a great distance may be photographed.

There are a removable back, full picture size ground glass, 14-inch bellows draw, revolving back with folding hood, accommodation for metal plate and cut-film holders, without removal, and film pack adapter provisions, folding peep sight, full wire frame finder, tripod sockets, and Schneider Xenar f/3.5 lens in Compur dial-set 8 speed shutter (illustrated).

The Linhof Precision Camera is manufactured by Valentin Linhof, Munchen, Germany, and is imported and distributed by Burleigh Brooks, 127 West Forty-second Street, New York City.

Station Sparks

By Alice Remsen

WLW WINS IN COUNT

ONE of the world's most powerful stations, WLW, Cincinnati, was ordered recently to curtail its wattage at night, because of interference with other stations, but Powel Crosley could not see why he should do this, particularly because of a $500,000 investment. So he obtained an order from the Court of Appeals and WLW is still tearing through the ether with its 500,000 watts. . . . Admirers of the eminent baritone, John Charles Thomas, will be glad to know that he is back on the air over an NBC-WJZ network on the Vince program, each Wednesday night at 9:30. He is at present on the Pacific Coast, but expects to be in New York within two weeks. William Daly's Orchestra will then accompany him. . . . There is a very interesting new series now being presented under the sponsorship of the American Tobacco Company, each Thursday at 8:30 p. m. over an NBC-WJZ network. The series is known as Red Trails and embodies genuine adventures of the Canadian Northwest Mounted Police. Stewart Sterling, well-known radio and detective story writer, is the author of the dramatizations. . . . The Pickens Sisters, those peaches from down Georgia way, have signed a new long-term agreement with the NBC. They are at present being featured in the Broadway musical, "Thumbs Up." . . . After a month as the first woman staff announcer for the NBC networks, Elsie Janis is glad to report that she hasn't yet pressed the wrong button that might turn the networks into a nut works; and I'm glad to report that Elsie is swell on programs, because she gets into the mood of an artist so quickly. She's a real professional ad libber, is on her toes all the time, is full of pep and livens up things for everybody.

CANDID CAMERAGRAPH

BEATRICE LILLIE . . . a riot on the air . . . but takes her rehearsing seriously . . . goes into huddle with engineers in control room . . . holds low-voiced confab with production men in studio . . . five men surround her as she stands near piano . . . much mumbling, much page turning, much secrecy . . . takes quick, nervous stride to microphone . . . lifts self on high-chair that looks like a ledger clerk's stool . . . sweeps left hand over closely cut hair . . . a favorite gesture . . . hunches shoulders . . . crosses legs . . . catches heel of left foot in top rung of stool . . . now rests elbow on music stand. . . now rests hand on hip . . . misses a cue . . . says "Sorry" . . . control room men call her "Miss Lillie" . . . repeats over and over her line, "Why, you old bach-elor" . . . mumbles line to self to get proper inflection . . . Warren Hull, her "straight," is told by directors to give an assent by saying "Mmm-mmm!" "How do you spell that?" Hull jokingly asks . . . "Umph, umph," the comedienne replies . . . an assistant proffers her a cigarette . . . then a light . . . raises left eyebrow as she sings . . . lifts the index finger of right hand . . . drops wrist of right hand in 'sissy' gesture . . . song over, pinches lips with fingers of right hand . . . wears low-backed evening gown at broadcasts . . . appears more careful as she takes high-chair . . . twists it around . . . lifts it . . . moves it . . . climbs on it carefully . . . quickly crosses legs . . . this time carries evening bag . . . which she rests on lap . . . appears always cool . . . flushes slightly at applause . . . walks to piano to silver thermos bottle for water which she drinks from paper cup . . . back on stool, rests her evening slipper on lower rung . . . sings . . . tosses music away . . . gestures conservatively during imitations . . . in real life called Lady Peel.

MRS. WIGGS COMES BACK

Alice Hegan Rice's beloved classic, "Mrs. Wiggs of the Cabbage Patch," may now be heard via the radio, each morning, except Saturday and Sunday, at 10:45 a. m. over the WABC-Columbia network. . . . Another new program which has been hailed by the kiddies with delight is the adventures of "Dick Tracy," the popular cartoon strip detective. Sponsored by Sterling Products, Inc., makers of California Syrup of Figs, this serial may be heard each Monday, Tuesday, Wednesday and Thursday at 5:45 p. m. over a WABC-Columbia network. Erwin Shawn is the author of the scripts, and the sketches are produced under the direction of Himan Brown. . . . The program featuring William A. Brady, master showman and theatrical producer, is on a new time schedule, each Saturday at 10:00 p. m. WABC-Columbia. . . . Charles Winninger brings a whole battery of NBC artists to the Columbia microphones with him in the new "Gulf Headliners" series, heard on Sundays at 7:30 p. m. Listen to Frank Parker, the Revelers, The Pickens Sisters and the Frank Tours Orchestra. . . . Bernice Claire, popular musical comedy soprano, is the new prima-donna with Frank Munn, on the "Lavender and Old Lace" series, heard on Tuesdays at 8:00 p. m. over WABC and network. . . . Ivy Scott, well-known musical comedy actress and singer, is now being heard on "The O'Flynn." Ivy portrays the role of The Duchess of Tyrconnel; she sings the part also. . . . The First Lady of the Land is now being heard in a new nation-wide series over WABC and network. Sponsored by the Selby Show Company, makers of Arch Preserver Shoes, Mrs. Roosevelt is devoting the entire proceeds of her broadcasts to charity. She may be heard each Friday at 8:00 p. m. Her programs are of special interest to women . . . . .

JACK PEARL STEPS OUT

When Jack Pearl stepped to the microphone on February 13 for his return to the air in the new role of Peter Pfeiffer, his cousin, Freddie Rich, was on the podium as musical director. The programs, presented over the nationwide WABC-Columbia network by Frigidaire, are heard from 10:00 to 10:30 p. m., EST, every Wednesday. . . . By an odd coincidence of programming, the featured comic and the maestro of the series are first cousins. Their mothers were sisters, and Freddie and Jack were brought up in the same neighborhood in New York City. They were playmates in their boyhood, but since that time they have followed separate paths to fame and have never before worked together professionally. . . . In addition to conducting his 30-piece orchestra in his own sprightly and sparkling dance arrangements, Freddie has a regular speaking part in the program. The musical selections are presented not as interludes to the script material but as integral parts of its episodic action. A 12-voice mixed chorus under the direction of Leith Stevens, young CBS vocal arranger and coach, is also heard with the orchestra. . . .

The Home Town Boys, formerly known as the Tastyeast Jesters, are now being featured on a new series of programs sponsored by John Morrell and Company over WOR, each Thursday at 9:15 a. m. . . . "Vignettes," a program which was heard over WOR last summer, is being resumed. Jack Arthur is the featured soloist, an 'a cappela choir conducted by Dr. Dolphe Martin, narration by Basil Ruysdael, and an orchestra directed by George Shackley, complete the bill, which may be heard each Wednesday at 10:30 p. m. . . .

STUDIO NOTES

Jimmy Tansey, the "Danny" of the CBS program, "The O'Neills," grew up in a theatrical family and has attended twenty-three schools in fifteen different states. . . . Edwin C. Hill, who arrives at the studio generally thirty seconds before broadcasting time, often delivers his talk without removing his fur-collared coat or his derby. . . . Bert Parks once ran a pop-corn vending machine. . . . Amos 'n' Andy are on the road again. . . . Sigmund Romberg has lost five pounds since he began his broadcast series. . . . Helen Gleason was known as "Elena Glisone" during her studies and singing abroad, but when she joined the Metropolitan Opera, she used her American name again.

A THOUGHT FOR THE WEEK

WINSTON CHURCHILL, the British statesman, whose name is perhaps as well known as that of any Englishman, evidently has had a hard time to convince the BBC authorities that he really is important enough to deserve recognition. Mr. Churchill recently was heard over the air in England and his chief concern seemed to be to let his hearers know that he had been trying for four years to reach them via the microphone. And yet in this country we are regaled—if that happens to be the word—by no less a national figure than Huey Long, whose outspoken air messages made the big American and foreign mike figures sound like shrinking drooling toddlers of the nursery.

Phillips Lord Safe

THE RECENT ORDEAL of Phillips Lord in a severe Carribean storm aboard the Seth Parker brought to the forefront the fact that this radio entertainer on his world cruise in a windjammer carries up-to-date radio equipment licensed to the National Broadcasting Company under the call letters of W10XC for a 1 kilowatt transmitter. He escaped the storm unharmed.

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Police thriller short-wave adapter plugs into set for police calls. For '27 detectors only. Order P-1402. Offer B.
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Silver-Marshall output transformer, push-pull pentode (7,000 ohm load) to 8-ohm secondary. Order P-1408. Offer B.
Kit of three doubly-tuned, aluminum-shielded, 175 kc. i-f transformers. Order P-1408. Offer D.
Set of four 6-prong plug-in oils, 200-15 meters, for use with 0.00014 mfd. Three windings. Order P-1426. Offer C.
Power transformer for 5-tube set (2.5v., 5v., h-v), 60 ma. Order P-1428. Offer C.
Power transformer for 8-tube set (2.5v, 5v., h-v.), 90 ma. Order P-1429. Offer D.

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Three-gang 0.00014 mfd. tuning condensers for short waves. Order P 1031. Offer C.
Selection of 15 fixed mica moulded condensers, .0001 mfd. to .001 mfd. State capacities and quantities. Order P-1415. Offer B.
Hammarlund Star Midget condenser. 0.00014 mfd. Order P-1417. Offer B.
De-Jur Amsco dual 0.00014 mfd. Order P-1418. Offer C.
Three 100 mmfd. compression type trimmer condensers. Order P-1419. Offer A.
Eight tubular condensers, 600 volts. Capacities, .002, .006, .01, .02. State quantity and capacities, your selection. Order P-1420. Offer A.
Three tubular condensers, 600 volts, .01, 0.25 mfd. Your selection. State quantities and capacities. Order P-1421. Offer B.
8 mfd. electrolytic. 500v. d.c. Order P-1422. Offer B.
16 mfd. electrolytic, 500v. d.c. Order P-1423. Offer C.
Two 8 mfd. eletrolytic in one case. Order P-1424. Offer C.
Three-gang 0.00035 mfd. ⅜-inch shaft diam. Order P-1425. Offer B.

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Kit of 25 fixed assorted resistors (our selection). Order P-1404. Offer A.
Kit of 50 fixed assorted resistors (our selection). Order P-1404. Offer B.
Volume control portentiometers with a-c switch attached:
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10,000 ohms. Order P-1410. Offer B.
20,000 ohms. Order P-1411. Offer B.
50,000 ohms. Order P-1412. Offer B.
500,000 ohms. Order P-1413. Offer B.
Selection of 15 pigtail fixed resistors, ¼ watt. State values and quantities desired. Order P-1414. Offer B.

MISCELLANEOUS

Two 45 tubes. Order P-1405. Offer B.
Two 26 tubes. Order P-1406. Offer B.
Assortment of screws and nuts. Order P-1407. Offer A.
Twelve tube shields and bases. Order P-1416. Offer A.
Set of 12 wafer type sockets, four, six, seven-medium holes. State quantity and holes. Your selection. Order P-1426. Offer B.
Set of 6 three-piece aluminum shields. Order P-1427. Offer A.

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0.0015 mfd... 12c	0.0006 mfd... 13c	0.0003 mfd... 15c
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Bridge Measured

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500 ohms..... 9c	12,000 ohms.. 11c	80,000 ohms.. 11c
700 ohms..... 9c	17,000 ohms.. 11c	.15 meg...... 12c
1,000 ohms.. 10c	20,000 ohms.. 11c	.2 meg....... 12c
2,000 ohms.. 10c	25,000 ohms.. 11c	.5 meg....... 12c
2,500 ohms.. 10c	30,000 ohms.. 11c	.6 meg....... 12c
3,000 ohms.. 10c	35,000 ohms.. 11c	.7 meg....... 12c
3,500 ohms.. 10c	40,000 ohms.. 11c	.8 meg....... 12c
4,000 ohms.. 10c	50,000 ohms.. 11c	1.0 meg...... 13c

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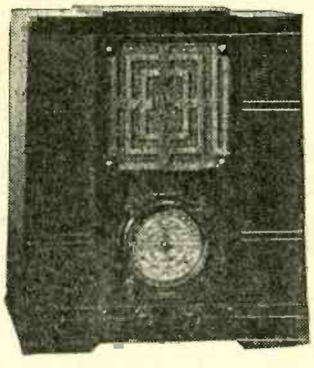

DE LUXE TABLE MODEL
$32.70

THE All-Wave Diamond, introduced only a few months ago, has proved the most popular receiver we have ever offered. Customers are completely satisfied, delighted, overjoyed. Not only low price—the lowest, in fact—but performance on full par with that of expensive receivers. We highly recommend the all-wave model to broadcast-short-wave listeners. It is obtainable in two table-model forms, De Luxe, as illustrated, @ $32.75, with eight RCA tubes, or Gothic, @ $31.55, or in a console model, as illustrated, @ $41.70. The set tunes from 150 kc to 22,000 kc (2,000 to 13 meters) by front-panel rotary switching. Foreign reception on short waves is guaranteed. Thus you have world-wide reception. Automatic volume control, tone control, manual volume control, five-band switch, latest RCA tubes, large airplane dial calibrated in frequencies and meters, 8" dynamic speaker, 3-gang condenser, and lowest price are the attractions. The circuit is a superheterodyne and easy to tune. Tone quality and selectivity are excellent. Sensitivity is remarkably high as far as consistent with low noise level.

You can buy the chassis, speaker and tubes, or either table model set, or console model, whichever best suits your needs.

Cat. 1008-WCH, wired chassis, with eight RCA tubes (one 6A7, two 6D6, one 75, one 76, two 42 and one 80) and heavy-duty dynamic speaker. 50-60 cycles, 110-125 v. Primary power consumption 80 watts. Chassis 13" wide, 7" high, 8¾" front to back. Shipping weight 25 lbs.)............ **$26.10**

Cat. 1008-WCH-25, same as above, except for 25 cycles (25 lbs.).. **27.60**

Cat. 1008-WCH-220, wired chassis, etc., for 50-60 cycles, 220 v. (20 lbs.)................................ **26.70**

Cat. 1008-WDL, standard chassis in de luxe table model cabinet 14½" wide, 16" high, 9½" front to back (28 lbs.).. **32.70**

Cat. 1008-WG, table model in Gothic cabinet (28 lbs.) **31.50**

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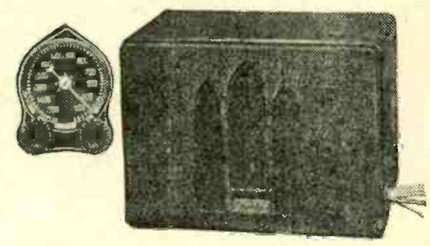
Cabinet models as listed above are for 50-60 cycles, 110-125 volts, but are also obtainable for 25 cycles, 110-125 volts @ $1.50 extra or for 50-60 cycles, 220 volts @ 60c extra.

CONSOLE MODEL
$41.70



DIAMOND AUTO SET
$23.95

OUR previous model Auto Set was so good that the model was not changed in three years. Now at last it has been improved upon, certain mechanical refinements introduced, and tubes of somewhat higher efficiency included. Some of these tubes were not manufactured until recently. Also the set now has a. v. c.

Our 1009-T Auto Radio is a six-tube superheterodyne set, using one 6A7, one 41, one 75, two 78's and one 84, and tunes from 540 kc. to 1,600 kc. It is a one-unit receiver, ruggedly built for long life, and is equipped with a dynamic speaker. It has an illuminated vernier airplane type control. The manual volume control and lock are one combination. The power consumption is 4 amperes.

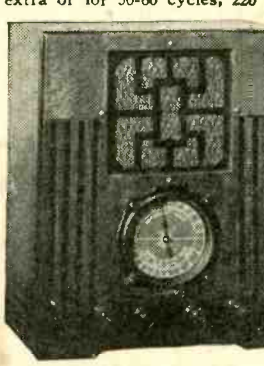
No B batteries required. There is a B-eliminator built in.

This is one of those fascinating auto sets that has single-hole mounting provision, and therefore is a cinch to install. There are only two connections to make: (1) to the ammeter; (2) to the aerial.

The remote tuner is, of course, supplied with the set. And the spark plug suppressors and commutator condenser are supplied also.

The size is 8¾ inches wide, 6 inches high, 6¼ inches front to back. Shipping weight is 18 lbs.

Order Cat. 1009-T, wired, in cabinet, complete with six RCA tubes. Price, $23.95



2-BAND DE LUXE
$20.37

ANOTHER popular receiver is the dual-wave type that covers the broadcast band and one short-wave band. On that one short-wave band are found the most important foreign stations. The coverage of the Model 1042-PD receiver is: broadcast band (550 to 1,500 kc) and short-wave band (5,500 to 16,000 kc). Therefore the short waves are tuned in from 18 to 55 meters, and that is the band on which the most important foreign program transmitters are working. Anybody who has not had his taste of short-wave reception will do well to be initiated with either of these two dual-band receivers. Model 1042-PG is illustrated at right, and is a superheterodyne for foreign and domestic reception. There are also the following valuable features: built-in antenna, frequency-calibrated dial, separate short-wave switch (no plug-in coils), dynamic speaker, figured walnut cabinet with figured Oriental overlays. And the price of Model 1042-PG is only $19.17 net.

Model 1042-PD, illustrated at left, is the same circuit in a de luxe table cabinet. The two table models have an airplane frequency-calibrated and illuminated dial, and besides can be obtained for battery operation and 32-volt operation. It is a superheterodyne of the switch type, covering the broadcast band and 18 to 55-meter short-wave band. It has automatic volume control and tone control. It is for 105-120 v. 50-60 cycle operation. Primary power consumption 60 watts; shipping weight, 17½ lbs. Net price. **$20.37**

Cat. 1042-PCH, wired chassis, 9" wide, 7" high, 6" front to back; dynamic speaker, five RCA tubes (one 6A7, one 6D6, one 75, one 42 and one 80), 550 to 1,500 kc and 5,500 to 16,000 kc. For 50-60 cycles, 110-125 v. (14½ lbs.) **$17.10**

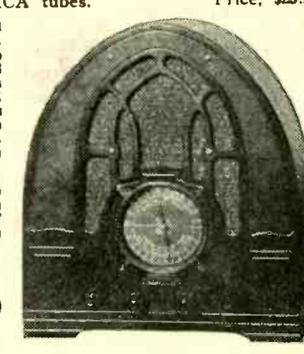
Cat. 1042-PG, table model Gothic cabinet. (17½ lbs.)........................ **$19.17**

Any of 1042 series, 50-60 cycles, 220 v. @ 60c extra; 110-125 v., 25 cycles @ $1.50 extra.

Cat. 1042-PBCH, battery model chassis for 6-volt storage battery and B battery operation (batteries not supplied); complete with tubes and speaker. (14½ lbs.) **$21.90**

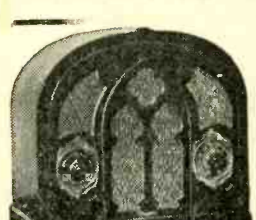
Cat. 1042-PBG, same as above (battery model) in Gothic cabinet, with tubes, speaker. (17½ lbs.).. **$23.97**

Cat. 1042-PBD, battery model, in de luxe table cabinet. (17½ lbs.)........ **$24.17**



2-BAND GOTHIC
$19.17

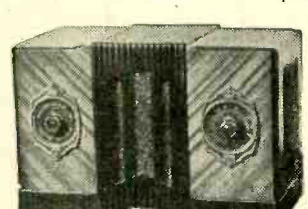
$13.17



$13.77

540-1900 KC BROADCAST SET

FOR those interested only in the broadcast band we have a splendid ac t-r-f model DIAMOND OF THE AIR that tunes from 540 to 1,900 kc. and therefore gets some police and amateur calls as well; that has frequency-calibrated and illuminated airplane dial; and that can be bought, complete with tubes, all wired and ready for operation of its self-contained dynamic speaker (left-hand illustration above) at only $13.17. Order Cat. 1041-XG, for 50-60 cycles a.c., 105-120 volts. The same set is illustrated at right in de luxe cabinet, price $13.77. Order Cat. 1041-XD. Not only may the receiver be bought already in either cabinet, but separately as a wired chassis, with speaker and tubes (less only cabinet). Besides, there is a model for 25 cycles a.c., 90-120 volts, and another for 220 volts a.c., 50-60 cycles. This is a tuned-radio-frequency receiver, five-tube model, using two 6D6, one 6C6, one 42 and one 80. It will be noticed that the economical and electrically strong 6-volt series tubes are used in the receivers proper. The primary power consumption is 55 watts. Not only is this a fine receiver, but it is made right, and every attention has been paid to detail. The airplane type dial is frequency-calibrated, so that the frequencies are read directly. There is provision for phonograph connection. The wired chassis is Cat. 1041-XCH, complete with speaker, tubes, $11.97. Shipping weights of 1041 series, 11½ lbs. 25-cycle models, $1.20 extra. 220-volt models 60c extra.



2-BAND OBLONG
$17.37

The above set is a two-band 5-tube ac-dc universal receiver for 50-60 cycles, 110-125 volts, and is Cat. 1042-U, $17.37 (10¾ lbs.). It uses one 6A7, one 6D6, one 75, one 43 and one 25Z5. Sold complete with RCA tubes. Ranges, 550 to 1,500 kc, 5,500 to 16,000 kc. Approximate kilocycle calibration. Band change by switching.

Cat. 1042-UE is in the same cabinet, etc., but tunes from 150 to 350 kc and from 540 to 1,500 kc. For European use. Price $18.57, complete with tubes.

Either above, with 220-volt adapter, 90c extra.

AC-DC MIDGET
$11.37

Model 1040-V. 4-tube universal, ac-dc, 90-120 v., wired receiver, complete with four RCA tubes, and coil for the broadcast band only; contained in attractive midget cabinet; dynamic speaker. Shipping weight, 8 lbs. Net price $11.37

Model 1040-VSW. Same as above, except that four coils are supplied for the short waves only, 1500 kc to 20 mgc. Shipping weight, 8 lbs. Net price $14.97

Model 1040-VAW. Same receiver, with broadcast coils, also low-frequency coils (to 110 kc) and short-wave coils (1,500 kc to 20 mgc). Shipping wgt., 8 lbs. Net price..$16.77

ADAPTERS

Auto adapter, complete with suppressor. Cat. 1040-VATAD.......$7.50

32-volt Farm Light Plant Adapter. Cat. 1040-VFLPA $5.60

220-volt adapter for ac-dc use. Cat. 1040-V-220 .... .95

GUARANTY RADIO GOODS CO.
145 West 45th Street, New York, N. Y.