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Television

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APRIL, 1929

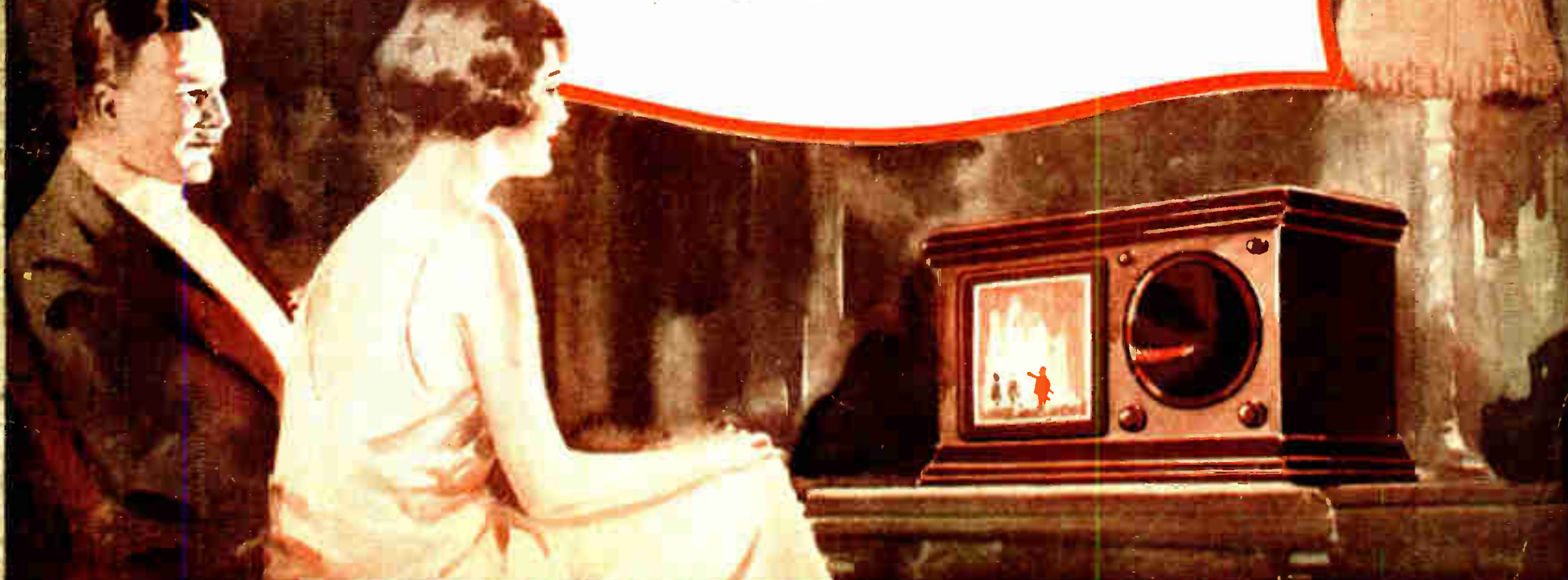
LAMPS THAT FLICKER 48,000 TIMES A SECOND
By H. WOLFSON

MASTERING THE OPTICS OF TELEVISION
By PROFESSOR CHESHIRE

HOW TO MAKE SCANNING DISCS WITH SQUARE HOLES
By PIERSON E. CUSHMAN

RICH REWARDS FOR THOSE WHO CAN SOLVE THESE PROBLEMS
By D. E. REPLOGLE

DO YOU KNOW THE THREE SOURCES OF PHOTO CURRENT?
By SAMUEL WEIN



AMERICA'S FIRST TELEVISION JOURNAL

In the Next Issue of This Magazine

CATHODE RAYS IDEAL FOR TELEVISION

By
W. G. W. MITCHELL

Thru the Editor's Spectacles

IT estimated that we now have at least 100,000 amateur television outfits in operation, most of them in the Middle West. Having reached what almost amounts to perfection in the reproduction of sound, there is little wonder that the great army of radio enthusiasts are turning their attention to visual radio. Their diligence and patience will no doubt soon bring about many important changes in technique and design. Engineers invent. Amateurs discover.

One has to live in Chicago nowadays if one is to enjoy the new sport of receiving television pictures. WRNY made an admirable effort to pioneer in New York, but the heavy hand of the Radio Commission stopped the work. Is it not better that WXYZ should be accorded the privilege of filling the ether with the cheap advertising of the Ajax Credit Clothing Co. than that television should be given an opportunity to prove itself? All in all, the Federal Radio Commission has done but little in any department of the radio art to justify its existence.

The Editor is most anxious to have letters from readers who have been experimenting with television reception. Photographs of equipment are welcome, too. If enough of this sort of material is received, a special department will be given over to it and no doubt many interesting developments and hints would be brought to light. The editorial latchstring is also out to those who have new ideas concerning this most fascinating of all hobbies.

(*Continued on page* 136)

Television

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VOLUME ONE NUMBER FOUR

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T E L E V I S I O N

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Editor-In-Chief
RAYMOND FRANCIS YATES
Member Institute of Radio Engineers, Fellow Radio Club of America

Managing Editor
GROSVENOR K. GLENN

Associate Editor
HENRY M. LANE, E. E.

Technical Advisor
RUTHERFORD KENNEDY

DAVID SARNOFF PREVISIONS TELEVISION*

"I look for great progress within the next five years in the dawning age of sight transmission. I see developments not only in the transmission of a rapid succession of still pictures, but also in the instantaneous projection through space of the light images produced directly from the object or scene brought to the broadcasting studio.

"And once these things are accomplished it is but reasonable to expect the transmission of objects in their natural colors. And finally, I look forward to the time when a three dimensional projection will be possible so that it will be difficult to differentiate between reality and its electrical counterpart.

"In the meantime, it must be remembered with the poets that art is long and time is fleeting. There is no short cut in the unfolding of an art that promises to extend the range of the eye as it has the range of the ear, to the four corners of the earth."

---

* David Sarnoff, Executive Vice-President of the Radio Corporation of America, is recognized as the foremost authority in America on all that has to do with the commercial development of radio. That television holds wonderful possibilities is manifest to him.

Television

AMERICA'S
FIRST TELEVISION JOURNAL

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Volume 1. March-April, 1929 Number 4

Lamps That Flicker 48,000 Times a Second

The flickering neon lamp is one of the most important components of a television receiver and yet but few experimenters fully understand its underlaying of operation. In this article, Mr. Wolfson, an authority on the subject of the discharge of electricity through gases, delves into the subject with fascinating clarity. The subject should be understood by every television experimenter.

H. WOLFSON

IN my previous articles I have endeavored to give readers of Television some idea of the problems underlying the transformation of light into electricity by the agency of the photo-electric cell, and by way of a change I am proposing to devote this article to the consideration of the device which is employed to effect the reverse process—i.e., the conversion of electricity into light.

The name of this device is, as we all know, the neon lamp. However, before we commence our consideration of this, we must of necessity be fully conversant with the theory of the discharge of electricity through gases, as well as with the practical problems to be encountered when dealing with this subject.

Apparatus Required

The apparatus employed consists of a glass tube about 30 inches long and two inches in diameter, with metal electrodes sealed in at the ends. A small side tube serves to connect the tube with a vacuum pump. The tube, which is shown diagrammatically in Fig. 1, is then gradually exhausted of air while its terminals are connected to an induction coil, the spark-gap of which is about ten centimeters long.

The purpose of the gap is to provide an alternative path for the discharge, and at first the whole of the discharge passes across this path of least resistance. On the air in the tube becoming partially rarefied, however, luminous lines appear in the tube, and the flow of sparks across the gap ceases. A most interesting series of changes now commences to become apparent. The first phenomenon to be noticed is that the tube is filled with a luminous crimson column, usually extending the full length of the tube, and called the *positive column*. At this stage the gas is a very good conductor, as shown by the fact that the spark-gap can be reduced in length to less than one millimeter without any spark passing.

After some little time the color disappears, and luminous discs known as *striæ* are formed. In a few seconds it will be noticed that there is a dark space, called *Faraday's dark space,* adjacent to the luminous cathode. Further changes take place as the rarefication proceeds, for the striæ become wider, and the dark space becomes less marked, while the luminous glow leaves the cathode, and thus gives rise to a second dark space in the neighborhood of the cathode which is called *Crooke's dark space,* after its discoverer.

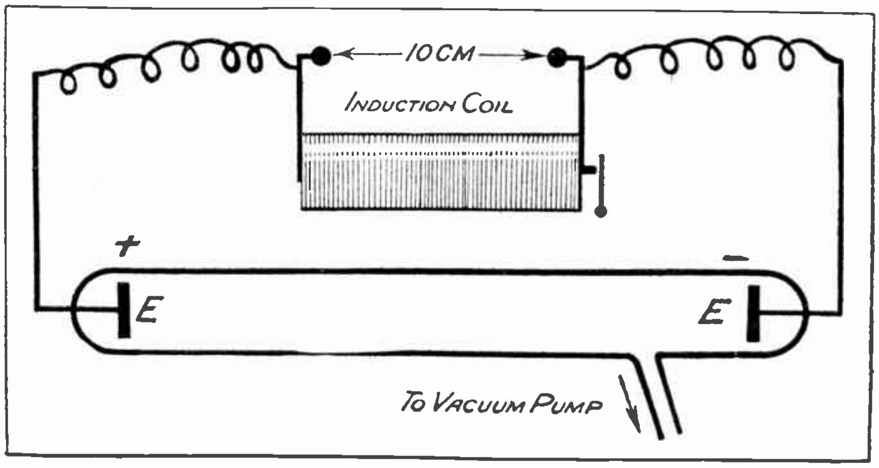


Fig. 1.—Simple apparatus required to demonstrate the conductivity of gases at varying pressures. EE=Electrodes.

Crooke's Dark Space

At this stage the conductivity of the gas begins to decrease, and the Crooke's dark space extends till it fills the whole of the tube. When this state of affairs is reached the walls of the tube are covered with a phosphorescent light, whose color depends on the chemical composition of the glass. More often it is bright green, due to the presence of soda in the glass, while a lead glass gives a blue color. The pressure now is of the order of *one-millionth of an atmosphere,* and the resistance is so high that it is extremely difficult to make the discharge pass through the tube.

I have endeavored to illustrate these various stages in Fig. 2, but since an actual demonstration is necessary to show the extreme beauty and wonderful variation of the many phenomena, the drawings are of necessity but poor representations of the phenomena associated with the discharge.

The presence of various gases in the discharge tube has a marked influence on the color and other characteristics of the discharge, and while the tube is in the early stages of exhaustion, it is possible to identify the gas present by the color produced. For instance, coal-gas produces green, air or nitrogen pink, with a violet cathode glow, while carbon dioxide gives white, and hydrogen blue or crimson, depending on the width of the tube. The case of neon, however, is the most interesting from our point of view, and the warm reddish-orange glow is familiar to most of my readers who have seen the Osglim lamp or those numerous electric signs, consisting of glass tubes twisted to form words which are filled with a flickering orange glow.

What is Neon?

At this point I feel that there are no doubt a number of my readers who are wondering about the gas neon, which plays such an important part in television. What is it, and how is it obtained? I feel, therefore, that I shall be pardoned if I digress for a few minutes in order to explain this matter fairly completely, in a manner as simple as possible.

During the course of a series of experiments to determine very accurately the density of nitrogen, Lord Rayleigh found certain discrepancies betwen the results obtained with chemically prepared nitrogen and that obtained from the atmosphere. This should not be so, for nitrogen is a chemical element, and thus has characteristic and unchangeable properties, both chemical and physical; hence suggestions were invited as to the possible cause of the greater density of atmospheric nitrogen.

Untenable Theories

A number of theories which proved to be untenable were put forward, but Ramsay, a famous scientist, suggested that the nitrogen from the air was contaminated with some gas or gases hitherto unknown, and after working on the problem for some little time he was able to announce in 1894 the discovery of a new gas, which he called *argon.*

After a short time, research on argon showed that this gas, too, was not a simple or elementary substance, but that it consisted of a mixture of five gases, all having a marked resemblance to one another in their extreme inactivity towards other chemical substances.

Helium, neon, argon, krypton and xenon were the names given to these gases, their names being derived from Greek words meaning respectively "the sun," "new," "idle," "hidden," and "stranger," all of which are singularly appropriate.

How Neon is Obtained

Neon is now obtained exclusively from the atmosphere, though it is present to a very small extent in the gases from certain minerals and mineral springs. The air is liquefied, and the liquid air is then fractionally distilled, and, since the boiling points of the various component gases in the air are all different, this enables a partial separation to be effected. By a repetition of this process several times with the crude fraction of the inert gases, it is possible to separate a mixture of neon and helium from the other contaminating gases. If, now, the mixture of liquid helium and neon is placed in a vessel surrounded with liquid hydrogen, the neon freezes to a white solid, and can thus be separated from the helium by the simple expedient of pumping away the helium with an air pump, which has no effect on solid neon.

This brief summary, though it will suffice to explain the process to those of my readers who have not made a detailed study of chemistry, gives only a very rough idea of the difficulties to be encountered in actual practice, in order to obtain the neon as pure as possible.

Minimum Voltage Required

Returning now to the consideration of the neon lamp from the point of view of physics, we find ourselves confronted with a difficult but, nevertheless, interesting problem. The glow discharge of the neon lamp is exactly the same as those which we have previously considered at the beginning of this article, though it differs in the one respect that the voltage necessary to start the discharge is very much lower—about 164 volts, to be exact.

In order to explain the colored glow we must realize that the lamp is filled with neon at very low pressure, or, in other words, the number of atoms of neon present is *relatively* small. Those who have done so much work to develop the neon lamp have found it to be very important to make certain that this pressure has a certain exact value in each lamp, in order that it shall function correctly.

When the lamp is switched on, an electric current at a voltage of 164-170 is forced through the tube, and as a result of this the neon atoms become heated, and glow with the color characteristic of the neon spectrum.

Two points of great importance to television should be noted at

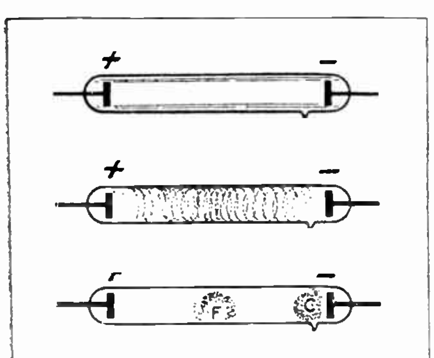


Fig. 2.—An attempt to illustrate the forms which an electrical discharge takes when forced through gases at varying pressures. These discharges are so vivid and beautiful that it is impossible adequately to describe them in a line drawing. C—Crooke's dark space. F—Faraday dark space.

this point. First, the neon tube possesses no appreciable time-lag or inertia, and thus responds instantaneously to the passage of an electric current. This fact becomes all the more remarkable when we realize that it has been shown possible to light or extinguish the lamp at the enormous rate of one million times per second. The second point is that the intensity of the glow is directly proportional to the current strength.

Light Source Requirements

The importance of these points lies in the fact that it is essential that we should employ a device at the receiver which can respond instantaneously and exactly to the received and amplified impulses, which correspond to those variations in light and shade of the transmitted object.

We come now to the most im-

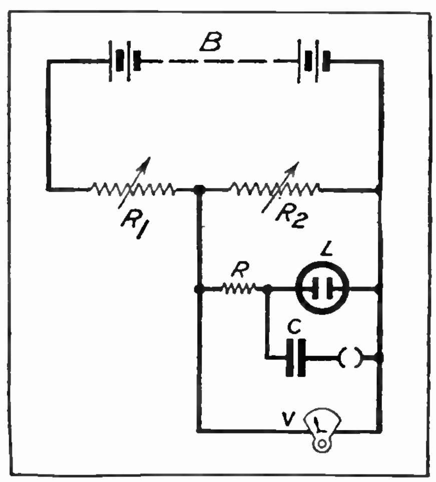


Fig. 4.—The circuit evolved by Pearson and Anson for determining the minimum sparking voltage of neon tubes.

portant part of this article, in which we shall consider fairly fully the electrical properties of the neon lamp, and the factors which govern the rate of flashing, for it is only by a thorough understanding of these matters that we shall be in a position to fully appreciate its application to television.

The first important determination in connection with the neon lamp, and one which has received a great deal of attention from various workers, is the voltage-current relationship, or characteristic curve, a determination analogous to the finding of the characteristic of the ordinary wireless valve.

Apparatus Required

The apparatus, the theoretical circuit of which is shown in Fig. 3, consists of a lamp in series with a

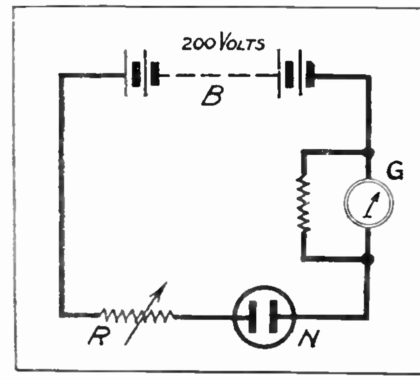


Fig. 3.—Circuit for determining the characteristic curve of a neon tube. N=Neon lamp. G=Shunted galvanometer. R=Variable resistance. B=Battery.

high tension battery of some 200 volts, a shunted suspended coil galvanometer which is calibrated to read as a milliammeter, and an adjustable resistance, which serves to vary the current through the lamp. The voltage is best determined by an electrostatic voltmeter, because this type of instrument takes no current from the circuit, since it works on the condenser principle.

It has been noticed by a number of workers that the current and voltage only settle gradually to their final values, so that it is necessary to wait about fifteen minutes after varying the resistance, before taking the readings on volt and ampere meters.

The next important figure to be determined is the sparking potential, which is the minimum voltage necessary to start a discharge. The method employed is to increase the voltage slowly until a discharge occurs, and to measure this voltage directly.

An alternative method, slightly more complicated, was evolved by Pearson and Anson, and I mention it here as it gives an insight into the practical principles involved in the flashing of the neon lamp, a property which has made the lamp of such great practical utility to television.

Determining Minimum Sparking Voltage

The circuit of the apparatus is illustrated in Fig. 4. *B* is a high tension battery, across which are connected resistances R_1 and R_2. The neon lamp, *L*, has a condenser placed across its ends, while *R* is

(Continued on page 137)

MASTERING *the* OPTICS *of* TELEVISION

PROFESSOR CHESHIRE, C.B.E.

The subject of light and optics is so closely allied to the subject of television that no television experimenter worthy of the classification should neglect this highly important branch of his art. Here indeed is a most absorbing article on the subject of reflection. It is being prepared by a widely-known authority and it may be read and digested with great benefit by those who are laboring to perfect improved optical apparatus for use in television.

IT is curious to reflect that the belles of the Stone Age who, some half a million years ago, knelt down by the sides of still pools to gaze upon the reflection of their charms, and apply the few cosmetics then known, were using an optical arrangement which, judged by the perfection of the optical images produced, has never been surpassed by optical science.

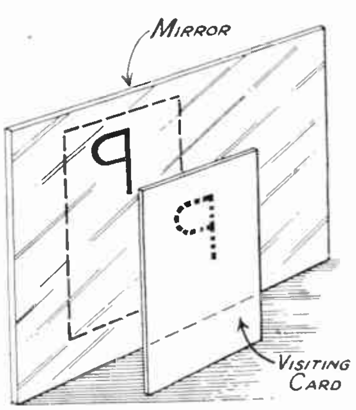


Fig. 1. The effect of a single reflecting surface.

The image produced by a flat reflecting surface of such an order of accuracy as that to be found on still water is appreciably superior in several important respects to the best image that can be produced by any lens, or combination of lenses. It is, however, a virtual image. The reflected rays do not actually come from it, they only appear to do so. A plane mirror, therefore, cannot do the work of a photographic lens.

The modern optician depends to a great extent upon reflecting elements, either plane or curved, in the designing of optical apparatus. The telescopes, periscopes, range-finders, gun-sights, position-finders, surveying instruments, signalling apparatus, and a large number of other instruments, used in such great numbers during the late war, all embodied in their construction, to a greater or less extent, the plane-reflecting element.

Fundamental Experiments with Plane Reflectors

A number of instructive and fundamental experiments can be carried out with three squares of ordinary looking-glass. (The thinner the glass the less troublesome becomes the light reflected from the first surface.) For use with these the letter "P" should be drawn boldly on a piece of cardboard, such as a visiting card.

Experiment 1.—Take one of the mirrors and hold the card in front of it as shown by Fig. 1. Observe the reflected image. The letter "P" is reflected as "q," i.e., it appears laterally reversed, or right for left, so that a right-hand glove, thrown down in front of the mirror, appears as a left-hand glove. Move the card in its own plane to the right and left, and up and down. The image moves with the object in every case. It is always seen as being opposite to the object. Each point of the object is duplicated in the image—the plane of the mirror is a plane of symmetry for object and image.

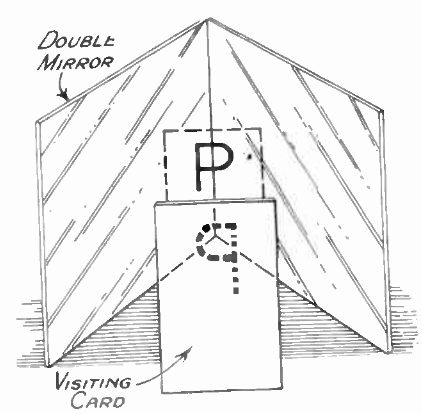


Fig. 2. Two mirrors arranged at right angles, to form a double reflector.

Experiment 2.—Take two of the square mirrors and erect them on the table, edge to edge, so as to make a right-angle with one another, like the covers of a half-open book, as shown by Fig. 2. The letter "P" is now reflected as "P": there is no reversion as in the last experiment. On moving the card vertically the image follows it as it did in Fig. 1, but when the card is moved sideways the image moves off in the *opposite* direction.

Experiment 3.—Arrange two of the mirrors as in Fig. 2, but on the face of the third mirror instead of

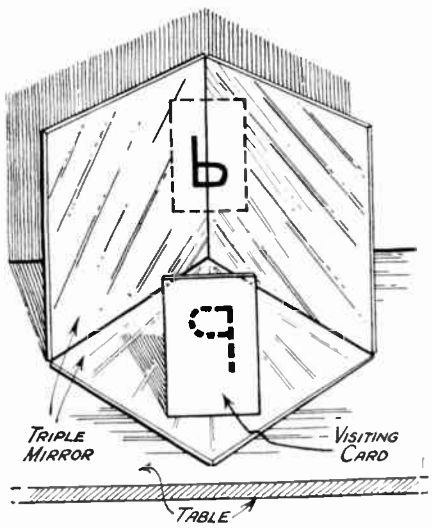


Fig. 3. Three mirrors arranged to form a triple reflector.

the table top. The three mirrors will now (Figs. 3 and 4) be mutually at right angles to one another, as though lining one of the inner corners of a box, and forming what is sometimes called a triple reflector. The letter "P" is reflected (Fig. 3) as "b," and in whatever direction the card is moved across the axis* of the mirror, the image moves off in the opposite direction.

A Weird Effect

A weird effect is obtained by looking directly into the mirror. Nothing is seen distinctly except an eye stolidly staring in the corner where the mirrors meet (see Fig. 4), and this eye appears to remain fixed in space no matter how the observer moves about in the room in which the experiment is carried on. Closing either the right or the left eye produces no effect. The observer becomes more and more bewildered until he is tempted to ejaculate: "Good heavens! Whose eye is it, and which?"

* The axis of a triple reflector is the axis of symmetry, *i.e.*, a line passing through the common meeting point of the three mirrors, to each of which it is inclined at the same angle.

This triple reflector, if angle-true, possesses the remarkable property of returning upon itself a beam of parallel light entering it at any angle, within wide limits, of inclination to the axis of the reflector, so that, in the experiment with the eye, the right eye sees the reflection of itself only—the reflection of the left eye is invisible to it. Similarly with the left eye.

This property of the triple reflector has been taken advantage of in several ways. Such a reflector, for example, could be fixed to the bottom of an aeroplane to reflect back along itself a beam from a searchlight below. Then by means of a postcard, flicked backwards and forwards across the opening of the reflector, an airman could transmit messages by Morse which could not be seen at any place other than in the immediate vicinity of the searchlight.

Optical Action of Plane Reflectors

The optical action of the most complicated system of plane reflectors can be determined from a single law, which may be stated thus:

When a ray of light is reflected at a point of a plane surface the reflected ray and the incident ray make equal angles with the normal

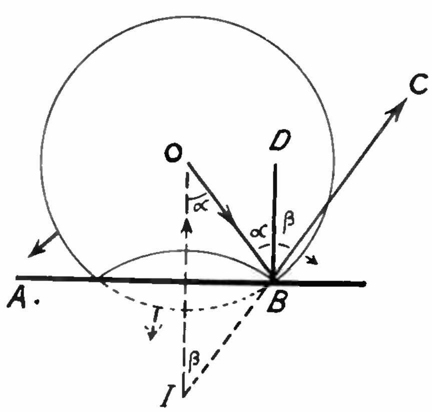


Fig. 5. The reflection of light waves and rays by a plane mirror.

to the surface at that point, and the incident ray, the normal and the reflected ray lie in the same plane.

This law can be proved experimentally, and it can also be shown to follow simply from Huygen's wave-theory of light. This proof follows these lines: Suppose that light waves starting from the point O, Fig. 5, strike the surface of the plane mirror A. Each spherical wave will first strike the reflecting surface at a point which occurs at the foot of a perpendicular dropped from the point O, on to the surface of the reflector A, so that the reflected wave must,

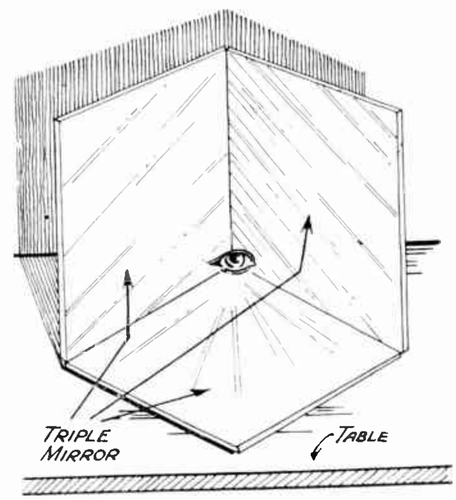


Fig. 4. The weird result of staring at a triple reflector. Only one stolid eye is seen.

from considerations of symmetry alone, have for its centre a point I, which occurs in the perpendicular dropped from O, and at a distance from the mirror equal to that of the point O. The point I is thus said to be the image of the point O in the mirror A—a phrase of which we shall make considerable use.

A direct wave and its corresponding reflected wave are shown as simultaneously passing through the point B. OB is a ray for the first of these waves, and BC, a continuation of the radius IB, a ray for the second one. The line BD is a normal to the mirror A at B, and is therefore parallel to OI.

Since, then, the angle x at O and the angle β at I are equal, and these angles are respectively equal to the angles of incidence and reflection, the angle of reflection is equal to the angle of incidence and the ray OB, the normal BD, and the ray BC lie in the same plane, i.e., the plane of the paper in the figure.

It should be noted that it follows from Huygen's construction here briefly referred to, that (1) spherical waves are reflected accurately as spherical waves, and (2) that the position of the image point is independent of the wavelength of the light employed. For white light, therefore, it is the same for all colors. Strictly speaking, neither of these two statements is true for an image produced by a lens, as we shall see later.

In some cases it will be found that a perpendicular cannot be dropped to the surface of the mirror. This surface must in this event be produced as shown in dotted lines in Fig. 6 as a preliminary to finding the position of the image. To trace a ray from the object O to the eye at E it is only necessary to draw a line in the direction EI until it intersects the mirror at A, and then connect A and O. The ray required takes the path OAE.

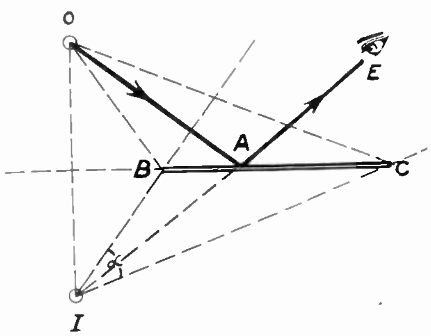


Fig. 6. Ray diagram for a mirror when the object point is on one side of it.

Fig. 7 illustrates multiple reflection such as occurs in the kaleidoscope. Two mirrors A and B are reared perpendicularly to the plane of the paper, and at right angles to one another. An object, such as a candle, is placed at O, and an eye, E, as shown. It is required to trace a ray from O to E which is reflected twice, once by each of the two mirrors. We must first find the positions of the various images by the usual device of dropping perpendiculars from O on to A and B, and continuing them for equal distances on the other side.

These images I_A and I_B must fall upon a circle struck from C with a radius CO. Any ray which enters the eye after a single reflection from A must do so from I_A, and similarly, in the case of the mirror B, from I_B.

Now let us find the position of the image of I_A in B and I_B in A. The two will coincide in I_{AB}. Any ray, therefore, which enters the eye after two reflections must do so in the direction E, I_{AB}. Draw this line and from its point of intersection with B continue it towards I_A, and from the point of intersection of this line with A to O, and the problem is solved.

If the eye had been above the line $I_{AB}C$ continued the first reflection of the ray from O would have taken place on the mirror B.

Optical "Billiard-Table" Problem

Fig. 8 illustrates in plan an old and interesting optical problem known as the billiard-table problem, which we will consider because it affords a beautiful example of how a ray can be traced through a system of plane mirrors.

Plane mirrors 1, 2, 3 and 4 are arranged to stand vertically on the top of a table in the form of a rectangle, the reflecting surfaces being turned inwards. A candle or other object is placed at A, and the eye of an observer at B. It is required to find out whether it is possible for the eye at B to see the candle at A by means of light which has been reflected *in succession* by the mirrors 1, 2, 3 and 4; and to trace a ray from A to B satisfying this condition.

From what we have already seen, if light emitted by the candle A is reflected by the mirror 1 then, after reflection, the light rays must appear to radiate from the image I_1 of the candle in the mirror 1. For the sake of simplicity we will consider the candle as rays emanating from the point A, which have been reflected in succession from the mirrors 1 and 2, placed by a point so that we may say that the point I_1 is the image of the object point A in the mirror 1.

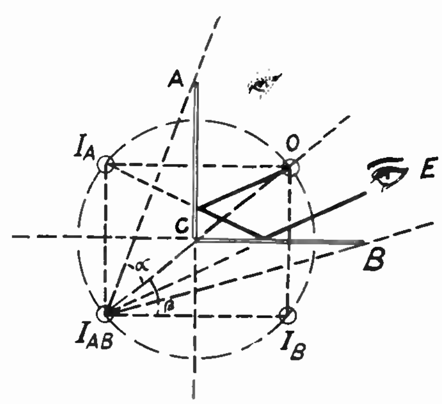


Fig. 7. Imaging by two reflectors placed at right angles to one another.

Further, we know that all light must then radiate from the point $I_{1\,2}$ which is the image of the image point I_1 in the mirror 2. By similar reasoning we find the image $I_{1\,2\,3}$ for successive reflections from the mirrors 1, 2 and 3, and finally the image $I_{1\,2\,3\,4}$ for successive reflections from the four mirrors.

We must be careful at this stage. All that our construction tells us, up to the present, is that if light does reach the eye at B from the candle A, after being reflected by the mirrors in the order named, then that light must appear to radiate from the point $I_{1\,2\,3\,4}$.

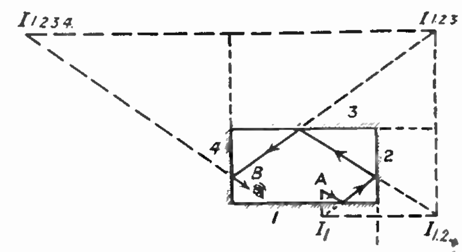


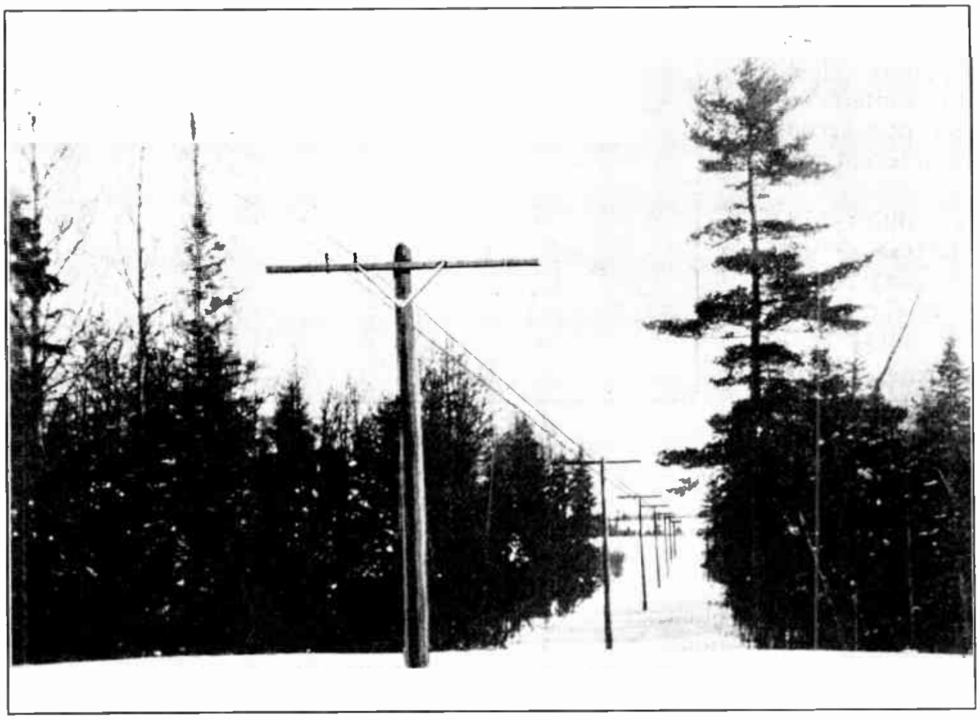
Fig. 8. Diagram showing the path of a ray reflected in one plane by four mirrors arranged like the cushions of a billiard table.

To solve the problem completely we must trace a ray between A and B, and since our image points belong to the source A, and not to the eye B this ray must be traced backwards from B to A, in the following way:

From B draw a line towards the image $I_{1\,2\,3\,4}$ to intersect the mirror 4, and from this point of intersection draw a line towards the point $I_{1\,2\,3}$ to intersect the mirror 3.

Similarly, draw lines to the image points $I_{1\,2}$ and I_1, and from the last point of intersection on the mirrors in the order named, object-point A itself. The line thus drawn from B to A shows the path of a ray passing from A to B, and since this ray is reflected from the mirrors in the order required our problem is solved.

For some positions of the candle on the table it will be found that the ray traced backwards from B does not intersect the mirrors in the order required, and does not after four reflections pass through A. Our problem then is impossible. In a complete solution the angular aperture of the system must be taken into account, a subject which will be dealt with later.



One of the modern antennae running a distance of several miles and used to receive trans-Atlantic messages of extremely long wave length.

Is the Ether "Big" Enough for Television?

By J. ROBINSON, M.B.E., D.Sc., Ph.D., M.I.E.E., F.Inst.P.

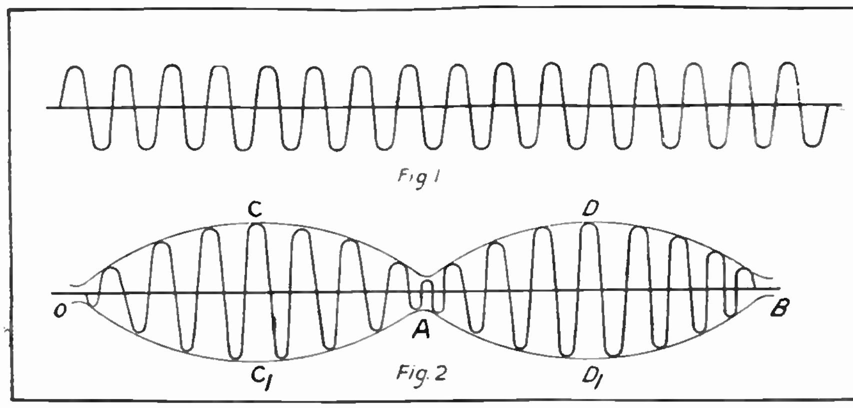
ONE of the most difficult problems in television is in connection with its transmission by radio. For certain purposes radio need not be employed, such as, for instance, in the well-advertised case where we expect to use the ordinary telephone and look at the person who is talking at the other end of the telephone line. There are other applications of television which will not involve radio, but in its most general application it is impossible to dissociate television from radio.

Everyone thinks at present of the broadcasting of television, and, again, it is desired to have instantaneous views of happenings in other continents, so that we cannot afford to allow television to proceed with the cable and land line as the only means of transmission. Incidentally, the problems of the transmission along cables are not very far removed from those that are present with the space transmission.

The opponents, or rather, shall we say, critics of television, have not failed to indicate the very serious nature of the problems that will arise in radio as soon as television becomes at all general. It has already been stated that for perfect television a single service will absorb so much of the ether that there will be very little space left for other radio services. Further, it is stated that in consequence of this it will be essential to operate television on the very shortest possible wave lengths, round about 10 metres.

Supposing these statements to be correct, television would be restricted very seriously, and the only possible means of communication that would be allowed for such services would be by beams, thus completely eliminating the idea of broadcasting.

In order to investigate these statements it is necessary to have a clear idea of the present-day radio transmission of a service such as telephony or telegraphy, as regards the amount of ether space taken up. This expression ether space is not a strict definition, but it should convey what is meant.



Figs. 1 and 2.
Fig. 1 indicates a carrier wave, unmodulated, whilst—
Fig. 2 shows the effect of modulation.

Radio communication is effected by wave motion, these waves traveling at the enormous velocity of 30,000,000,000 centimetres or about 186,000 miles per second. The waves can have different wave lengths, ranging from over 20,000 metres or about 11 miles to at present about 10 metres. We always employ the metric system for these waves in place of the English system of yards and miles.

In place of referring to wave lengths, we may refer to the number of waves that would pass a particular spot in one second, and we have the very simple relation that wave length × number of waves per second = the velocity of the waves.

Thus a wavelength of 1,000 metres would cause 300,000 waves to pass a certain spot in one second, and we call 300,000 the frequency in this case. Referring to frequencies, the range at present in use is from about 15,000, which corresponds to a wave length of 20,000 metres, to about 30,000,000, which corresponds to a wavelength of 10 metres. The loose but convenient expression of ether space available means the whole frequency range from 15,000 to 30,000,000.

Obviously we cannot conveniently have two services employing the same frequency unless they are being employed in different parts of the world, for they would interfere with one another, and the term interference is the actual technical term employed in such a case. Thus at present frequencies should be, and in fact are, allocated to various services to avoid as much interference as possible. If it were possible to restrict each service to one definite frequency this problem of allocation would be very simple, but unfortunately as soon as one attempts to use simple waves of this nature in order to convey a signal the simple frequency spreads, and usually does so to both sides.

Thus, instead of considering simple frequencies we must take into consideration frequency bands. If a simple wave has a frequency of 300,000, as soon as we put a signal, say a Morse signal, on it, there will be other frequencies present, say 300,500 and 299,500, and the number of such frequencies depends on the regularity of the signaling, whilst the range of the frequencies, *i. e.*, the maximum distance in frequency from the original frequency, depends on the speed of signaling.

Other factors enter into this problem, such as the method employed to put the signal on the original wave, which is usually called the carrier wave. The method usually employed in telephony and in television is called an intensity modulation method, where the signal that we wish to convey causes the intensity or amplitude of the carrier wave to change. This whole problem must appear very complex to those who have never before considered it, and in fact it appears almost paradoxical, for all that the signal purports to do is to change the intensity of the carrier wave, there being no deliberate attempt to change the frequency. The frequency changes that are, in fact, produced are, however, unfortunately a necessary accompaniment of this form of signaling, and whenever the intensity of a carrier wave is changed there is present at least one other frequency in addition to the carrier frequency.

In order to understand how this spread of frequencies arises we shall consider the simplest possible case. Fig. 1 shows a uniform series of waves whose frequency is, say, n per second, and whose amplitude intensity is constant, these being the carrier waves. Fig. 2 shows these waves modulated, or having the amplitude varied from a maximum at C or D to zero at O, A and B. We shall suppose that the number of times per second that the amplitude goes from a maximum to zero is p. There are many methods of producing a modulation of this type, and all that we have intended to do is to keep the frequency of the carrier waves constant at n, and to vary their amplitude from zero to a maximum p times per second. The result is to produce trains of waves, the first being OCA, the second ADB, and so on.

Looking at Fig. 2 in a different way, it appears as if there are two influences at work, which help each other at C and D, and which are opposing each other at O, A and B. Two such influences are two series of waves which sometimes help each other and sometimes oppose each other.

One way in which we can have two such series of waves to do this is for these series to be of different frequency and each series to have the same and constant amplitude. When we have two such series of waves they will sometimes be in step and sometimes out of step with each other. When they are in step they will help each other, and when out of step oppose each other. Fig. 3 shows two series of waves of frequency n and p at a and b, and the combination at c. They are in step about the points m, m_1, and m_2, and out of step about n, n^1, . . . giving the maxima and minima of the combined wave at c.

Reference to the mathematical treatment of this subject will explain this principle completely. The waves in Fig. 1 are represented by the curve $y=a \sin nt$. We apply to these waves a regular variation

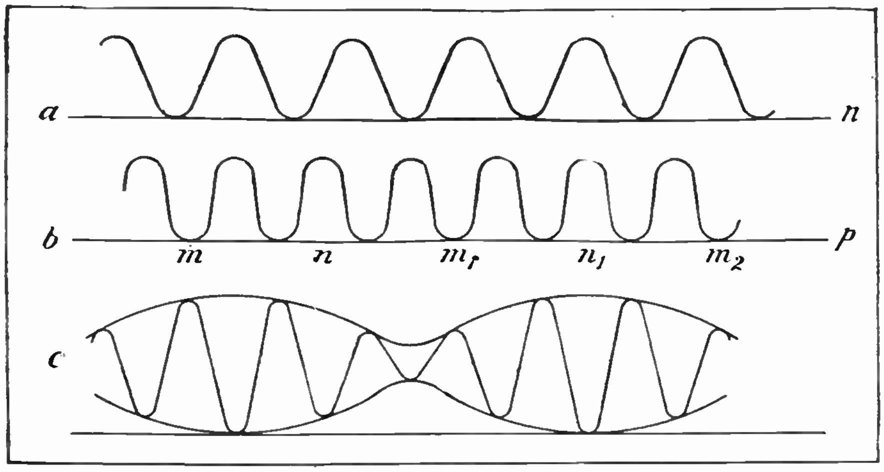


Fig. 3.
Illustrating the heterodyne principle. Two waves (shown at a and b) of different frequencies combine to form the resultant wave-form shown at c.

of amplitude of the form $b \sin pt$ where p is a lower frequency than n. Thus the final result is

$$Y = ab \sin pt \sin nt,$$

which can be transformed into

$$Y = \frac{ab}{2}[\cos(p-n)t - \cos(p+n)t].$$

The two frequencies are thus

$$(p+n) \text{ and } (p-n),$$

i. e., our original carrier frequency n which is modulated by a lower frequency p results in the presence of two frequencies

$$n+p \text{ and } n-p.$$

Usually the frequency n itself is also present, for the type of modulation given here is a complete modulation, whereas in practice for telephony this is seldom achieved, and we have partial modulation leaving three frequencies present, the original frequency n, with n — p and n—p.

This is no mathematical abstraction, but these waves really have an objective existence, and in fact in ordinary wireless telephony all receivers depend on their existence to receive the signals.

The example given here corresponds to the old tuning note of the B.B.C. stations, the transmission by wireless of a single note. If we take this note to have a frequency of 500, and if the carrier waves have a frequency of 800,000, we have present three different frequencies, *viz.*, 799,500, 800,000, and 800,500.

Suppose now that many notes of different frequencies are being transmitted simultaneously in the form of speech or music. We shall then have the mean carrier frequency present of 800,000, and a number of frequencies greater than this by the acoustical frequencies present, *i. e.*, if the upper limit of these latter frequencies is 10,000 we shall have this range of frequencies from 800,000 to 810,000. In addition, we shall have a similar range on the lower side of 800,000, *i. e.*, from 790,000 to 800,000. Thus we have a band of frequencies from 790,000 to 810,000 required for ordinary telephony transmission, *i. e.*, a telephony service requires a frequency band of about 20,000 cycles.

This wide range of frequencies required for telephony means that in order to avoid mutual interference the frequencies allocated to the various telephony services should be at least 20,000 cycles apart. In fact, with the receivers in use at present, it is wiser to have stations more than 20,000 cycles apart, as a receiver for telephony should be capable of receiving the whole of the 20,000 cycles frequency range uniformly in order to avoid distortion, and thus present-day receivers are arranged to receive a much wider range of frequencies than 20,000.

When we come to consider television it has been stated by critics that the frequency band required will be of the order of 3,000,000 or 4,000,000, thus requiring a range as great as 150 telephony services. This estimate would naturally make television impossible, and we must examine it in some detail.

Referring back to my article on Dots or Strips, a criticism was reproduced where it was stated that for perfect television it would be necessary to divide a picture of 1 square foot into about 250,000 dots, and to transmit the equivalent electrical effect obtained from the light effect of each dot 16 times per second, thus requiring 4,000,000 signals per second. Then the assumption was made that this signaling speed is equal to one side band of the frequency bands, and that our total frequency bands would thus be 8,000,000 on the ordinary method of transmission. However, it was granted that we might employ what is called single side band transmission and thus still require a frequency band of 4,000,000.

In the article referred to I showed that this was far too high an estimate and that we should probably require only something of the order of 16,000 signals per second for satisfactory television even on the "dot" method of considering the subject. However, it is essential to examine the assumption made in this criticism that the width of a frequency side band is equal to the number of dots on a picture multiplied by the number of times per second that the picture is scanned, *i. e.*, 16. We shall soon discover the fallacy in this assumption, and in doing so we shall be able to keep our minds on the practical methods of television.

In practice there is in fact no simple relation between these two factors, and the calculation of the width of the frequency band either on the "dot" conception or on the practical strip conception is not easy. Suppose, however, that we could have the picture divided into dots, say 4,000,000, and that it were possible to employ the jerky motion, equivalent to the gate motion of the cinematograph, where one dot is viewed completely, then the light is extinguished or shaded till the next dot were in view. In such a case, *"if the dots were all of the same intensity,"* we should have a signaling speed equivalent to 4,000,000 signals per second, and there would be present two frequencies differing by 4,000,000 from that of the carrier frequency.

In fact, if such a movement were possible at all, it would most probably be irregular, and we should have many more frequencies also present, some of them probably differing by more than 4,000,000 from the carrier frequency. Such movement is, of course, impracticable, and if we transfer the conditions to the real case, instead of having a number of dots of constant intensity, we shall have a number of strips of constant intensity to be scanned by a slit.

Suppose now that the slit were of very small dimensions we should have merely one continuous unchanging effect throughout the whole of one strip and in fact throughout the whole of a picture. Thus no extra frequency will be introduced at all, and we shall have merely one frequency transmitted. Owing, however, to the fact that the slit must have finite dimensions, we shall have end conditions at the beginning and end of each strip, these conditions depending on the size and shape of the slit. Reference to my earlier article on Dots or Strips will explain this.

In place of a continuous record we shall have a record as shown in Fig. 4, with small dips at the end of each strip. If there are 50 strips we should then have extra frequencies introduced, these being very difficult to calculate, as they depend on the size and shape of the slit. However, we are fairly safe in stating that such frequencies will be of the order of the carrier frequency plus about 50, and minus about 50.

Let us examine another case as shown in Fig. 5, where the light is distributed in the original scene along one strip, as shown at $Y_1Y_2Y_3$ . . . *i.e.*, in step formation, the intensity increasing by the same amount after the same distance, this distance being the width of the slit. Without going into detail, we know from my former article on Dots and Strips that the reproduction in this case is in the form of two straight lines OH_4 and H_4Q. Suppose that the time required for the slit to pass across one step Y_2Y_3 is one hundredth thousandth of a second, we ought to obtain extra frequencies differing by 100,000 from the carrier frequency, but in fact whilst this ought to happen we have the light effect in our reproduction rising continuously to a maximum. Thus the extra frequencies introduced will not differ by so much as 100,000 from the carrier frequency, and in fact in this case they will be much smaller.

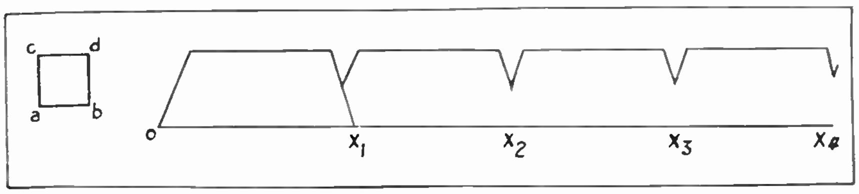


Fig. 4.

Showing the sort of modulation record given by a slit of finite dimensions.

Further examples could be worked out, although it is impossible to calculate generally what the frequency bands would be. Sufficient examples have, however, been given to show that it is unwise to equate the number of dots multiplied by 16 to the resulting frequency bands. In fact, it is unwise to do so if we assume that a "dot" is equal to the area of the scene viewed by the slit when it is at rest.

In the examples given the actual frequency bands obtained are smaller and, in fact, much smaller than those given by such calculations. We again have the result that the necessity of having slits of finite dimensions tends to introduce a rounding-off effect of irregularities and thus to keep down the width of the frequency bands.

It is very essential to have as much information as possible about this aspect of the subject. At the present moment it is not possible to do more than estimate the width of these frequency bands, but for the case corresponding to about 1,000 strips per second a fair estimate should be 100,000 cycles.

At the present time it is not proposed to transmit scenes which will demand anything like this magnitude of frequency band. I have not heard of any measurements of this nature of the Baird, Alexanderson, Carter or Jenkins transmissions, but it is very necessary to have them on record as early as possible. Then there should be some data on which to base calculations, and it cannot be too strongly emphasized that with the present transmission methods in wireless the controlling factor of the advancement of television is the width of frequency band that is required. In fact, whenever a new service of television is allowed, it will be given on the definite understanding that the frequency band allocated must not be exceeded. Thus here we have a field of work which is of the utmost importance, as it bears on the relation of television to other radio services.

We have discussed here, in fact, the most serious criticism that television has to face, and I think it has been shown that although the magnitude of the frequency bands required for television is fairly large, by keeping our minds to the practical method of considering the subject, we need not contemplate having to require a side band of more than 100,000 cycles for very satisfactory television, and this would allow us to have the whole of a theatrical performance, and scenes of similar magnitude transmitted.

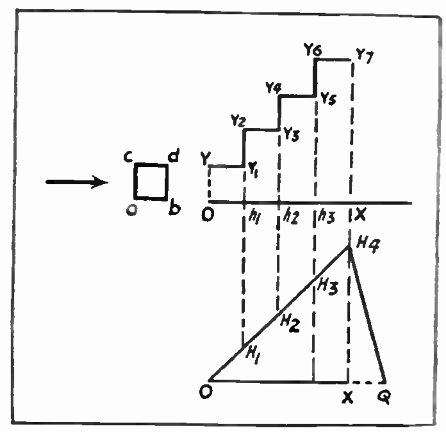


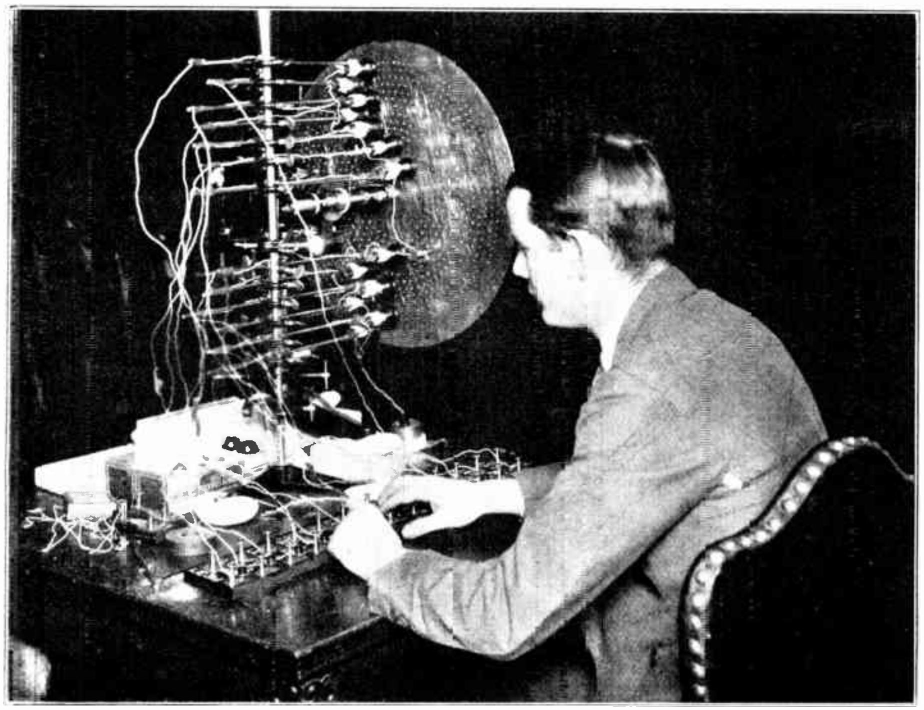
Fig. 5.

Illustrating how the passage of the slit across the image builds up the light intensity in steps

Such a frequency band would be equal to that of five telephony services, and thus the criticism that no room would be left for other services was far too severe in nature.

One other aspect of this subject needs some consideration and that is how the width of these frequency

(*Continued on page 137*)



The photograph shows a group of photo-electric cells mounted behind a perforated disc. Light shining through the holes in the dics, while the latter is revolving, causes the amplifier attached to the cells to emit sounds of various frequencies. Thus an electric "piano" is made.

STRANGE NEW FACTS ABOUT PHOTO-ELECTRIC CELLS

By the Technical Staff

THIS month we must consider carefully two factors which are very important in the study of photo-electric cells.

In a previous article we have already seen that we may regard a photo-electric current as an emission of particles of negative electricity, which are known as electrons, from the surface of the photo-electric substance under the influence of the exciting light.

If, then, we consider the effect of temperature on these fast-moving electrons in the light of modern physical research, it becomes necessary that we first understand how the phenomenon of temperature is explained by the electronic theory.

Let us imagine for a moment that we can see the atoms which compose, say, the ordinary domestic poker, and that by some means or other we are able to measure and record their velocity under varying conditions of temperature.

If now we place the poker in the fire, and record the velocity of the atoms and molecules as the temperature gradually rises, we

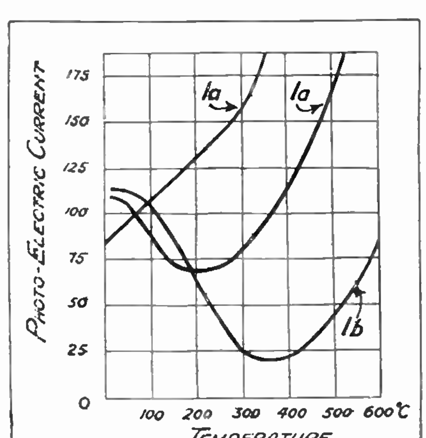


Fig. 1

should find on inspection of the results that as the temperature rises the atoms and molecules composing the metal of the poker are in a more violent state of agitation. In adopting this method of considering temperature changes we must, however, realize that the molecules are incapable of moving continuously from place to place, for the motions associated with heat take place about a fixed position.

In the case of gases, however, the motion of the molecules suffers no such restriction, the progress in any direction depending only on the occurrence of collisions with other molecules. Finally, in the case of liquids, though the molecules do move continuously from place to place, the rate of transfer is comparatively small.

A change in the temperature of the photo-electric substance should then cause a change in the initial velocity of the electrons composing the substance, and may also cause a change in the number of electrons emitted. We have already seen the effect of temperature in the case of gases, and it would not therefore be surprising if the presence of a gas or gases in the photo-electric cell were to further complicate the effect of temperature on the photo-electric cell.

Furthermore, there may be a secondary action or actions, such as might arise through a chemical or physical modification of the surface of the photo-electric substance, or of the gas in contact with it. Those of my readers who have constructed the selenium cell as described in a recent issue of this journal will remember how important a consideration was the temperature regulation in the annealing process. This process illustrates quite simply what is meant by a physical change in the substance. From being a black, amorphous substance, the selenium has changed into the grey, crystalline variety.

Experiments have been carried out with plates of various metals heated in an air-bath to some known temperature, after which observations of the photo-electric current were taken at intervals while the plate was cooling down to the room temperature.

For example, Hoor found that the activity of zinc increased greatly while cooling from 55° C. to 18° C. This result was not confirmed, however, by the experiments of Elster and Geitel, but they were able to show that the activity of a potassium photo-electric cell increased with increasing temperature up to 60° C., the cell in this case containing gas at the critical pressure of 0·3 mm. of mercury. J. J. Thomson found a great increase in the photo-electric current from the alkali metals on raising the temperature to 200° C. or thereabouts.

Other workers, experimenting with platinum plates, found somewhat complicated changes to occur when the apparatus was gradually heated up to 200° C. Although there was a very definite increase in the activity, taken as a whole, it was observed that there was a secondary maximum and minimum value, the minimum being between 100° C. and 200° C. This is illustrated in a graph shown in Fig. 1*a*.

Some interesting results were obtained by Varley and Unwin as the result of a long series of observations under varying conditions. The tests were carried out at (1) atmospheric pressure, (2) a pressure of 50 mm. of mercury, and (3) very low pressures. The temperature of the platinum foil was varied between 5° C. and

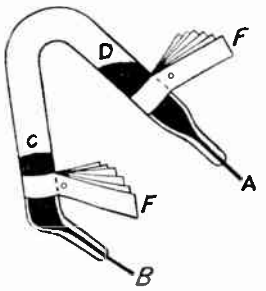


Fig. 2.—Mercury vapor arc lamp. FF=Copper cooling fins. CD=Mercury reservoirs. AB=Leading-in wires.

500° C. by passing an electric current through it, this current being obtained from large accumulators. The temperature of the platinum was measured by means of a thermo-couple consisting of a platinum-rhodoplatinum junction used in conjunction with a sensitive micro-ammeter, having a scale marked to correspond to "degrees Centigrade" in place of the usual microamp scale.

Experiments of Varley and Unwin

The second electrode employed was a copper disc, since Varley had found the usual gauze electrode unsuited to his purpose. The cell was illuminated by means of the light from a discharge between iron electrodes in an atmosphere of hydrogen. If we plot the results at atmospheric pressure a curve (Fig. 1*b*) similar to Fig. 1*a* is obtained, but the minimum value is at a temperature some 200° higher. This is explained by the different potential differences, employed by the various workers in their measurements, and by the different time intervals allowed between the readings.

Fig. 1*c* shows the steady increase with the temperature of the photo-electric current in an atmosphere of hydrogen.

At the pressure of 50 mm., in air, there was no increase of activity with the temperature, though the value of the current diminished at first in a manner similar to the previous case.

In the third series of experiments, where the pressure of the residual gas was very small, the nature of the gas was found to have very little influence on the result. When the temperature was raised very slowly there was at first an increase in the value of the current, but after the temperature reached 60° C. there was no further change in the value of the photo-electric current, even when a temperature of 350° C. was reached.

Consideration of the results of Lienhop, obtained by working at very low temperatures, as low as —270° C. in fact, shows us that below the ordinary room temperatures there is no change in the value of the photo-electric current.

As we saw in the case of photo-electric fatigue, that the cell which did not suffer from this defect was one containing an alkali metal in a very high vacuum, so now we note with interest that Dember could detect no influence of temperature on the activity of a high vacuum alkali-metal cell.

A number of elaborate experiments have been carried out by other workers, chief among whom are Millikan and Winchester, and Ladenburg. With a vacuum as high as 0·00001 mm. all experiments showed that in the case of a large number of metals, such as aluminum, copper, silver, gold, antimony, zinc, etc., there was no change in the photo-electric current when the temperature was changed.

Ladenburg has pointed out that the occluded gases on the surface of the plate are responsible for many of the contradictory results previously obtained. To overcome this the plate was heated while the evacuation was still being carried on, and in this way he succeeded in obtaining a perfectly gas-free plate. If air or hydrogen are occluded in a platinum plate the activity may be as much as 50 per cent higher than with a gas-free plate.

Apart from a slight variation in the current in the neighborhood of 100° C., Ladenburg, too, found the activity to be independent of the temperature. This variation was attributed to the presence of traces of water vapor.

If, therefore, we omit or eliminate secondary actions, most of the available evidence goes to prove that the photo-electric effect is independent of the temperature. Pochettino has shown that the light-sensitiveness of selenium does not change between 20° C. and 185° C.

Two possible theoretical explanations of this result have been put forward by Lienhop and Ladenburg, which, though more satisfactory than previous attempts which endeavored to explain the result from the standpoint of the older mechanics, are nevertheless not altogether satisfactory when their significance is fully understood.

If, however, we examine the result from the point of the quantum theory we can fairly safely assume that the system passes between two stationary states, corresponding to the emission or absorption of an amount of the same type of radiation, represented by the quantum of energy hu. In the case under consideration the two states would be (1) the atom with its electron, and (2) the atom and electron after separation has taken place.

In examining the influence of the intensity of the light on the photoelectric effect a brief study of the various light sources will not be out of place.

The source of light in use at the time of the original discovery of the photo-electric effect by Hertz was the electric spark, obtained from an induction or Ruhmkorff's coil. The terminals of the spark gap can be of aluminium, zinc, cadmium, etc., and a number of later workers have employed this type of source, employing a spark of length 6-10 mm. The spark has an advantage over the mercury arc, which I shall discuss a little later, in that it emits light of shorter wavelength and greater intensity—for instance, using aluminium terminals, wavelengths of between 1,852 and 1,693 Angstrom units have been obtained, whereas the shortest line present in the mercury arc is 1,849 A.

Then, too, if a short spark from a coil taking 90 amps. in the primary is made use of, as in the experiments of Lenard, the energy of the spark exceeds 1,000 watts, which is in excess of the power of many carbon arcs. Hughes found that it was extremely difficult to obtain reliable results when the spark was used as source, and considers the mercury arc the most useful for experiments in photoelectricity.

Artificial Sunbath

This apparatus is now familiar to many under the name of an "artificial sunbath," and consists of a tube of transparent fused quartz, containing mercury in reservoirs located at its ends. The apparatus is evacuated as completely as possible, and connected to a supply of direct current by means of metal contacts sealed in the tube, and making contact with the mercury reservoirs. On tilting the tube, thus joining the two mercury reservoirs, an exceedingly brilliant arc is struck, which is very rich in ultra-violet light. A diagram of the lamp is given in Fig. 2. If it is desired to run the lamp on alternating current a specially designed three-electrode lamp must be employed. A useful range of lines from 2,300 A to 5,790 A is available, the line 2,540 A being particularly useful by reason of its great intensity and situation well in the ultra-violet.

Arc vs. Spark Illumination

If we desire to obtain light very rich in the extreme ultra-violet lines we can employ the discharge in hydrogen at a pressure of from 1-5 mm. The discharge is but faintly perceptible to the human eye, as the spectral lines which it contains are beyond the range of human vision. Hull and St. John found that if the light from such a discharge, after passing through a fluorite plate, was allowed to fall on a polished zinc plate the photoelectric effect produced was 250 times as great as that produced when the mercury lamp was used as the source of light.

It is also possible to employ the ordinary carbon arc lamp with a considerable measure of success, as this contains lines in the ultraviolet down to 2,400 A, and it has the additional merit of being within the reach of most experimenters. With this point in view I hope to be able to publish a constructional article dealing with the carbon arc at an early date.

Early investigators assumed that the ratio of the photo-electric current to the light intensity could be regarded as constant, that is, the current increases proportionally as one increases the intensity of illumination.

In order to test the correctness of this supposition, Griffith, in 1907, carried out experiments in which he was able to vary the intensity of the light in the ratio of 1:126, and arrived at the result that the photo-electric current was not directly proportional to the intensity of illumination. Since, however, these experiments were carried out at a pressure of several millimetres, the results are not entirely a safe indication of the true state of things.

From the investigations of Richtmyer we can safely conclude that the current is directly proportional to the intensity. He placed a sodium cell in a blackened wooden box and allowed light from an incandescent lamp of 16 candle-power to fall upon it. The intensity was varied by interposing between the lamp and the cell sheets of writing paper, or by varying the distance of the lamp. It is interesting to note that a second series of experiments, employing a carbon arc as source, gave the same result, which would thus seem to have been found to hold over a wide range of light intensities (approximately 0·007 foot-candles to 600 foot-candles).

Further experiments along similar lines carried out by Dember indicate that at very high intensities of illumination there is a slight diminution of the photo-electric current as compared with the light intensity, but again there was a small pressure of hydrogen in the potassium cell, which may be a possible explanation of the discrepancy observed, though Kemp, working with potassium hydride cells, which, of course, are not completely evacuated, found that the variation from proportionality was not more than 7 per cent over a very wide range.

(Continued on page 136)

Rich Rewards *for Those Who Can Solve These Problems*

D. E. Replogle, the author of this article, is an engineer of national reputation and his reflections on the subject of television should be especially interesting to those who are devoting themselves to the big problems of the art. Here Mr. Replogle discusses the outstanding weakness of our present systems and offers possible remedies and suggestions for future developments.

D. E. REPLOGLE

THE radio audience is blind. Irrespective of the marvels of radio broadcasting, and without detracting in the slightest degree from the praise due broadcasters for their magnificent service to society in bringing a world of music, entertainment and enlightenment into every home equipped with a radio receiver, the fact remains that the radio audience is blind and must continue to be blind until broadcasting technique includes television to complete the presentation. Today we have only listeners-in for our radio audience; tomorrow, we shall have lookers-in, as well. Television will supply the *visual,* as a supplement to the *aural,* effects in completing the service of broadcasting.

However, as engineers we cannot permit our enthusiasm to run away with our better judgment. Most of us know in a general way the many and serious problems that stand in the way of television development. In fact, we have received the greatest challenge yet issued to our branch of engineering; for television, we note, calls for doing a lot of things in a fraction of a second; it calls for minute attention to detail; it requires the analysis of images in terms of dots and light values, and the transmission of such an analysis, followed by the reconstruction of the dot elements into a replica of the original image. Electricity, mechanics, gaseous conduction, distortionless amplification, new forms of modulation and demodulation, chemistry, optics and even a new stage technique are among the problems confronting us. And it is for the purpose of reviewing the more obvious problems, and inviting engineering co-operation, that this paper has been prepared.

It has been held by some students of television that the greatest problems to be solved are in the direction of presentation. Such views, however, appear unfounded. The same was said of talking motion pictures, yet even at this early date many excellent talking picture plays have been produced. With the entire world to draw upon for visual as well as aural material, there should be no dearth of subjects, although, it is true, much ingenuity will be required to present the world through the tiny window of the television screen. As television develops, the presentation will become increasingly popular, but at first there will be serious but not insurmountable problems by way of staging playets within the limitations of the close-up picture, which is as much as television can handle for some time to come.

As I see the matter, television presentation may be based on the subject matter of the usual moving picture screen, except that it has the added advantage of instantaneous reproduction. In other words, the television presentation shows the subject as it is at that particular moment. There is no elapsed time, as with the motion picture. And so the television screen will no doubt be largely devoted to portraits of speakers and artists before the broadcast microphone, with the aural accompaniment entirely optional. Later, there will be playlets, to take the place of the present shadowgraphs which show such simple things as playing ball, dancing, skipping rope, and so on. Today we are not so much concerned with the theme of our television pictures, as we are with the propagation and reception of the images, irrespective of their interest, *per se.*

I believe we should, as engineers, be vitally interested in television presentation. For instance, there are already certain television actors, whom, we are told, have the necessary television face and television acting requisites. These considerations are highly important in the early stages of television. Just as early motion pictures, with their frugal amount of detail, called for persons with prominent features, plenty of makeup, and a high degree of expression in their hands and arms, so must we count on these requisites while television is scanty in detail. Later, with more refined image reproduction, we shall come down to the beautiful technique of screen acting, with the slight arching of an eyebrow conveying the same thought which the waving of an arm would now convey.

So among our first problems are those of acting and stage setting for our television pictures. We must have the co-operation of those skilled in the histrionic art and stage setting art, if we are to have suitable material to handle with our television systems. Already the General Electric Company has done some excellent work by way of developing a suitable television stage technique, even with a multiplicity of television pick-ups for quick changes of scene, special settings, actors made up for television requirements, and so on.

The logical problem that follows the production of the television subject is that of detail. In fact, the problem of detail will be a difficult one to solve, since it involves questions of dot elements, time limitations, luminous intensity, accurate synchronizing, and wave band available.

Because of the wide frequency band required for satisfactory television modulation, we are compelled to employ high frequencies or short waves. The broadcast spectrum, which covers from 200 to 550 meters in the United States, and up to several thousand meters in other countries, cannot provide a place for a television channel at least 100 kilocycles in width, which is necessary for satisfactory detail. In the United States the broadcast channels are placed every ten kilocycles apart, which is deemed the narrowest possible channel consistent with good broadcast results.

With the necessity of employing short waves or high frequencies, then, a number of considerations are immediately introduced into the problem. Short waves, unlike the higher wave lengths, are by no means universal in application. Thus a single wave length of frequency cannot be employed in the short-wave spectrum for a universal television service. An analysis of satisfactory television service discloses the necessity of utilizing three simultaneous short-wave channels, as follows:

1. A channel for urban or city service, under conditions of marked absorption of radio waves. A satisfactory frequency will have to be found by actual experiment, so as to provide television service to those residing in congested metropolitan areas.

2. A channel for suburban or rural audiences, located outside and at varying distances from the metropolitan areas. Since the particular wave length employed for urban or city service may not have the desired carrying power, both this frequency and that for the metropolitan service will have to be determined through long and careful experimentation.

3. A channel for distant service and rebroadcasting purposes, with the sky-distance phenomenon of certain short-wave frequencies utilized to the best possible advantage. It will be this channel which will provide an exchange of television services between nations, and will span the oceans with pictorial and living presentations of important events.

Those who legislate the division of the crowded radio sky or ether may well question the necessity for wide television bands, especially since our present-day broadcasting is handled on relatively narrow channels. Yet the width of the channel determines the dimension of the television image and the amount of pictorial detail. With a radio channel 10 kilocycles wide, such as we employ in American broadcasting practice, the television image will be limited to one capable only of handling close-ups of heads or other comparable figures, with crude detail. Such, obviously, is not the ultimate ideal in television.

Let us stop for the moment to analyze just what the basic television technique comprises, as we know it today:

At the transmitting end, we really analyze or scan our image by lines. The greater the number of lines into which we break up our image, the greater the detail, as is the case with the dots of the half-tone screen used in making photo-engravings. We obtain our line analysis by utilizing what is known as the scanning disk, comprising a revolving disk with a suitable arrangement of holes. The holes are so spaced from the center of the disk and from each other on the spiral curve as to provide practically straight lines for just that portion of their swing through the field of vision.

The scanning disk can either throw a beam line by line on the subject, with photo-electric cells picking up the reflected light and translating the varying light intensities into electrical variations; or again, the scanning disk can analyze the focused image line by line and pass the varying light intensities back to a photo-electric cell contained in a camera or light-proof box. The first system is the most commonly employed. The subject, in this case, must be in a studio or indoors, where the light can be controlled. However, it is surprising how powerful the lighting may be, without interfering with the scanning beam action. The second system permits of scanning subjects outdoors, in bright sunlight, since the photo-electric cell, and not the subject, is being subjected to the scanning beam.

At the receiving end, we have just the reverse operation. The signals are amplified and fed to a kino-lamp or neon glow tube, which varies in luminosity according to the modulation of the incoming wave. The varying luminosity must now be translated into lines corresponding to those used in analyzing the subject at the transmitting end. A scanning disk, revolving in step with the scanning disk at the transmitting end, is employed. The holes serve to break up the glowing kino-lamp plate into a series of lines of varying intensity. At any given instant there is only a single point of light on the television receiving screen, and this dot may be bright, medium or dull, depending upon the radio modulation at that given instant. However, in the short space of less than a fifteenth of a second, the lines for the entire image have been formed by the sweeping dots. The persistence of vision which causes the eye to retain an image for approximately one-fifteenth of a second causes all the dots projected for that interval to appear as a complete pattern. By overlapping the lines slightly, the pattern appears fairly solid. In this way, therefore, we convert the moving dot into an apparent line, and the many lines into an apparent solid pattern. Thus we have a continuous illusion, with fresh dots and lines constantly forming to replace those fading out of sight, giving us the living image effect.

Our television image is therefore a pattern of successive lines, so closely packed together that the usual screen fails to suggest successive lines. In some respects it is much the same as the usual half-tone engraving used in printing, made up of dots of varying size. We obtain black when the dots are so large that they meet; gray when the dots are medium sized with a little space between; and white when the dots are very small and surrounded with a preponderance of space. Actually, the varying shades of gray are simply an optical illusion, since we are working only with black ink and white paper. Television, likewise, is an illusion. We have dots woven into lines, and lines into a complete image. It is simply a question of how many lines we are using, how much contrast we have between full intensity and minimum intensity, how accurately the lines meet or overlap, and how well we can maintain the synchronism of transmitter and receiver scanning disk.

Now a newspaper half-tone is usually a 65-line engraving, which means 65 horizontal rows and 65 vertical rows to the square inch, or a total of 4,225 dots. Every one is familiar with the modest amount of detail permissible with such engravings. It leaves much to be desired.

In television practice, however, in order to present an even cruder image, say of 50-line texture, or the equivalent of 2,500 dot elements to the square inch, we must transmit these lines in one-sixteenth of a second, or at the rate of 40,000 dot elements per second. The numbers in television are stupendous. Furthermore, we are dealing with fractions of a second.

Our experiments so far lead us to believe that with single side band transmission, it is necessary that the frequency in kilocycles be one-half times the number of dot elements. For a 50-line image, a 20-kilocycle band is required for satisfactory results, and for a 100-line image, an 80-kilocycle band is necessary.

If we refer back to our newspaper half-tone, we will note that an image 3 by 5 is about the minimum for viewing persons and events and entertainment. It would be, in fact, a very small window through which to look out upon the world. Yet such dimensions, with, say, a 50-line texture, would call for an image 150 lines high, and 250 lines wide, or the equivalent of 37,500 dot elements to be transmitted in one-sixteenth of a second!

We have accepted the 100-line image as about the maximum for present-day technique. It permits of presenting two or three persons, full length, with some background, and again with two or three lines of type for caption, if desired, together with sufficient detail considering the nature of the picture.

Even with a 100-kilocycle band, we cannot expect to enjoy anything like the crisp, crystal detail of the motion picture screen. We cannot hope to see the individual bricks in a brick wall. We cannot expect to see individual soldiers in a parade. To provide such detail, a band thousands of kilocycles wide would be needed.

Unfortunately, there are various systems now being exploited, with 24-line images. While these may be capable of presenting close-ups of faces, with a crudeness of detail and pronounced shades suggestive of an animated poster rather than a living image, they are quite unsuited for the more serious purposes of ultimate television service. Such systems may even be crowded into a wave band 4 or 5 kilocycles wide, so as to be handled in the usual broadcast spectrum, yet the results are only in the nature of a crude experiment. Surely the radio audience will not be satisfied for long to gaze upon decapitated persons, with no promise of something different and better.

Aside from the matter of screen dimensions, a wide radio channel is essential for proper detail. High and low frequencies are imperative. Thus if we cut off the low frequencies, we introduce spurious shadows and also change the tone of the picture. If we cut off the high frequencies, we delete the sharp lines and lose details such as eyebrows in the case of a close-up portrait. Cutting off the high frequencies also limits us to slow motion, since fast motion is badly blurred. For comparable pictorial quality, it requires a band at least twenty times the width of that for the finest broadcasting of good music.

Our greatest problem in television development is going to be one of finding the necessary space in the radio sky. With our present technique, we must have a wide channel.

Another problem is that of greater luminosity. It is surprising what we are able to accomplish with the present neon tubes, which have such a low candlepower. Here there appears a genuine opportunity by way of developing new forms of lamps which will be as responsive as neon, yet will give greater light. Again, there is an opportunity by way of developing more efficient methods of utilizing the light that is available. In this connection the four-target or four-plate neon lamp of C. Francis Jenkins, pioneer television experimenter of Washington, D. C., is a step in the right direction, particularly in conjunction with his light-conducting rods. Jenkins has also developed a lens scanning disk, which permits of utilizing the light source to better advantage, particularly in projecting pictures on a screen for a small audience. Alexanderson has also made use of a scanning disk with lens, instead of the usual plain scanning disk.

Synchronization is a problem which calls for the efforts of inventive minds. In metropolitan areas where the same alternating current system is available, it becomes a relatively simple matter to keep transmitting and receiving disks in step by means of synchronous motors. That system is the simplest and safest, of course. However, television service is bound to extend over a considerable territory, where the same current is not universally available Hence an independent means of

(*Continued on page 135*)

100-AMPERE PHOTO CELLS

Photo-electric currents which have been produced up to the present are so minute that they have had to be measured in microamperes, and before they can be used for television purposes they must be amplified very considerably. In the following article we describe some highly interesting investigations which have been made in Germany in connection with high-power metal-cased mercury arc rectifiers. The investigators tend to the belief that they have been successful in detecting and measuring photo-electric currents as high as 100 amperes. If their deductions are correct, they may well lead to revolutionary developments in television.

By RAYMOND HILSON

IN this paper I am proposing to put before the readers of TELEVISION an account of the work of two German scientists, Herren Schenkel and Schottky, who claim to have measured photo-electric currents of 100 amperes, together with a resume of the paper of Dallenbach and Jahn, who hold an opposite view of the question.

Before commencing a discussion of the work which has actually been done, let us consider for a moment precisely the effect such a discovery would have on the future of television, if it could be successfully applied.

Bearing in mind that the ordinary photo-electric cell gives a current of, at the most, about ten microamperes, we can see that here we should have a current at our disposal approximately ten million times as great. This would immediately enable a substantial reduction to be made in the number of amplifying valves necessary to amplify the minute fluctuating currents which are fed into the transmitter from the "electric eye," with a consequent reduction of distortion due to amplification.

Then, too, small changes in the intensity of the light received by the cell would produce larger variations in the resultant current, with improvement in the detail of the televised image, and this great sensitiveness would enable the intensity of illumination to be very considerably reduced. It must be remembered that up to the present

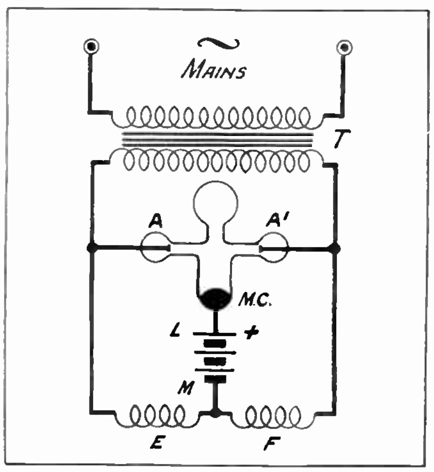


Fig. 2

How the rectifier is connected. T=Transformer. AA¹=Anodes. MC=Cathode. LM=D.C. load. E and F=Reactances.

time no cell designed on the principles discussed below has yet been made, but the author hopes that this paper, which is the first account of the subject in English, may be the means of encouraging research along the lines indicated.

While carrying out work with metal-cased mercury arc rectifiers at the works of Siemens-Schuckert, in Germany, Schenkel and Schottky discovered that there were certain things about the graphs and results which they obtained which were not in accordance with those previously obtained when working with the small type of rectifier.

It will perhaps be convenient to deal first with the nature and action of mercury arc rectifiers, before discussing the actual results obtained.

The all-glass type, shown in Fig. 1, consists of an evacuated glass bulb through the walls of which are sealed platinum leads to make contact with the mercury which is

1,000 GET PHOTO OF KING BY RADIO

London, March 14.—More than 1,000 Britons equipped to receive still pictures by radio today were proud possessors of a photograph of King George seated in his invalid bath chair at Bognor, Sussex, England. The high-powered Daventry radio station broadcast the picture.

contained within the bulb. The apparatus is connected to the supply of alternating current through a transformer, as shown in Fig. 2, and an arc struck by the usual method of tilting the bulb till the mercury joins the anode for a fraction of a second. This produces a heating effect, resulting in the vaporization of the mercury, and a consequent sparking across the low-resistance path created by the vapor between the anode and the cathode, this sparking being maintained to form the arc. Under these conditions it has been found that the alternating current supplied to the arc is rectified, and if we place a load at the points LM (Fig. 2) we have a continuous current produced at those points. The inductance shown is

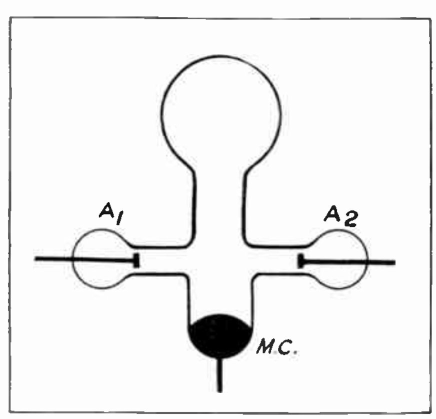


Fig. 1.

An "all glass" mercury vapour rectifier. A_1A_2=Anodes. M.C.=Mercury Cathode

placed there to stabilize the arc, and for the purpose of the present article, need not be taken into account.

The metal-cased rectifier, though little used in England at present, is extensively employed on the Continent. In principle it is identical with the ordinary glass-bulb mercury rectifier, but the metal casing necessarily introduces several differences.

The electrodes have to pass through insulating bushes in the metal case, and the sealing of these joints, so as to be airtight, though difficult, has been overcome in a very ingenious manner by carefully plugging the annular space between the electrode and the bush with asbestos washers, over which is placed a layer of mercury. On evacuating, the mercury is drawn into the pores of the asbestos and thus makes an airtight joint. To

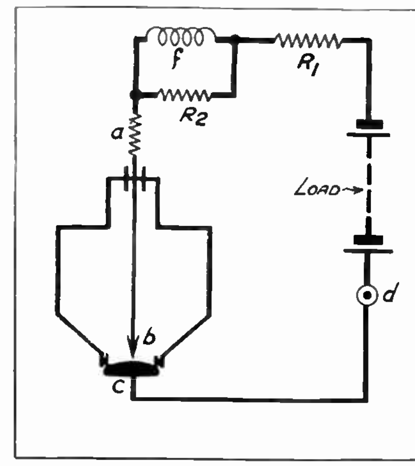


Fig. 3.

Diagrammatic circuit of metal-cased mercury rectifier. a=Starting Solenoid. b=Starting Anode. c=Cathode. d=push button to start. f=inductance. R_1R_2=starting resistances.

ensure a well-maintained vacuum, however, the rectifier is connected to a small pump, which is always kept running. Beyond the starting devices, which are of a special pattern, the large rectifier does not differ from the glass-bulb type already described. It is shown diagrammatically in Fig. 3.

The iron vessel of a large mercury rectifier takes a potential difference of ten volts higher than the working value to drive a discharge to the isolated cathode opposite. If we put in circuit (as shown in Fig. 4, between the cathode and the vessel) a potential difference continuously variable between positive and negative, then the vessel will become the anode or cathode of a discharge according as E is larger or smaller than the potential of about ten volts, which is indicated as "vessel free."

The electric potential characteristic of this discharge depends on the rectifier current being a constant quantity in the equation; this quantity being represented by the symbol JG. Fig. 5 shows a few of the curves obtained by Schenkel and Schottky, taken from their paper in the original German. These curves show, above all, that by their arrangement, the potential which is represented as "vessel free" (therefore J=O) increases with the rectifier current JG.

If one increases E in this manner then J rapidly rises, and the vessel then becomes the normal anode of the rectifier, i.e., the anode of a discharge whose cathode is the mercury bath (Fig. 4, M). Let us, on the contrary, decrease the value of E to J=O, and then change to negative value; a negative stream is produced already after a decrease of potential of several volts, which has the characteristic of a saturation current which retains its value fully unchanged by further decreases of potential. Schenkel and Schottky have been able to carry this on only to a potential value of −30 or −40 volts, for at these potentials the discharge in an arc ceases, and observation has shown that the cessation forms a cathode spot on the vessel.

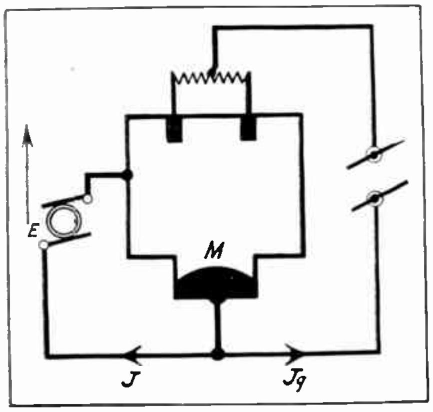


Fig. 4.
Another simplified diagram of the metal-cased rectifier.

This saturation current grows with JG more than proportionally. Their curves in Fig. 5 show that they are approximately quadratic. Fig. 6, obtained by Dallenbach and Jahn, is a confirmation of Fig. 5.

The description which one can make concerning the changes in an electric arc are unfortunately still doubtful, but the work of Frank and Hertz, and that resulting from it, indicates new aspects and intelligence for the happenings in the arc, and more especially in mercury vapor rectifiers. We know, however, no results of this work on the elementary changes of ionization and recombination at higher temperatures and higher current densities, and in so complicated gaseous mixtures as are present in the cylinder of a mercury vapor rectifier. At least, it appears problematical to calculate the ionization potential of pure mercury vapor, as was done by Schenkel and Schottky, but if one looks at the qualitative aspect of the curves in Fig. 5, the arc consists of a dissociation equilibrium of electrons and positive ions, in which the process of ionization, recombination and diffusion to the walls held the balance.

Thus it is nearer to assume that when the vessel current J becomes positive it will attract more electrons than positive ions, but the negative cathode part draws more positive ions. Electrons and positive ions are distinguished by their different mobility in an electric field, and one would expect that the axes of the graph in Fig. 5, if gradually altered, would cause the qualitative similarity to disappear, but this is not the case, as a glance at Fig. 5 will show. From the positive anode part of the curve one can think that it is indicative that the vessel of the arc attracts most strongly a mass of electrons, and least strongly a mass of positive ions; but the negative cathode axis where the current strength becomes independent of the potential at the sharp bend is explained by Schottky in the words: "the negative saturation currents are therefore photo-electric currents."

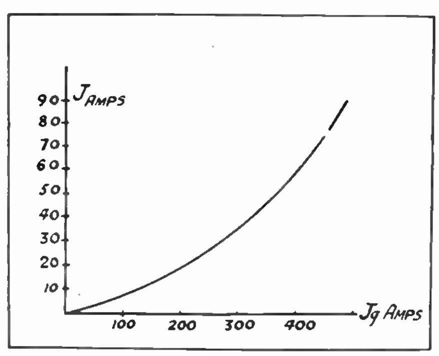


Fig. 6.
Curve obtained by Dallenbach and Jahn, which confirms Fig. 5.

They have observed, when working with rectifier currents of 400 amps., that they have measured photo currents of about 100 amps.

They appreciate that the almost quadratic rise of the photo-electric current with the rectifier current is not easily understood, for on account of the constancy of the descent of arc the cylinder loss, and presumably also the developed light energy, is proportional to the current strength. Further, they find the supposed photo-electric change unusually high, without having resort to absolute measurements of the photo effect, for Dallenbach and Jahn contend that if 400 amps. rectifier current and 10 volts fall of potential were changed into light energy then this would give, according to their measurements, a photo effect of 100 amps. per 4,000 watts, or 4·19/40=1/10 coulombs per calorie of absorbed light energy. (N.B.—4·19 is a figure called Joule's Mechanical Equivalent of Heat.)

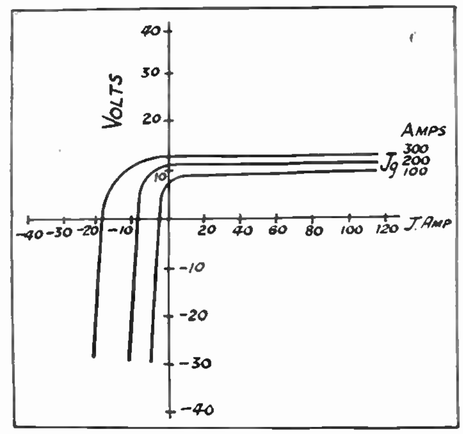


Fig. 5.
The curves obtained by Schenkel and Schottky.

But Pohl and Pringsheim have measured for potassium amalgam a maximum of 11/10,000 coulombs per calorie for absorbed light energy, and for the selective effect on sensitive sodium cells for light of a wavelength 365 *uu*, 15/1,000 coulombs per calorie. Dallenbach thinks, on this ground, that an explanation other than "photo-electric effect" must be advanced for the unexplained behavior of large mercury rectifiers at this so-called "saturation current."

The paper of Dallenbach and Jahn contains a very full account of their work on the subject, together with the conclusions at which they have arrived. The curves which they obtained are reproduced in Fig. 7, and an enlarged copy is given in Fig 8, which shows the behavior of the curve in the neighborhood of the current axis. It will be noted that the only essential difference between Fig 5 and Figs. 7 and 8, is that the axes of the latter two are turned round, as only the cathode discharge interests us.

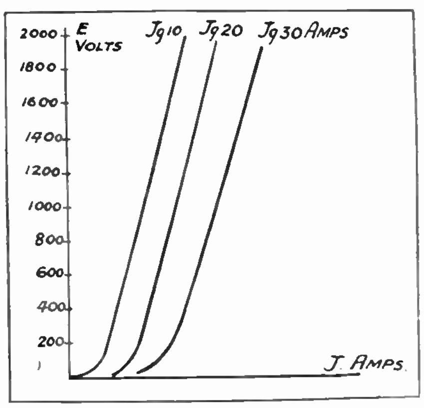


Fig. 7.

Curves obtained on a large mercury rectifier by Dallenbach and Jahn.

Fig. 7 was obtained on a large mercury rectifier. Between an iron anode and a mercury cathode burns a rectifier arc, the so-called main arc, of current strength JG. It acts in the neighborhood of a stimulating electrode. Fig. 4 shows the current potential graph of the inter-cathode discharge of this stimulating electrode, at current strength of the main arc of 0, 10, 20, and 30 amps.

In a very lengthy discussion they bring forward a large amount of conflicting evidence which space does not allow me to discuss, but they conclude by saying: "The speculation concerning the positive column of the arc and the transport of electricity in a mercury vapor rectifier, as far as Schenkel and Schottky build it up from their hypothesis of photo-electric saturation, is one which must be taken with caution."

Herr Schenkel, however, gives us further insight into the question, in a reply to his critics, which was published a short while after their paper appeared.

He thinks that it is possible that the energy which is stirred up by the main discharge of the rectifier mercury atoms, which serves for the release of the observed strong currents, is not only in the form of rays, but also arrives at the upper surface of the vessel in some other way. As has been shown by other workers, the velocity of vapor rays in an ordinary mercury vapor discharge is about 10 metres per second. On the other hand, it is known that the resonance rays of mercury, if once stimulated, are maintained in the pure unrarefied mercury vapor, on account of the continuous reabsorption being proportionally big in a definite volume element of the vapor, and to some extent only arrives at the walls by diffusion. It is therefore to be thought that by sufficiently great ray velocity each ray quantum, let it have originated where it will, reaches by being carried along, those parts of the apparatus where the mercury condenses. But that place is the vessel in which the large currents are observed.

By this energy balance the change would be considerably improved in the sense of an Einstein equivalence law, for now, not only the energy of the free-burning part of the arc would come into question, but also that in the cathode chamber. Let us assume on account of the agreement with the critics that for the stimulus of the operated rays the definite fall of potential of 10 volts is required; then we obtain with a driving current of 500 amps. an available impulse of 10 (500−100)=4,000 watts. If this impulse is fully replaced in the operative rays of wavelength, 2,537 Angström units, and if for the quantum of energy hν an electron is seized, there results at this frequency a vessel current of 800 amps. The observed current of 93 amps. is then not beyond the bounds of possibility. At the same time, by this research a very plausible reason for the slope of the relative photo-electric value of the driving current is found, for with the increasing driving current the rays' velocity always becomes greater, and thereby the actual loss of the operative rays always becomes less, which results from absorption at the cathode beaker, etc.

Now as to the agreement of Dallenbach and Jahn with direct measurements of the share of the photo effect with absorbed rays. The highest recorded up to now was by Pohl and Pringsheim, 0·0015 coulombs per calorie of the considered rays at wavelength 3,650 A units. By this the value 93/4,000 amp. per watt=0·023 amp. per watt, which is equal to 0·0055 coulomb/calorie, which is certainly only four times the previous highest value. As there are no means of ascertaining the wavelengths which come into the question (but they are very short), we cannot exclude with certainty an effect only four times greater than the previously known values.

Later work has convinced Schottky that there is an effect which he names the "Konvektiven" photo-electric effect, though there is no evidence to show this to be any other than the ordinary effect. The resonance rays are responsible for certain emissions of atoms, and in a very complete

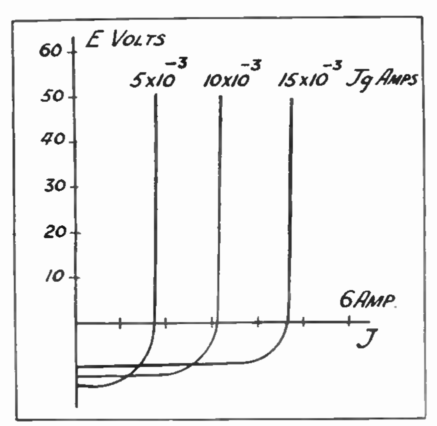


Fig. 8.

Curves showing behavior near current axis of Fig. 7 curves.

discussion of these views Schottky certainly has good grounds for his belief in the existence of these photo-electric currents; for the conclusion one arrives at after reading his paper, is that there appears to be a fundamental convective transfer of the ray quantum to the rectifier walls, and therefore the process for the release of electrons at the vessel wall would appear to be nothing more than the usual photo-electric effect.

Experiments with Dark Light

The commercial possibilities of noctovision are enormous. The ability to see through fog, for example, would rob harbor and coastwise navigation, as well as railway operation, of their greatest dangers.

AT the British Association meeting in Leeds, England, last year persons seated in total darkness were seen on a screen in another room as if they had been brilliantly illuminated. In the opinion of many experts noctovision holds forth greater potentialities than does television, the power to see in the dark and to see through fog opening up immense commercial possibilities.

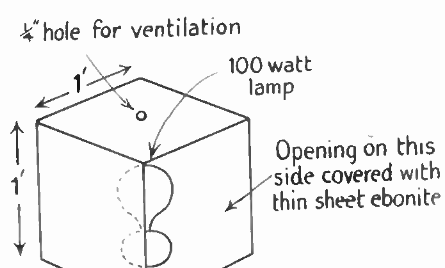
Infra-Red Ray Experiments

The apparatus used by Mr. Baird is beyond the scope of the ordinary amateur, but in this article we will show how to construct apparatus with which it will be possible to demonstrate the existence of these rays and to use them for carrying out most interesting experiments. In later issues we hope to develop this subject and open the pathway to a field of research offering the most fruitful possibilities.

The apparatus required for the experiments described here does not entail any expenditure, with the exception of the purchase of a sheet of very thin fibre. This sheet of fibre is used as filter. Fibre possesses the property of passing the infra-red rays while completely absorbing all visible light. An ordinary 100-watt lamp is fixed in a little box, the front of which is covered with a sheet of thin fibre—.019 inch or even thinner ebonite is quite suitable. The arrangement of the box and lamp is shown in Fig. 1. About one yard away from this box is placed an interrupter disc, as used in the simple televisor apparatus described in our first issue. Behind the light interrupter is placed an ordinary selenium cell, connected to a two- or three-valve amplifier and to a pair of headphones.

If now the light interrupter is started up and the headphones attached to the amplifier a loud humming will be heard, due to the infra-red rays falling upon the selenium cell after being interrupted by the revolving disc. This humming sound is stopped immediately a hand is interposed between the infra-red radiation and the cell, proving that the note is caused by the infra-red rays.

These infra-red rays can be focussed and dealt with in the same way as ordinary light, and if a lens is arranged to focus an image of the lamp on to the cell before the screen of fibre is interposed and the fibre is then placed in position the note will be heard with almost undiminished vigor.

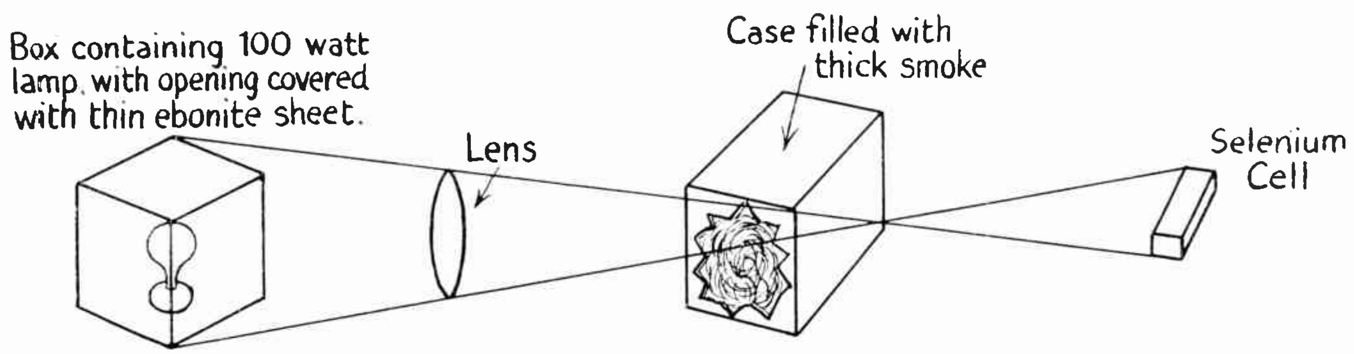


This shows the construction of the infra-red ray generator complete with electric light and ebonite or fibre ray filter.

A further most interesting and instructive experiment is performed by making a little case of thin fibre or gelatine. As shown in Fig. 2, this little box is filled with thick smoke, and although the smoke appears quite opaque to the eye it will be found that the infra-red rays will penetrate it and still affect the selenium cell.

Try Ultra-Violet Rays

Instead of using fibre the same experiments may be duplicated using the ultra-violet rays instead of the infra-red. The ultra-violet rays require a different form of screen to the infra-red, and this ultra-violet screen may be obtained for quite a small sum. It resembles a piece of intensely blue glass and is quite opaque to visible light. If interposed in place of the fibre it will be found that the cell is still affected and the experiments carried out using the fibre aperture can be duplicated using Chance glass, only in this case fog is not penetrated. By increasing the power of the amplifier i is remarkable over what distances this interrupted light (or rather these interrupted rays) can be detected, and many modifications of the apparatus will no doubt suggest themselves to the investigator.



The layout of the apparatus for the experiments with infra-red rays. The selenium cell is here illustrated without its attending vacuum amplifier and B battery.

How to Make Scanning Discs With Square Holes

PIERSON E. CUSHMAN

Last month Television *printed an article describing the construction of a special jig for use in drilling holes in television scanning discs. These, however, were round holes while the latest practice in the art calls for discs with square holes. The present article describes a method of laying out and "drilling" square holes in a scanning disc.*

SINCE the articles dealing with the Simple Televisor have appeared, so many readers have written to us asking for further information on the methods of marking out and cutting spiral discs that it has been decided to devote a special article to a more complete description of this fascinating subject. It is proposed to give in some detail particulars for constructing discs which will give a finer grain and more detail than those specified in the original design.

A spiral disc consists essentially of a disc of thin sheet metal carrying one or more spirals of holes: these latter may be either round or, preferably, square. The holes approach nearer the centre of the disc as we go round the circle, the radial distance being decreased by an amount equal to the width of a hole each time.

Referring to Fig. 1, which shows a typical disc with one set of 12 square holes each 1/8 inch square, it will be seen that the circumference has first to be divided into 12 equal parts. Radial lines are then drawn through the division marks. Now commence with any radial line, and with a compass strike an arc of a circle with the centre of the disc as centre, with radius, say, 1/2 inch less than the radius of the disc, to intersect the selected radial line. Now decrease the trammels by 1/8 inch (the width of the square holes) and strike another arc to intersect both this radial line and the next one, which will be referred to as the second radius.

Marking out Discs

Again decrease the compass by the same amount and strike an arc cutting both radius No. 2 and radius No. 3. Repeat the process, decreasing the compass again and cutting radii Nos. 3 and 4. Continue to decrease the compass and strike arcs until the disc has been traversed once completely. We now have a series of radii each of which is intersected by two parallel arcs of circles 1/8 inch apart, and to complete the marking out it is only necessary to draw short lines parallel to each radius at its points of intersection and 1/8 inch away from it.

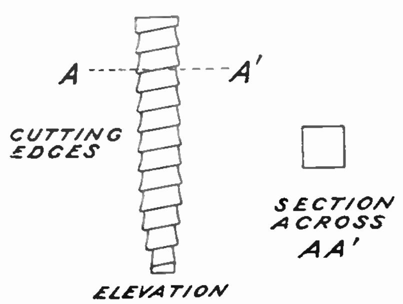


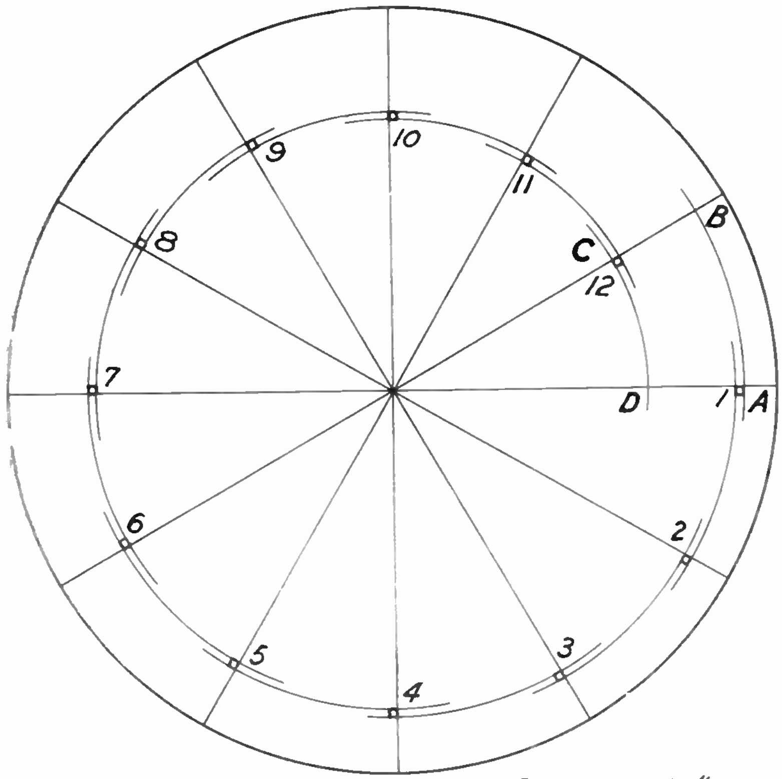
FIG. 3. DRIFT

It will be seen that there are now 12 small 1/8 inch squares, one on each radius: this should be quite clear from the drawing (Fig. 1) which shows this stage of the proceedings, the radii having been numbered to indicate clearly the order in which they are marked out. The holes are, strictly speaking, not mathematically squared, since two of their sides are arcs of circles, but they approximate so closely to squares as to be indistinguishable in practice from proper squares.

Making Square Holes

All that remains to be done is to drill small round holes in the centre of these squares, and to open the round holes up square by means of a square needle file, using a lens or a watchmaker's eyeglass to ensure accuracy. Each hole must be filed exactly to the marked lines, and may be finished exactly to size by means of a small drift, if the reader cares to go to the trouble of making one.

For the benefit of those readers who are not acquainted with this simple tool a brief description will be given. It consists of a short length of hardened steel of square section, parallel for most of its length, but tapering slightly for the remaining portion. Each of the four faces has backed off cutting edges formed on it so that on placing the small end in the roughly finished hole and tapping lightly through with a hammer a perfectly square hole of exactly the correct size is formed. Note that the cutting edges are not cut squarely across the tool, but slantwise, so as to give a more even



Marking out for 12 Hole Disc: Diameter 12" Holes 1/8" Square.
Fig. 1. *Picture Area of Disc = ABCD.*

cut (see Fig. 3). The reader will find it quite easy to make these tools for himself out of short lengths of square silver steel, which may be filed to shape and size, after which the cutting edges may be formed, and then hardened and tempered to a deep straw color.

This completes the disc, with the exception of one rather important little detail which was omitted in the description of the Simple Televisor, namely, that since the material used is aluminium sheet, which is very highly polished and consequently reflects quite a lot of light, the disc must be coated with some form of dead black paint. The best kind to use is that known as acetate black, which has a cellulose in amyl acetate base and which dries rapidly leaving a very fine dead black surface. Care must be taken, however, that none of the holes are blocked up by it, and to this end it is advisable to pass the drift through all the holes again after the paint has dried.

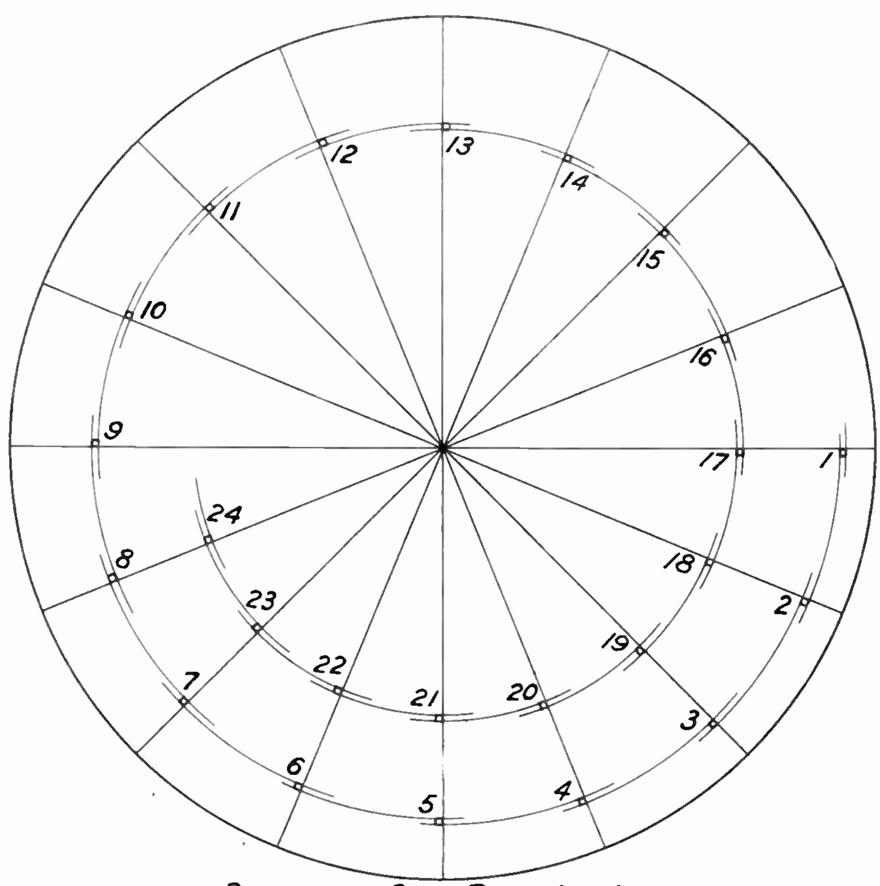
We will now consider one or two theoretical points in relation to discs, with which the reader should familiarize himself, as they will occur frequently in future.

The most important point is what is called the "ratio" of a disc. Just as a reel of photographic film is specified, not by the total length of sensitive material on it, but by the length and breadth of the pictures which are to be taken on it, so a televisor disc is specified by the length and breadth of the received image, or by the ratio of length to breadth. Thus, a disc capable of giving an image 1½ inches long by 1 inch broad, would have a ratio of 1½ to 1, as also would a disc giving an image 3 inches by 2 inches.

Disc Ratios

Now obviously, only one of our square stops must be within the picture area at any given instant, for if there were two we should have two points of the picture area having exactly the same brilliance (both being illuminated from behind by the neon tube), whereas there is only one initial signal. That is to say, two similar images would be formed. This phenomenon can actually be observed with the Simple Televisor by shifting the

(*Continued on page 137*)



Design for Disc Ratio 1½:1
Diam: Disc = 15". Holes Start ½ In.
Size of Holes 1/9" Square.
Fig. 2.

DISCOVERING THE SECRETS OF THE PHOTO-VOLTAIC CELL

This is the second installment of Mr. Wolfson's series dealing with liquid type photo-electric cells. Not only does the author penetrate to the very bottom of his subject but he offers many fascinating experiments for those who would investigate the mysteries of photo-electric activity in connection with fluids. Incidentally the apparatus needed is simple and inexpensive.

H. WOLFSON

(Continued from February issue)

WE must now consider the apparatus and the methods employed to detect and measure these minute photo-electric currents, generated as we have seen in solutions of certain dyes such as Rhodamine B, Rosorufin, etc. Naturally we cannot expect to measure them on the ordinary type of voltmeter, since the magnitude of the current is of the order of a few millivolts only.

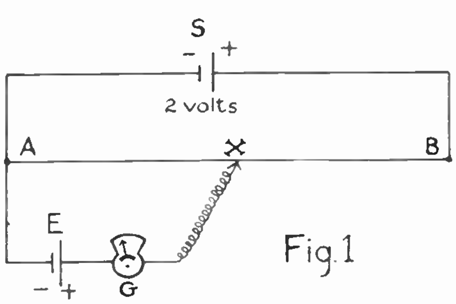
Staechelin makes use of the Poggendorft compensation method, which method I have myself employed with considerable success. This is, in fact, the ordinary potentiometer method for comparison of E.M.F. The apparatus consists of a two- or four-metre potentiometer wire, with a sliding contact and scale graduated in millimeters (AB, Fig. 1), across whose ends is applied a constant potential, obtained from a two-volt accumulator.

Measuring Potential Drop

We then have, if the wire is uniform, a constant fall of potential along the wire. That means that if we tap off half-way along the wire the potential difference across the portion tapped off (AX, Fig. 1) is half that across the ends of the wire, *i.e.*, one volt. Thus we see that the voltage across AX for any position of X is equal to

$$\frac{AX \times 2 \text{ volts}}{XB}$$

In the circuit AX is included the E.M.F. to be measured, in this case the photo-electric cell, and a sensitive galvanometer G, which may be either a sensitive mirror galvanometer or a capillary electrometer. I use the latter type of instrument, a description of which appears a little later on.



A.B. Potentiometer wire. S. Sliding contact. G. Galvanometer. E.M.F. to be measured. S. Accumulator.

It is possible then to find a point X on the potentiometer where the galvo gives no deflection, the so-called null point. Since the batteries were connected in opposition we see that the E.M.F. of the photo-electric cell is the same as the potential across AX. If then we illuminate the cell, and thereby give rise to a photo-electric current, we shall disturb the balance and there will be a deflection of the galvo. After readjusting the potentiometer to restore the balance, if we observe the distance which we move the slider we can calculate the E.M.F. produced as a result of illuminating the cell. The accuracy is very high, since we can read the potentiometer to an accuracy of one millimetre, which corresponds to a voltage drop of 2/2,000ths of a volt or 2/4,000ths of a volt, according to whether the length of the potentiometer wire is 2,000 or 4,000 millimetres. That is to say, we can take readings to within one-millionth or half a millionth, as the case may be.

The other part of the apparatus, shown diagrammatically in Fig. 2, consists of a U tube in which is placed the solution under examination. This is fitted with a glass tube in one limb of such a diameter as to leave room for the electrode of platinum foil (P), connected by a salt bridge of normal potassium chloride through a beaker of the same solution with a normal calomel electrode (C), which can either be made at home or bought from any scientific suppliers. Fig. 3 shows the complete disposition of the apparatus.

Capillary Electrometer

This instrument, although known in many forms, can be constructed by the experimenter in a very simple manner. Fig. 4 gives two simple forms of the instrument.

In Fig. 4 (*a*) the outer vessel is a test tube (T) three inches high and one inch in diameter, which is filled with battery acid and carries a cork fitted with a tube which consists of a piece of 5 mm. tube fused on to a piece of 1 mm. capillary tubing. This tube is nearly filled with pure dry mercury, as illustrated (M).

The outer tube (Fig. 4 (*a*)) has a platinum wire (P) sealed in at the bottom, as shown, and a small globule of mercury is placed over this to ensure a good contact. The other connection to the circuit is taken from the mercury in the U tube. If the instrument is arranged so that the acid contact is always positive no trouble will be experienced. Care must be taken to see that the capillary is filled with acid above the mercury thread C, but no acid should be allowed in any other part of the U tube.

This is accomplished by blowing down A to expel a few drops of mercury, which drop to the bottom of the tube and form the contact, and on ceasing to blow the acid is sucked back automatically.

The other form is slightly better, since with a horizontal capillary one obtains a larger deflection. The diagram (Fig 4 (*b*)) is self-explanatory. Both these instruments need a low-power microscope to read them accurately, but one such as opticians sell should be sufficient. Personally I use a $\frac{1}{4}$-inch objective for the purpose.

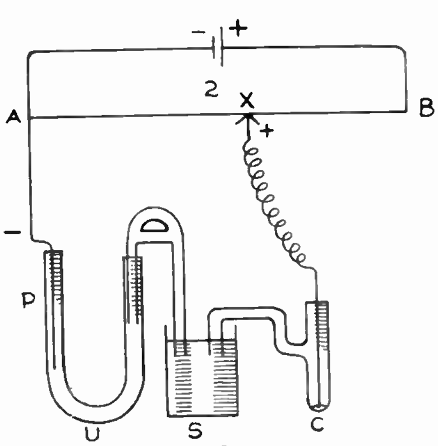


Fig.3.

P. Platinum foil. U. U-Tube. S. Salt Bridge. C. Calomel Electrode.

Alternate Construction

The calomel electrode is shown in two forms in Fig. 5 (*a*) and (*b*). The more scientific form needs a little glass-blowing. Either

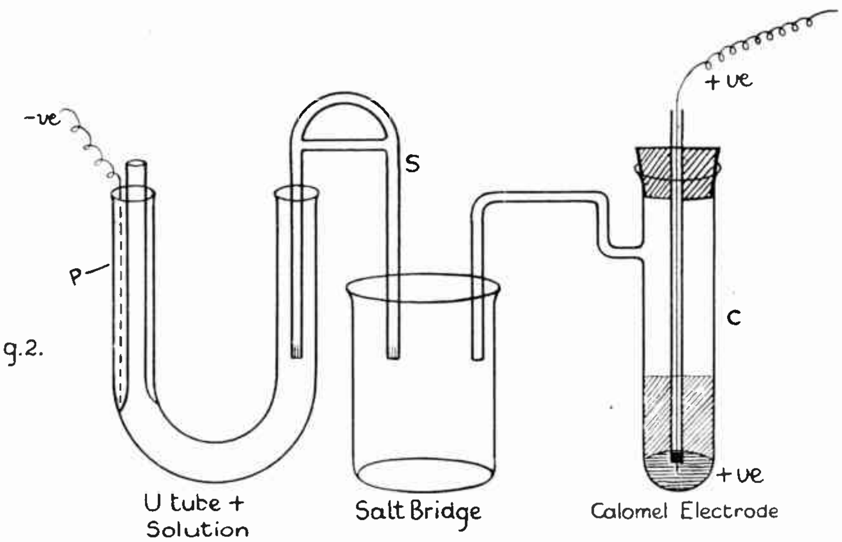


Fig.2.

Apparatus for Testing Light-sensitivity of Solutions

form has a layer of mercury (M) at the bottom, and over this is placed a layer of paste (P) made by shaking mercury with calomel and a solution of potassium chloride containing 74·5 grams per 1,000 cubic centimetres of water. Over this is poured the potassium chloride solution (S) which is saturated with calomel. A tight rubber stopper carrying a glass tube with a platinum contact completes the cell. The tube C and the beaker and salt bridge are also filled with the same potassium chloride solution.

To carry out the experiment, first balance the circuit with the cell in the dark. Then illuminate the cell, and if the solution is photo-sensitive there will be a change in the balance point.

It might appear at first sight as if I had gone too much into detail over the detection and measurement of photo-electric currents, but when we realize that the most important part of any television transmitter is the "Electric Eye," and that the only part of the Baird televisor which is being kept a strict secret is the light-sensitive device which Mr. Baird has invented, we see the necessity for immediate and intensive research on the subject. The amateur who equips himself with the apparatus described in this paper will find much interesting work to do, with the chance of making a discovery which will render television a much easier problem than it has been hitherto.

The next point which I should like to discuss is in connection with the results which I have obtained in my laboratory, using colloidal solutions, chief among which is colloidal selenium. This is an aqueous solution of selenium in which the particles are ultra-microscopic. It is, however, not a true solution, and for those readers who are sufficiently interested in the nature of colloidal solutions I would recommend the perusal of a book on Colloid Chemistry, such as may be obtained through most public libraries.

The method of preparing colloidal selenium is to dissolve a

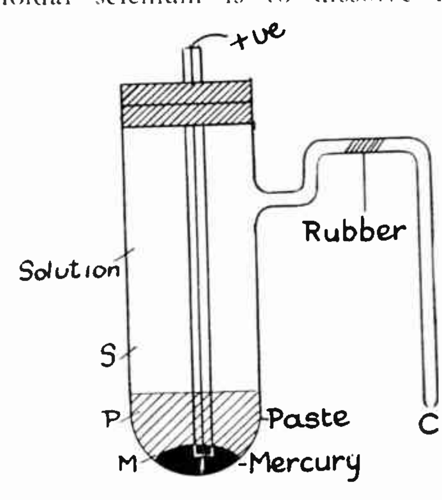
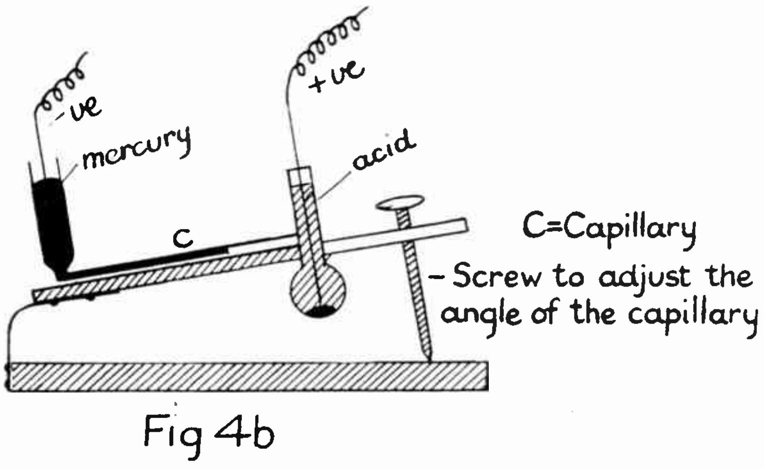


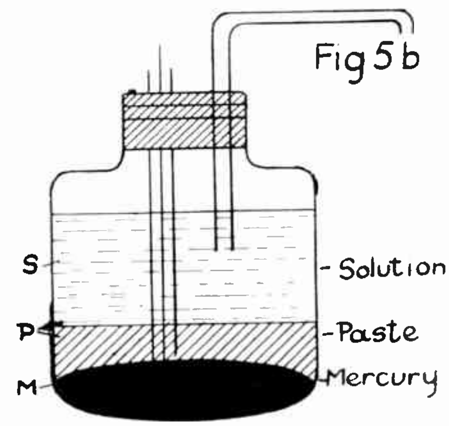
Fig.5a.

Details of Calomel Electrode

very small quantity of selenious acid in pure distilled water in a very clean beaker. To this it is best to add a *small* quantity of gelatine solution as a "protective" agent. The solution is heated to boiling point and a few drops of



Improved Form of Capillary Electrometer



Simple Form of Calomel Electrode

hydrazine hydrate solution added. There should result in a few minutes, after cooling, a perfectly clear red solution. (There must be no trace of cloudiness.) The solution should be kept in a clean stoppered bottle in the dark.

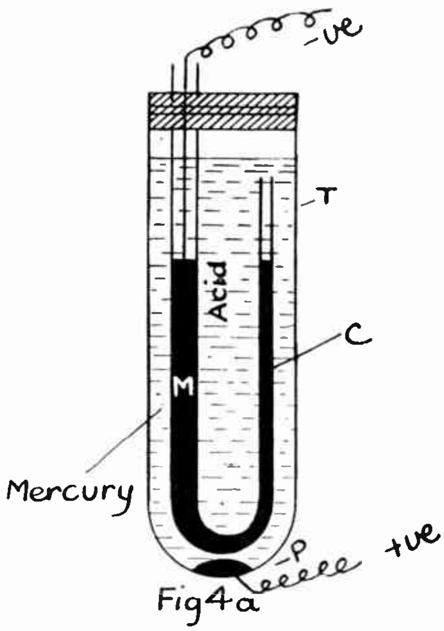
Results Obtainable

Taking care that the solution is free from excess of hydrazine hydrate (which can be best overcome by a process known as dialysis), a quantity of the solution is placed in the U tube shown in Fig. 2 and the potentiometer adjusted so that no current is flowing through the galvanometer. The cell is then illuminated and I find that there is a deflection of the galvanometer which corresponds to a potential difference of 10-15 millivolts. This means that a colloidal solution of selenium is somewhat light-sensitive, and that with suitable adaptations it might be used as an "Electric Eye" in the television transmitter.

It is interesting to note that the surface area presented by the Colloidal particles is very much greater than that of the substance in the solid state. For example, one gramme of selenium, when spread in a thin layer such as is employed in the cell described in the first number of this journal, would have a surface of about 30 square centimetres, while a colloidal solution containing the same weight of selenium can be shown by calculation (assuming the average size of the particles to be 5×10^{-6} cm. diameter) to have a surface of 200,000 square centimetres!

Further experiments have been or are being carried out with other colloidal solutions, such as colloidal silver and gold, which can be prepared in a similar way to colloidal selenium.

A very dilute solution of silver nitrate has one or two drops of dilute ammonia added, and a cu-



Capillary Electrometer

bic centimetre of tannin solution is poured in to the solution after it is heated to boiling point. A solution is then obtained which is brown to transmitted light, but green to reflected light, a so-called dichroic solution, in fact.

Finally, I would like to draw the reader's attention to the statements that Mr. Baird uses a *light sensitive device*, not a photo-electric cell. Taken in conjunction with remarks made to the author by Mr. Baird when demonstrating his televisor before the British Association last year, and the statement that he (Mr. Baird) had carried out experiments with visual purple (which contains a pigment called rhodopsin) we can see that a complete investigation of the subject of l i q u i d light-sensitive cells is of vital importance.

CAESIUM PHOTO-CELL

The values of the work functions of the alkali metals and their color-sensitivity curves indicate definitely that caesium is the most favorable material for use in photo-cells. The practical difficulties of handling caesium metal have been overcome in the caesium-magnesium cell, in which a freshly evaporated coating of magnesium not only binds an invisible layer of caesium to the walls of the cell, but also provides an electrical connection with the cathode terminal. Average color-sensitivity curves given for more than twenty cells show that the maximum sensitivity lies at about 4850A, as compared with 4400A for pure potassium, 5390A for pure caesium, and 5560A for the human eye. The photo-electric properties of the cell have been detailed by means of response voltage curves, response-illumination curves and illumination limit curves. The maximum response for vacuum type cells is about 2 microamperes per lumen, and for gas-filled cells about 25 microamperes per lumen under normal operating conditions.

—*Physical Review.*

THROWING LIGHT ON THE SPECTRUM

Light and television are two very closely allied subjects. As a matter of fact, no television experimenter can possibly hope to make any real progress in mastering the art of seeing by radio until he gains a comprehensive knowledge of certain phenomena as they affect the problems of transmission and reception.

CYRIL SYLVESTER, AM.I.E.E.

IN television all that we are concerned about are the light rays which go to make up the normal spectrum, termed the visible spectrum. These, combined, form white light. We are also concerned with the deviation from the normal spectrum, through the use of artificial light. In comparison with normal daylight the intensity of artificial light is very small. When taking a photograph we do not measure the intensity of daylight, beyond giving a plate more or less exposure according to the quantity, or intensity, of the

Fig. 1

light prevailing at the moment the plate is exposed Since all objects which are seen on the televisor screen are manifest from the light which is reflected from them, it will be seen that the projection of a picture will depend, not only upon the quality of the light but upon its intensity.

Light Variation

The intensity of normal daylight varies between 2,000 foot-candles and 20 foot-candles; it depends upon the location and conditions which prevail when the tests are made. If we are in the country, in the middle of a meadow surrounded with tall trees which are more or less dark green, thus cutting off a certain amount of the skyline, the intensity of the light as measured from the sun will be merely the intensity of the *direct* light. If, with the same intensity of direct light, we take our measurements (foot-candles) in a stone quarry from which white stone or marble is obtained, the intensity of light will be higher. The reason is that we have the intensity of reflected light in addition to that of direct light.

The same may be said of artificial light. A light source, an ordinary electric lamp, gives off light rays in all directions. If a light source is located in a room, the interior of which is painted dead black, the intensity of light which can be measured is that of direct light. The reason is that black absorbs all light rays and reflects none. If a sheet of white or colored paper were placed over the light source, as illustrated in Fig. 1, some of the upward light rays would be collected and reflected in a downward direction. In this way the intensity of the light, if measured on the floor of the room, would be increased.

The reflection factors of colored materials vary considerably. To mention a few:

Color of material	Reflection factor
White paper	80 per cent
Grey paper	66 "
Ivory white	79 "
Caen stone	69 "
Ivory	70 "
Primrose	65 "
Lichen	64 "
Pearl grey	66 "
Buff	63 "
Satin green	63 "
Sky blue	34 "
Shell pink	51 "
Pink	46 "
Forest green	19 "
Cardinal red	19 "

These reflection factors are for normal daylight. The effect of colored light upon colored mate-

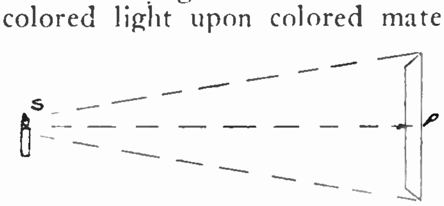


Fig. 2

rial has already been explained, from which it will be seen that, with artificial light, the proportion of reflected light, when it is projected upon colored material, will depend upon the color of the incident light. This, as I have pointed out in a previous article, varies considerably.

Some Basic Facts

I have referred to the intensity of light; this must not be confused with the velocity of light, light of all wave-lengths. The term "light" may be used in two different ways: (a) To designate the visual sensation produced normally on the eye by radiant flux. (b) To denote the luminous flux which produces the sensation of sight. This brings us to the units used in the measurement of light, without a knowledge of which a clear conception of television is impossible. There are four fundamental subjects, or concepts, associated with light: the luminous flux, luminous intensity, illumination, and brightness. Luminous intensity is sometimes termed candle-power.

Luminous flux may be stated as the *rate* of flow of radiant energy evaluated with reference to visual sensation. The following analogy may make this more clear. Let us assume that we connect a hollow ball, studded with small holes, to a water tap: the pressure is regulated by the cock. The water would stream out in all directions through the holes, and the force of the water would depend upon adjustment of the cock. In the same way, electrical energy is transformed in a lamp filament into radiant energy which streams out in all directions: that which is visible to the eye is the luminous flux. It is analogous to power, the rate of doing work. It is sometimes referred to as being emitted, transmitted, or intercepted.

Light Intensity

Luminous intensity, or candle power, is the term used to indicate the solid angular density of the flux in a given direction. Let

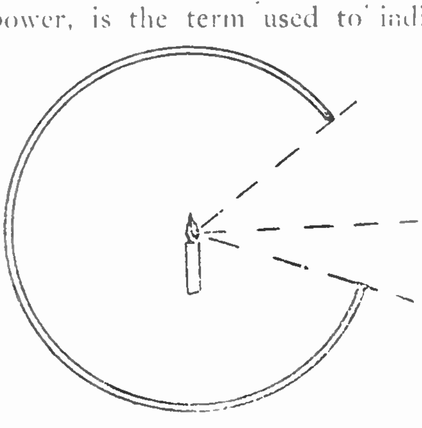


Fig. 3

us assume, for instance, that we have a light source *S*, of one candle (Fig. 2) situated at a distance of one foot from a sheet of Paper *P*. The intensity of light would be one foot-candle. If the *strength* of the light rays were the same in all directions the intensity of light at any point round the candle, at a distance of one foot, would be one foot-candle.

If we were to inclose the light source in a sphere, with a portion of the wall cut away as illustrated in Fig. 3, providing that the reflection factor of the interior of the sphere is zero, the intensity of light at one foot distant would still be one foot-candle. This brings us to the term lumen, which is the unit of luminous flux and is equal to the flux emitted in a unit solid angle whose average candle-power throughout the unit solid angle is one candle.

Referring again to Fig. 2, the intensity of illumination falling upon the sheet *P* is not even. The reason is that the distances from the light source to the sheet are different. Let us assume that the sheet is one foot square, that it is perfectly vertical, and that, from an alignment point of view, the candle is situated in a horizontal plane with the centre of *P*. The centre of *P* would be the nearest point to the light source. The corners of *P* would be the farthest away. It can be seen how difficult it would be to measure the quantity of illumination of a light source by any means in which angles or sides were involved. Since, however, the intensity of illumination from a light source must be readily calculated, it may be said that the method adopted is to imagine a light source in the centre of a sphere which has a diameter of two feet. The distance from the source to any point of the sphere is one foot, and, assuming an even distribution of light from the source, the intensity of illumination at any point on the inside of the sphere will be the same.

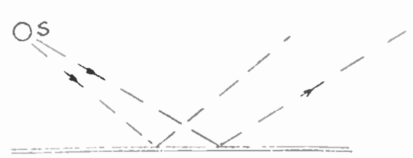


Fig. 4

Ray Absorption

We now have to consider the inside of the sphere and how the unit, the lumen, is derived. The area of the sphere is $4\pi = 12.57$ square feet. If we take one square foot of the interior, a difficult quantity to measure, although simple for our purpose, we can say that the illumination falling upon an area of one square foot in the sphere is one lumen. Similarly,

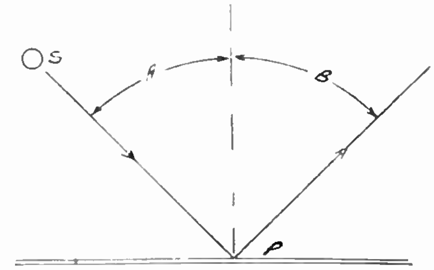


Fig. 5

the quantity of illumination which can be obtained from a uniform light source of one candle is 12.57 lumens.

It may be well to emphasize the importance of candle-power and its relation to luminous flux. The total flux in lumens of a standard lamp (a lamp against which the intensities of other light sources are measured) is determined by obtaining the mean spherical candle-power, either directly or through measuring the mean horizontal, and multiplying this by 4π. Candle power, then, is always associated with a source, whether self-luminous or otherwise, and gives information regarding the luminous flux at its origin.

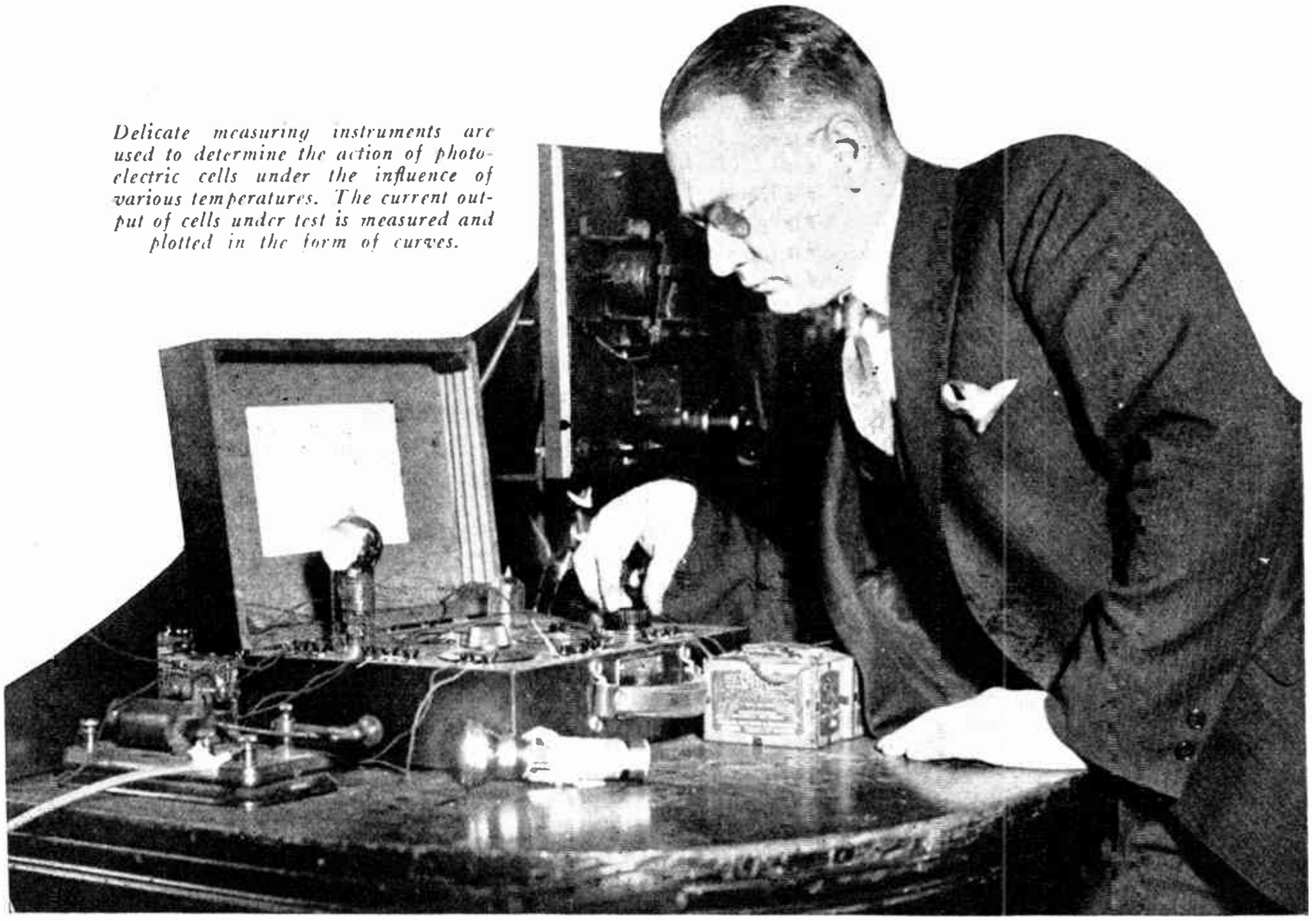
When an opaque (black) body intercepts the rays of light from a source the rays are absorbed. With all other materials, however, no matter how low the reflection factor may be only a proportion of the rays are absorbed; the remainder are reflected. There are many interesting factors about reflected light which should be understood.

Reflected Light

I have already referred to the light rays from a luminous point being divergent. That is, they emanate from a light source at different angles. If, therefore, direct light rays strike an object they will be reflected from that object at different angles. This is illus-

(*Continued on page* 135)

Delicate measuring instruments are used to determine the action of photo-electric cells under the influence of various temperatures. The current output of cells under test is measured and plotted in the form of curves.



Do You Know the Three Sources of Photo-Current?

By SAMUEL WEIN

The effect of light on certain elements and compounds has been known for more than one hundred years, but the best contributions to art have been made in the last ten years. This is due to the wonderful progress made in the development of the three- and four-element vacuum tube. In other words, the progress made by the light-sensitive cell has followed closely the perfection of suitable amplification equipment.

It is strange indeed that the light-sensitive cell should depend for its development upon progress on the audion, when the former was discovered many years before the latter. The reason for this dependancy was because the three- and four-element tube found immediate commercial use and demand, while the light-sensitive cell was still buried away in the scientific literature, and its adaptability to the commercial arts was ever a question of doubt.

The recent progress made in television, telephotography and talking motion pictures, immediately made the demand for light-sensitive cells so great, that contributions to this art soon ran almost apace with the audion. To-day, the light-sensitive cell is no longer looked upon as a laboratory curiosity, but as a dependable and valuable device in commerce, as well as a laboratory instrument with endless possibilities.

The present writer has been experimenting with light-sensitive cells for twenty-six years, and during this period, he has collected several hundred compounds that have reacted to light, as well as collected over fifty thousand publications (magazine articles, patents, etc.) reviewing various light-sensitive cells, materials and their divers applications to the technical and industrial arts.

As a result of classifying this literature, the writer soon found that (1) much erroneous technical information has been published from time to time, and (2) the present popular conception as to the divers forms of light-sensitive cells is still a hazy one.

It is the intention of the writer in the present article to define the definitions of the various types of light-sensitive cells, so that a more clear idea may be had by the average radio fan and television experimenter as to what light-sensitive cells are. The more technically inclined reader will see a new angle as to light-sensitive cells in general.

Specifically speaking, there are three different types of light-sensitive cells. It is hoped that these definitions or classifications will be used universally, merely as a means for placing in their proper categories the different types of cells, and thus help the progress.

Photo-Conduction Cells

The term "photo conduction" or "photo resistant" cell has been applied to that series of light-sensitive cells which depend on a change in resistance (Ohmic value) on exposing the material under observation to a source of light.

The conventional form of photo-conduction cell is made by winding two fine wires over an insulating material, and the light-sensitive material is deposited between the two wires. This then forming a "bridge" or "unit," the term "cell" is used extensively, and therefore

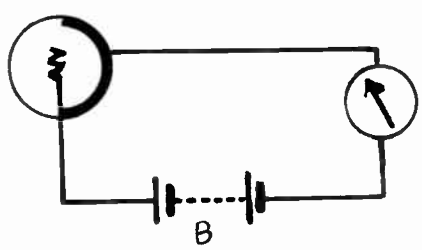


Fig. 2

we shall abide by this word here.

Of the photo-conducting materials, there is the element selenium, which has held an important place in the history of this art until recently. In recent years much has been done with the metallic sulphides (reaction product between the elements and sulphur), and the halide metals (reaction product between the elements and bromine, chlorine, fluorine and iodine) including the oxides, etc. Among these compounds we find molybdenite, a natural sulphide of molybdenum; argentite, silver sulphide in mineral form; thallium oxysulphide, etc.

Some of these materials require certain conditions of temperature changes to bring about the best consistent light-sensitiveness in the material under observation, whereas, on the other hand, certain of the materials do not require heat treatment ("annealing") to bring about this light sensitivity.

The conventional manner of hooking up a cell of this type is

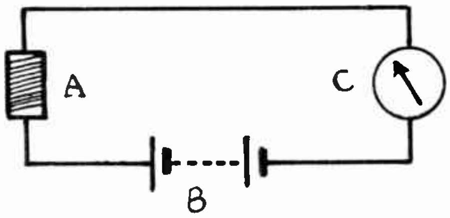


Fig. 1

shown in Fig. 1. Here the cell is shown at A, and the source of current at B and a meter at C.

Usually cells of this group are high in their Ohmic value, running anywhere from 5,000 ohms in the dark up to and over 1,000,000 ohms. The "dark resistance" varies with the various types of cells, and so does the percentage change on exposure to light. There are too many unknown factors concerning the resistance value of these different types of cells, and, therefore nothing specific can be said of them in this respect. Generally speaking, cells having higher dark resistances have greater percentage change in resistance when exposed to light, and therefore a greater sensitivity for weaker illuminations.

These types of cells may be made analogous to the rheostat in its characteristics, i.e., the more light the cell is exposed to the greater will be the percentage change in resistance. In the rheostat, we get a change in resistance by manual means, as by sliding a contact over "buttons" of the rheostat, or by pressing high resistance materials.

Sometimes the name "actino-electric" effect has assigned to this type of light-sensitive cell, in the place of photo-conducting cell, merely because it is so much simpler to pronounce. Be that as it may, a change in names to distinguish this type of light-sensitive cell from the other forms is at this time one worthy of consideration.

The Photo-Electric Cell

The photo-electric effect is altogether different in its characteristics from the former types of cells. Here we do not depend on a change in resistance of an element or compound, but rather on an "emission" or tearing off from the surface of an alkali metal film in an evacuated glass bulb. This type of cell is analogous to the "diode" or two element tube. In the diode we get an emission of electrons from a hot cathode, i.e., a filament coated with certain metallic oxides, and in the photo-electric cell, the emission is obtained from the coating by exposing the cell to a source of light.

Photo-electric cells are usually enclosed in a form of glass that is transparent to the higher and lower radiations of the spectrum. On the inside of the glass bulb is deposited a mirror in the conventional order, this film acting as an electrical contact. In the center of this bulb is fixed a "collector." In the diode, the collector is a metal plate, whereas in the photo-electric

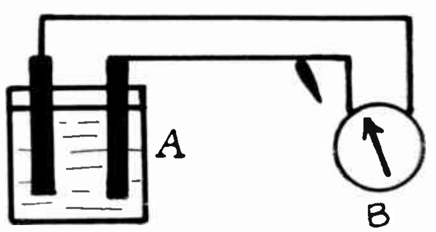


Fig 3

cell the collector is in the form of a coarse grid of fine wires so as to prevent a shadow falling on the deposit made on the silver film. Leads are brought out through the glass bulb to which the electrical contact is made. The bulb is highly evacuated and the alkali metal is distilled onto the silver film. The alkali metals used are sodium, potassium, rubidium, caesium, etc.

Of the photo-electric cells, there are two specific kinds, the "hard

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Radio Commission *Puts Television on the Short Waves*

The Radio Commission, having issued an order on January 14 that no more picture or Television broadcasting would be permitted on the bands between 550 and 1500 kilocycles, except by express authority of the Commission and then only between the hours of one and six A.M., announced that a hearing would be held on February 14 to determine whether such broadcasting could be done on a 10 k.c. band, if interference would result, and if any actual demand for television broadcasting existed.

At this hearing, John V. L. Hogan, the well-known consulting radio engineer of New York City, made the opening address at the request of the Commission and outlined a policy which was practically identical with the one subsequently adopted by the Commission. His remarks, in effect, were as follows:

"It seems to me that the problem should be considered from two viewpoints. First, the research, experimental and technical development of the machinery, so to speak, of transmission, and second, and quite independently, the matter of development of program value for whatever type of picture transmission may be found available at any particular time, now or in the future. For the technical development of the means of transmission and reception it seems to me that there is little place in the broadcasting band and that work of that character should be done largely in the laboratories, without even involving radiation of actual radio waves at any frequency. And then we must, I think, consider the fact that even after the laboratory work, which does not involve wave transmission, is completed to a point that satisfies the investigator at that particular time, his product as then finished must of course be tested in actual space transmission, and therefore waves must be provided for that purpose.

Independent development of program value in the picture transmission art, it seems to me, would result in an earlier availability to the public if given a certain character of transmission either of facsimiles or of motion pictures or of actual vision, and having determined that that particular apparatus for transmission had some finite program value, then the development of the program service with that particular apparatus might be permitted within the broadcasting band. The reason I say this is that there are so many listeners, so many potential critics available in the broadcast band that if a given service having, as I say, necessarily and initially a finite program value, is submitted to those people there will be an infinitely greater response than if that program test is limited to frequencies outside the broadcast band.

You will note that I have said that before any picture transmission should be allowed on a broadcasting band it would be necessary to show that it had a finite program value, and that it was not merely a technical development. Who is best able to pass on the existence of a finite program value I cannot say, but I should think that it would be the Radio Commission. I think that for the development of program service it should be recognized that a finite program value would be less in its actual program service to the public than would be accepted as even an approximation of the ideal. In other words, I think that for the development of program value in picture transmission the Commission in judging the current program value of any particular set-up should not be as critically inclined as, for example, an engineer would be. Let me say that in general an engineer will say, "This thing is no good to the public because it is rather feeble in its service value." On the other hand, if that criterion had been applied to broadcasting in 1920 and 1921 and if broadcasting had been hedged in by many artificial restrictions at that time it is undoubtedly true that the service would have developed at a much slower rate than it actually did develop.

Now the only reason I am urging this consideration is that I believe the development of picture transmission as a public service will come much more rapidly if given some program value,—if the attempt to develop that program value is carried on under proper restrictions—than if it is kept entirely out of the broadcast band. That is because of the potentiality of great listener or observer criticism. We all must recognize in that connection that the one thing that develops program value in any service of either the sound or the picture type is listener criticism or observer criticism.

As to the type of restriction that should be placed upon any such program service in the broadcast band it seems to me that there are several considerations, but that one is paramount. I think the Commission is absolutely right in its view that the sound services, that is to say, the music, speech, entertainment services, must be protected, and that it would be utterly unwise to allow so much picture transmission in the broadcast band that the sound services would materially suffer.

I would like to emphasize again the fact that I think the Commission should be convinced that there is a finite, though not necessarily high, program value in any picture transmission that is permitted on the broadcast band, and that technical development of means of transmission should not be either permitted or encouraged at the expense of the broadcast listeners.

One other feature that perhaps should be considered is that to a very large extent the protection of the broadcast listener will be automatic and quite apart from any regulations formulated by the Commission. That is to say, if Station WXXX decides that it would like to transmit pictures for one hour per evening from 8 P.M. to 9 P.M. and if Station WXXX is of such character that it enjoys an excellent reputation among its normal broadcast listeners, it is quite obvious that that station will not risk an hour in the best time of its program service in favor of a picture transmission experiment unless the particular picture transmission which it has in mind has already demonstrated itself to that station management as having a definite program value.

If the judgment of the station is wrong on that point, if the judgment of the station is that the picture will have program value, and it turns out that it has not program value, we can reply upon that station management to take the picture service off the air and replace it by the normal sound broadcasting upon which the popularity of that station has already been based. In other words, no station management having a high degree of popularity will risk its reputation by bothering or pestering its listeners with a service that does not contain a real element of service to those listeners.

There is one other feature that I should mention, namely, that if and when any stations are allowed to develop program value of picture transmission on the broadcast bands they should be required to operate in such fashion that they produce no more interference with other stations while transmitting pictures than they would while transmitting voice or music."

Dr. Lee De Forest told the commission that he hoped they would not make the mistake in regard to television which the Federal Radio inspectors made in 1919 when they ordered his broadcasting station closed on the ground that radio had no entertainment value and that his broadcasting was interfering with commercial wireless sending.

The decision of the Commission was announced on February 19, when licenses for experimental television broadcasting were issued to seventeen stations, existing or to be constructed, for operation in the high-frequency channels between 2,000 to 2,200 and 2,750 to 2,950 kilocycles, as follows:

W2XBW and W2XBV of the Radio Corporation of America, in New York and New Jersey, and a construction permit for a third station.

The Jenkins Laboratory, Inc., W3XK, to be located in Washington, and a construction permit for another station in Jersey City.

Westinghouse Electric & Manufacturing Co., four licenses for stations to be located in East Pittsburgh, Pa., and Springfield, Mass.

General Electric Co. at Schenectady, N. Y., and Oakland, Cal., two licenses.

WAAM, Inc., at Newark.

Lexington Air Station at Lexington, Mass.

Pilot Electric Manufacturing Co. at Brooklyn.

Chicago Federation of Labor at Chicago.

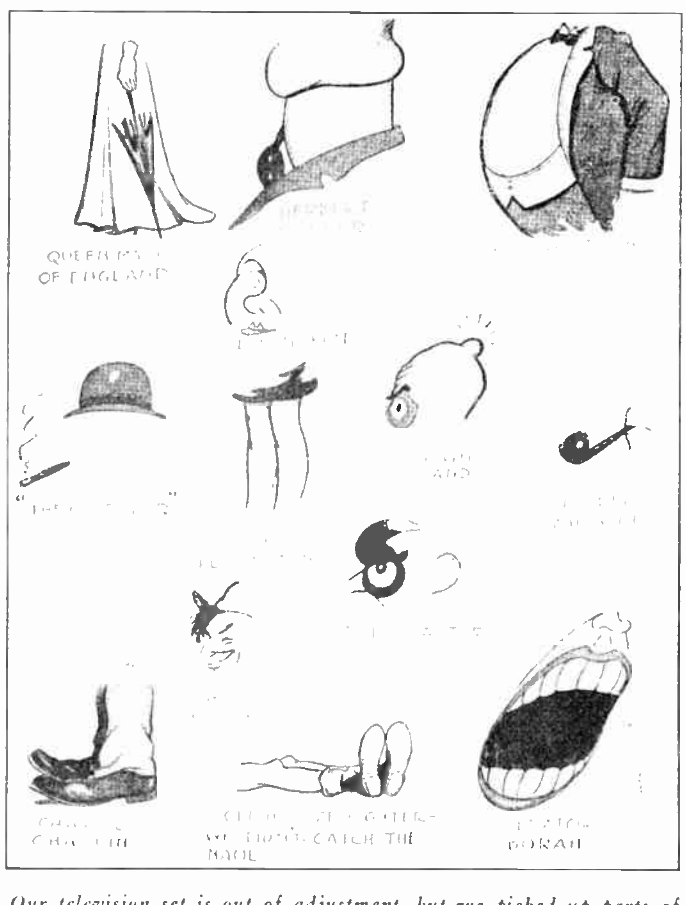
W. J. Lee at Winterpark, Fla.

Aero Products, Inc., at Chicago.

The Commission announced that these licenses were authorized for six months and subject to revocation if any interference was caused to services operated by other North American stations. This action definitely placed television experimentation on the short wave bands.

EXTENDS COMMISSION

Among the measures approved by President Coolidge on the morning of March 4 was one extending the authority of the Radio Commission until next January 1. That body would have automatically ceased to exist on March 16 had the bill not been approved and the commission's work would have reverted to the Commerce Department.

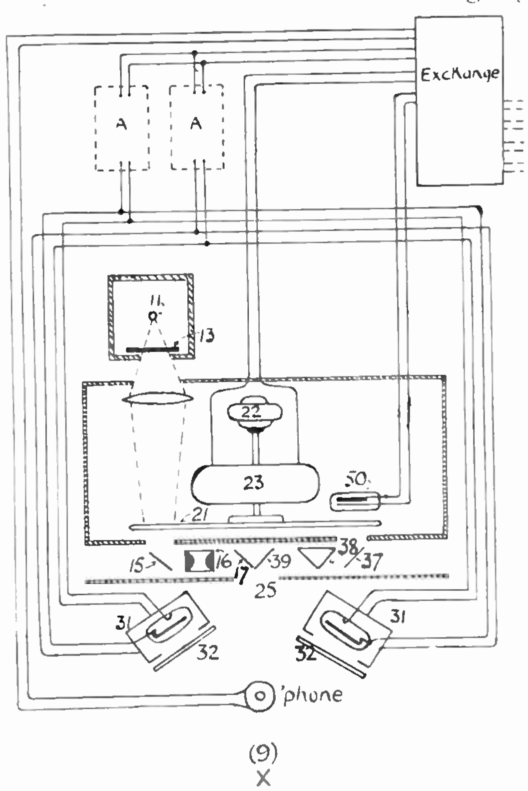


Our television set is out of adjustment, but we picked up parts of some recently transmitted portraits.—Courtesy of LIFE

With the TELEVISION INVENTORS

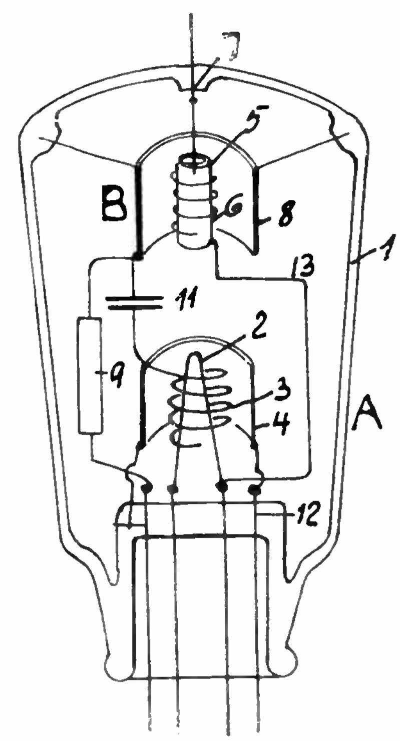
What the inventors are doing to improve the transmission of living and still pictures and how they propose to do it. The Television magazine does not in any case hold itself responsible for the technical correctness of the ideas proposed. A résumé of each patent issued is given solely for the purpose of permitting the reader to keep abreast of the art.

No. 286262.—Dr. H. E. Ives and Electrical Research Products seek provisional protection for a two-way television system, which it is claimed may be used in conjunction with the ordinary telephone system and work through an Exchange. The object (9 is irradiated with invisible radiation in order that he may not be dazzled, and light-sensitive cells selective to such radiation may be employed at the transmitters.



An exploring beam of ultra-violet and infra-violet rays from the source (11) passes through the screen (13), the scanning disc (21), an optical system (15) (16) (17), and one-half of an aperture (25); the screen (13) serving to filter out the visible part of the spectrum. The radiation is diffusely reflected from the face of the subscriber (9), through further filter screens (32) (32), on to pairs or groups of cells (31) (31), of which each pair may comprise one photo-electric cell sensitive to ultra-violet radiation and one thalo-sulphide cell sensitive to infra-red radiation. The relative effects of the two kinds of cell can be adjusted to give the right tonal value to the picture. The output of the cells after amplification at (A) is sent to line.

Incoming signals are applied to the neon lamp (50) and the resulting variable illumination is built up by the scanning disc (21) and the optical system (37) (38) (39) so as to be visible through the remaining half of the aperture (25). The scanning disc is of special design, being provided with two diametrically opposite spirals of holes so that received and transmitted signals pass at the same instant through diametrically opposite holes. The disc is driven by a motor (22) synchronized by an A.C. generator (23).

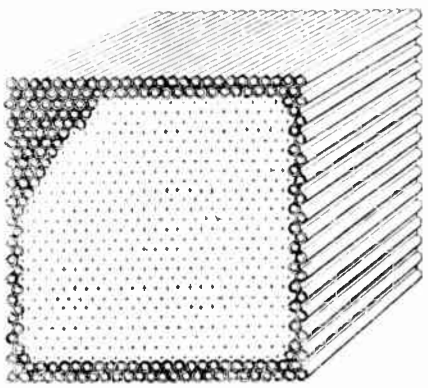


One of the problems met with in television is that of magnifying the extremely small currents liberated by light-sensitive cells. The photo-electric valve amplifier, which is the subject of a recent patent (No. 261391) by Dr. Siegmund Loewe, employs an incandescent cathode for the final stages of amplification (A), and one or more "cold" photo-electrically active sources of emission for the preceding prior stages (B), with a consequent saving of filament heating current. At least two of these stages are mounted in a common vacuum. The illustration shows a multiple unit valve containing two separate sets of electrodes, the cold cathode being a cylinder (5) whose surface is coated with a photo-electric substance (sulphide of thallium, a hydride of potassium or selenium or rubidium are suggested). Its photo-electric energy is mainly due to the light or heat radiated from the lower filament (2), which reaches it by reflection from all parts of the inner glass wall (1) and by using a perforated anode (8). The electron emission from the upper cathode may also be assisted by a direct metallic connection (13). Inter-valve coupling consists of a special high-resistance element (9) and a blocking condenser (11).

The valve may be used as either a high- or low-frequency amplifier. In operation, incoming signals are applied between the grid lead (7) and the filament. These currents control the system (5) (6) (8). Alternating voltages are thus transmitted through the condenser (11) to the lower grid (3).

PRODUCING IMAGES WITHOUT LENSES

A method of producing images without lenses is referred to by J. L. Baird in Patent No. 285738. The illustration shows a screen



No. 285,738

made out of a bank of closely assembled tubes in the form of a honeycomb. By placing a ground glass screen at the back of such a bank of tubes an image appears on it of any object placed in front, due to the fact that the individual light rays in passing longitudinally through the tubes are not spread laterally. When the tubes are arranged parallel with one another the image will be of the same linear dimensions as the object, but magnification or diminution of the image can be obtained by using a slightly diverging or converging arrangement of the tubes. The inner surface of the tubes may be of a non-reflecting nature so as to avoid any dispersion of the light by internal reflection, or the tubes may be in the form of thin rods of glass quartz or other transparent material.

THREE SOURCES OF PHOTO CURRENT

(*Continued from page* 130)

vacuum" and the "gas filled." In the former, the cell is highly evacuated and the photo-electric current is directly proportional to the amount of light the cell is exposed to. Whereas in the gas-filled type, the photo electric current is not directly proportional, since the characteristics of cell is dependent directly on the gas used, as well as the pressure of the gas.

In manufacturing the photo-electric cell of the gas-filled type, after the alkali metal has been properly distilled over the surface, pure (dried) hydrogen is introduced and a disruptive discharge of low-potential is passed between the alkali metal film and the grid, thus converting the film into a "colloidal" surface. The hydrogen is thereafter completely pumped out, and an inert-gas, such as argon, neon or helium, is introduced. The bulb is thereafter sealed off and it is ready for use. The formation of the colloidal surface makes the cell much more sensitive to weaker illumination, and the introduction of the inert gas tends to amplify the photo-electric effect in the cell itself before it has been used in the circuit.

As seen in Fig. 2, the photo-electric cell is not dependent on its functioning as a light-sensitive cell by a change in resistance, but on the emission of electrons.

The Photo-Voltaic Cell

And now we have reached the third of the different types of cells, the photo-voltaic cell, or "light-sensitive battery" as it might be best termed in simple English.

The photo-voltaic cell usually consists of two metals inserted in a glass vessel containing a liquid, and on exposing one of these metal elements to a source of light, a potential is generated. A diagram of connections used is shown in Fig. 3. The cell is seen at A with its two metal elements, and the meter at B. No potentials are required for this type of cell, since it is in itself a "light-sensitive battery."

The photo-voltaic cell consists essentially of two similar metals, coated with films of the corresponding halide metal films thereon, and the liquids used are dilute acid or alkaline. With some metals, acid solutions give better results, and again, with other metals, the alkaline solutions are the better. This is also the case with the nature or kind of film deposited on the metal used.

Of this type of cell there are two kinds, one in which the light-sensitivity is the result of action on the deposit of films on the surface of metals, and one in which action is in the electrolyte itself. This latter type of electrolyte is common only with phosphorescent or fluorescent materials.

It is hoped that a general survey of the different types of light-sensitive cells will give rise to a better understanding of the "electric eye" which is the device that television depends upon as a means for breaking up the variations in light into electrical impulses. If the writer has helped but one of his readers he will have been amply repaid by his discourse on the different kinds of light-sensitive cells, and their definitions.

ON THE WAY

A dispatch from Los Angeles to the *Wall Street Journal* on March 3 stated that plans are now under way by engineers of Radio Corp. of America, who recently arrived in Hollywood, to establish an electrical research laboratory and to erect a television broadcast station. R-C-A is understood to have perfected a television receiving set which can be leased to homes at $5 or $7.50 a week. R-C-A now is installing photophone equipment in the R-K-O studios in Hollywood.

On the same day it was announced that R. C. A. Photophone, Inc., New York, had filed with the Secretary of State of Delaware, notice of an increase in no-par capital stock to 1,000,000 shares from 200,000.

Looks as if the day when we can sit by our firesides and see and hear our favorite motion picture stars entertaining us from Hollywood was drawing near.

RICH REWARDS FOR PROBLEM SOLVERS

(*Continued from page* 116)

obtaining and maintaining synchronous operation must be employed.

Very ingenious automatic speed controls have been developed, with centrifugal governors making and breaking contacts across speed-control resistance, for maintaining steady speed of the scanning disk irrespective of the fluctuations in line voltage or other causes.

To my mind, the problem will probably be solved more in the direction of ingenious braking devices, which will regulate the scanning disk by means of a definite frequency impressed on the television carrier wave along with the television signals. Again, there may be a synchronizing signal sent out for each revolution of the scanning disk, tending to start the scanning disk out in step with the transmitting disk, at each revolution. There are many ways in which synchronous operation may be obtained.

The problem of obtaining a nation-wide television broadcasting service is a serious one. In fact, the production of television receivers is largely handicapped until television service is available in various parts of the country. Here it is my belief that the film or radio movies method of broadcasting is going to meet with the greatest favor at first, until such time as broadcasters are prepared to give the necessary time, space, care and money involved in broadcasting television subjects themselves.

Jenkins of Washington, D. C., Frank Conrad of Westinghouse and others have worked out systems whereby the television pictures are first recorded on film, the positive of which is placed in a machine which scans each frame line by line. The advantage of the film is that the subjects may be posed under ideal conditions in the motion picture studio, with all the talent desired; secondly, that the films can be widely distributed and broadcast by small or large stations without special skill or equipment; thirdly, that a nation-wide hook-up can be effected by the radio movies method, even though no wire lines are required; fourthly, that the uniform service over a large part of the country will permit of selling television service to large advertisers, who can sponsor television in much the same manner that broadcast programs are now patronized. Of course, broadcast radio movies, will lack the news value which is available when the subject is picked up direct and televised. However, in time the direct pickup will come into more extensive use, and network operations will be necessary.

It is my belief that while television will continue for some time as a separate service, without much attempt to combine sight and sound broadcasting, the eventual outcome is a single carrier wave with double modulation to include sight and sound presentations. This will present an interest problem in modulation and demodulation for the ingenious radio engineer to work out.

THROWING LIGHT ON THE SPECTRUM

(*Continued from page* 128)

trated in Fig. 4. Here *S* is a light source from which the two rays shown strike a horizontal reflecting surface. The direction of the rays is indicated by the arrows. This proves that, since only a small pencil of light enters the eye, the intensity of light from an object cannot be accurately gauged by the eye.

There is a definite relation between the light incident upon an object and the reflected light. This can be best shown by an illustration. In Fig. 5 *S* is a light source and *P* is a reflecting surface. The arrow shows the direction of a light ray from *S* to *P*, and from *P* into space. The angle *A* is equal to the angle *B*; angle *A* is known as the angle of incidence, and angle *B* is termed the angle of reflection. This law of incidence holds good only when light is reflected from the surface only.

HOW TO MAKE A SCANNING DISC

(*Continued from page* 123)

neon tube to various positions round the disc: there will be found to be a multiplicity of images arranged around the disc, though as the neon tube is taken further away from its correct position these images will be seen to be more and more displaced radially owing to the presence of what is known as a phase difference between the transmitted signal and the receiving disc.

This condition then determines the length of our picture, for it must be no larger than will lie between two consecutive radii of the disc. The breadth of the picture is obviously the distance measured radially between the inner edge of the innermost hole and the outer edge of the outermost hole. Referring to Fig. 1 we see that the picture area for this disc is represented in shape and size by the area ABCD. It will be seen to be not truly rectangular, so that the term "length of picture" is rather vague, but the usual convention is to consider the chord AB as being the length: then BC is the width of the picture and the ratio of the disc is AB/BC.

Refining the Grain

In a previous issue it was suggested that better definition could be obtained from the Simple Televisor by using discs with a larger number of holes. A design for one is given in Fig. 2, which is drawn to scale. It will be noticed that a spiral is shown which extends one and a half times round the disc. The purpose of this i as follows.

The early combined transmitting and receiving machines was fitted with a disc having two spirals arranged consecutively round the disc, so that while one set was being used to analyze the shadowgraph at the transmitting side the other formed the image at the receiving side.

In the disc shown in Fig. 2, however, holes Nos. 1 to 16 inclusive are used to analyze the shadowgraph, while Nos. 8 to 24 inclusive form the image at the diametrically opposite side of the disc. Masks are arranged accordingly at the transmitting and receiving sides, so that this is the case always.

If the reader has constructed the separate synchronized receiver he should make two similar discs, only cutting the first 16 holes, since one disc will be used on the transmitter and one on the receiver.

The difference of grain between 10 holes and 16 is quite surprising, and with these discs a much finer image is obtainable. The discs are 15 inches in diameter, and the first hole starts ½ inch only from the periphery, the holes being of such a size as to give a picture with a ratio of length to breadth of 1½ to 1.

It should be explained that there is no particular merit in the diameter being 15 inches, as it might just as easily be 20 inches, or any figure the reader may care to use, but care should be taken to make the holes larger in proportion. Also, while we have shown 16 holes, the amateur will find it extremely interesting and instructive to design and construct discs of varying ratios and in varying numbers of perforations.

PHOTO CELL FACTS

(*Continued from page* 113)

Finally, we must consider the dependence of the velocity of the photo-electrons, if any, on the intensity of the light.

Lenard was the first to show that a variation of the intensity of the light from a carbon arc in the ratio of 1:70 had no effect on the velocity of the emitted photo-electrons. Further conclusion was given to Lenard's result by the work of Millikan and Winchester, for the eleven metals which they experimented upon in a high vacuum, the source of light employed being the spark.

THRU THE EDITOR'S SPECTACLES

(*Continued from page* 99)

The broadcasting monopoly held in England by the British Broadcasting Company is proving a most embarrassing obstacle to the development of television in that country. England, after all, must be looked upon as the birthplace of practical television, for it was due to the untiring efforts of Baird that the art was first brought to the attention of the world. The high and mighty B. B. C. not only ridicules the idea but actually appears to be going out of its way to suppress it. B. B. C.'s and Federal Radio Commissions are both bad.

Those erstwhile American critics of television who claim that radio fans have exhibited little interest in the new art would do well to go over the circulation figures of TELEVISION. The newsstands have been swept clean of practically every issue and the subscription file bulges anew with the arrival of each mail. Seeing by radio is, after all, something more than a mere scientific curiosity.

It is said that the United States Patent Office has, during the past year, received a large number of patent applications having to do with improvements in television receiving and transmitting equipment. The majority of these have been filed by the large electrical and communication companies. It appears that some of our largest and most conservatively managed industries are quite sanguine over the future of television. The great Bell Laboratories have spent large sums of money in the perfection of this new art and certainly no one could really call it a spendthrift in matters that have no communication significance.

The Editor has recently heard of a serious accident having been narrowly averted when a scanning disc, insecurely fastened to its shaft, set out on a journey at prodigious speed. It must be kept in mind that a disc two feet in diameter driven by a quarter-horsepower motor and with a peripheral speed of several miles per minute, is an exceedingly dangerous thing when it sets out on a rampage. Its striking force is not only sufficient to kill but also to cause serious damage to surroundings. One might just as well be struck with a buzz saw.

THE EDITOR.

LAMPS THAT FLICKER 48,000 TIMES

(*Continued from page 103*)

a ballast resistance. The voltage is measured by a voltmeter *V*. The values of R_1 and R_2 are such that the lamp glows when *R* is at zero, and it is then possible to set the lamp flashing by increasing *R* to a high enough value. The sparking potential is found by adjusting the apparatus as just described, and then, leaving *R* at the flashing value, decrease R_2 till the lamp just ceases to flash. Under these conditions the voltage across R_2 is a measure of the sparking potential. The value is independent of the value of *R* and *C*, except when *C* is zero.

If we now summarize these various results in the form of a graph, such as is illustrated in Fig. 5 we shall have at our disposal the complete characteristic curve, which it is possible to interpret as follows:

Interpreting Characteristic

The point marked *B* represents the last point at which the glow completely covers the cathode, the slope of the graph decreasing at this point, remaining straight, however, until the point *C* is reached. That part of the graph included between the points *C* and *D* shows the minimum value of the

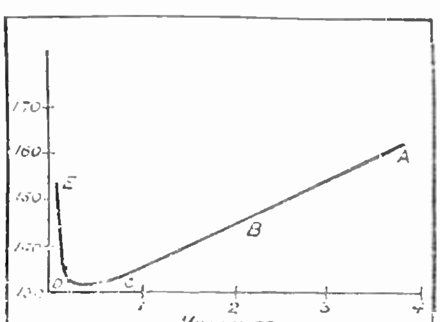


Fig. 5.—Characteristic curve of a neon lamp.

voltage, which remains constant for some time while the current drops gradually through half a milliamp. The last portion of the curve is that between *D* and *E*, where there is a rapid increase of voltage, to the fixed value (for the particular lamp) which we call the sparking potential.

The last region of the graph is of especial interest, because in this part the characteristic is definitely negative, since an *increase* in potential is accompanied by a *decrease* in the current. This region of so-called negative resistance gives us the exact conditions necessary for the lamp to act as a rectifier of alternating currents, and it is not therefore surprising to note that the lamp can be used to receive wireless signals in much the same way that one uses an ordinary rectifier valve.

Final Survey

A careful survey of this article brings to light a number of important facts, which are important to those experimenting with a neon lamp as a generator of light in the receiving televisor.

We see that the lamp will not light until the applied voltage from the output terminals of our radio set has a value at least equal to the sparking potential. On reference to the characteristic shown in Fig. 5 we see this value, at the point *E*, to be in the region of 160 volts. This value, though invariable for any one lamp, varies in different lamps between 150 volts and 165 volts, though lamps of more modern manufacture are fairly constant at about 164 volts. These differing sparking potentials are due to the variable amounts of impurities present in the neon with which the lamp is filled.

Furthermore, we must not forget that certain lamps are supplied with a ballast resistance in their base, so that in this case the applied voltage will have to be even greater, in order to overcome the resistance without falling below the sparking potential.

Once lighted, the lamp can be run on a voltage less than this value, but before the minimum voltage of 133 volts is reached (*CD*, Fig. 5), the condition of the lamp becomes unstable, and, as I have mentioned, the glow ceases to cover the whole of the cathode after the point *B* (142 volts) has been reached. The moral of this is to see that your high tension supply is invariable, besides being high enough at the beginning. Given these two essentials, the television experimenter should have little difficulty in working his receiving televisor, and in obtaining satisfactory results.

IS THE ETHER BIG ENOUGH?

(*Continued from page 110*)

bands influences the actual carrier wave frequency or wave length. Had we to consider side bands of the order of 3,000,000 it is impossible to conceive, however, this would be possible for wave lengths longer than 100 metres, for the actual frequency corresponding to a wave length of 100 metres is 3,000,000 and the frequency bands required in such a case would be from 6,000,000 to zero, *i.e.*, from 50 metres to a wave length infinitely long. In order to receive such a service we should need a receiver capable of receiving all wave lengths equally from 50 metres upwards to infinity, which is very impracticable.

However, with a frequency band of 100,000 the problem is not so difficult, for if our carrier frequency were 3,000,000 the frequency band would extend from 3,100,000 to 2,900,000, which corresponds to a wave-length range from 96.8 to 103.4 metres, which is quite practicable.

At the present moment television of comparatively small scenes probably requires a frequency band much smaller than that for telephony, so that any ordinary wave length that can be used for telephony will suffice for television.

What's New in TELEVISION

RADIO AS A PROFESSION

IN a recent radio address, J. E. Smith, President of the National Radio Institute of Washington, stated that the development of radio had been so phenomenal and so swift that many people still regarded it as the "plaything" it was half a dozen years ago. Mr. Smith pointed out that radio has already developed into a billion-dollar industry, providing employment for some 300,000 trained workers, and stressed the fact that the ones who are making big money in radio today are those who have approached the profession after an orderly and well-defined plan.

"There is still room for thousands of trained men," asserted Mr. Smith "and many avenues of success are freely accessible to those with the proper knowledge. This success comes not only in the form of increased salary, but in the way of recognition and standing in the industry as well. The man who gets a good foothold and makes a name for himself in radio will never be found walking the streets for a job, and the prospects which advanced age holds for him are sound investments, a comfortable bank account, a fine home and the many pleasures that the successful man and his family enjoy."

GASTON FONTAINE BUILDS A NEW RECEIVER

Gaston Fontaine, the 14-year-old boy who constructed his own Television Receiving Apparatus, as described in our last issue, states that he has remodeled the apparatus and that it is now "bigger and better than before."

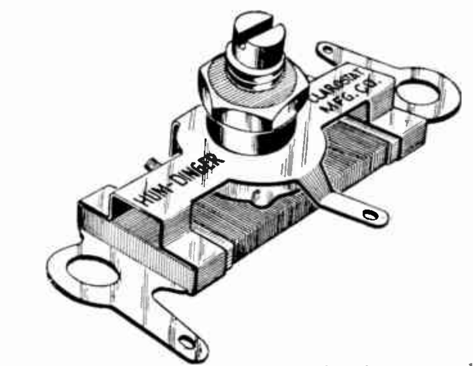
"Lately I received pictures from Station W-3-XK at Washington on 48 holes, and from W-1-XAY. My receiver is now equipped with a G. E. 1/6 h.p. motor which I think is series wound, a Clarostat power resistor, and a 24-36-48 hole combination disc, and synchronizing is not a problem as it has been.

GRID BIASING FOR SCREEN GRID TUBE

WITH the advent of the screen grid or 222 tube, several new problems have been brought to the set manufacturer or set builder. Chief among these, and perhaps the most neglected, is that of biasing the control grid at 1½ volts negative potential, a factor that assumes even greater proportions with the employment of the 222 tube in short-wave sets and adapters.

Many manufacturers and constructors have disregarded this feature entirely, having found that the tube will function without a grid bias. However, the characteristic charts of the tube show that the plate current is actually considerably higher when a bias is applied.

There are several ways of securing the necessary potential, most of which are too costly or impractical in short-wave television reception where a storage battery filament current is essential for good results. The potentiometer system, while satisfactory, generally causes too much drain on the battery, while the in-



sertion of a flashlight cell in the ground lead, shunted by a condenser, results in unstable operation. The ideal solution is to secure the bias from the storage battery without creating any additional drain. This may be done with the aid of a very small variable resistance of the center tap type, and the Hum-Dinger is being selected for this purpose. This device is a compact wire-wound resistor wth variable center tap covering half the total length. In the 20-ohm rating, it may be inserted in the negative filament lead of the screen grid tube in such manner that it acts as a filament limiting resistance and a variable grid bias at the same time, by connecting one end to the negative of the storage battery, the other end to the filament lead of the tube, and the center contact arm to the ground side of the antenna tuning unit, as shown in the accompanying diagram. A smooth variation of grid bias is obtained, the tube filament is operated at proper temperature, and maximum results are obtained from the tube.

JENKINS TO BE INTERVIEWED BY DE FOREST

The interview between Dr. Lee DeForest and C. Francis Jenkins, respectively the "Father of Radio" and the "Father of Television," to be broadcast over the Columbia Broadcasting System, has been changed from March 24th to April 21st. On that date, during the usual Sunday evening DeForest Audions Hour, between 10:00 and 10:30, Eastern Standard Time, these eminent scientists will discuss the subject of television before the microphone, for the benefit of the nation-wide radio audience.

Also, there will be announced at that time the prize contest for the best essay on "What Television Means to the Home," written by any boy or girl under eighteen years of age. The prize for the best essay, as judged by a jury of well-known business and radio leaders, will be the first home television receiver produced by the Jenkins Television Corporation.

The name of the Arcturus Radio Company of Newark, N. J., has been changed to the Arcturus Radio Tube Company. The change is merely a matter of policy and the same personnel continues to operate its five New Jersey A. C. tube plants.

Television Broadcasting

The Radio Division, Department of Commerce, furnished this list of stations licensed for Television Broadcasting:

		Kcs.
W9XAG	Aero Products, Inc., 1768 Wilson Ave., Chicago, Ill.	4700-4900
W9XAA	Chicago Federation of Labor, Ft. of Grand Ave., Chicago	4460-4660
W1XAY	J. Smith Dodge, Adams St., Lexington, Mass.	4800-4900
W2XAD	General Electric Co., Schenectady, N. Y.	2100-2200
W1WX	Shortwave & Television Laboratory, Inc., 104 Brookline Ave., Boston, Mass.	
W6XN	General Electric Co, 5555 E. 14th St., Oakland, Cal.	2052-4560
W2XX	Robt. F. Gowan, Overton Rd., Ossining, N. Y.	2000-2100
W3XK	Jenkins Laboratories, 1519 Connecticut Ave., Washington	4900-5000
W2XCR	Jenkins Telev. Corp., 346 Claremont St., Jersey City, N. J.	2100-2200
6XAM	Ben S. McGlashan, Wash. and Oak Sts. Los Angeles	2000-2100
W6XC	Robert B. Parrish, 5155 S. Grammercy Place, Los Angeles	4500-4600
W2XCL	Pilot Elect. Mfg. Co., 323 Berry St., Brooklyn, N. Y.	2000-2100
W2XBS	Radio Corp. of America (Portable), 411 Fifth Ave., New York	2000-2100
W2XBV	Radio Corp. of America (Portable)	4500-4600
W2XBW	Radio Corp. of America (Portable), Initial location: River Road, Bound Brook, N. J.	15100-15200
W6XF	Calvin J. Smith, 334 N. Serrano Ave., Los Angeles	4700-4900
W2XBU	Harold E. Smith, Beacon, N. Y.	4700-4900
W2XBA	WAAM, Inc., Newark, N. J.	2750-2850
W8XAV	Westinghouse Electric Mfg. Co. E. Pittsburgh, Pa.	4700-4800 5100-15200
W4XA	WREC, Inc., Whitehaven, Tenn.	2400-2500

They Could Hardly Believe Their Own Ears –

when I Switched to *Ground Wave Reception!*

IT'S no use trying to listen in tonight," said Bill, as I took his hat. "Jane and I tried to get reception during dinner but all we got was static. It's usually this way—just the night they broadcast Paul Whiteman's band or some other good program it's spoiled by howls and fading. Why own a radio at all?" he ended up disgustedly.

"Perhaps my set will do a little better." I suggested. I had a surprise in store for him!

He looked doubtful as I turned on the set switch. I had left my old aerial antenna attached on purpose and soon the room was filled with an ear-splitting excuse for music. Manipulation of the dials only served to make it worse or to choke down reception until it was hardly audible. Occasionally it faded out altogether and I could picture the roof aerial swaying helplessly in the strong wind. Then the jumble and howls would start up again until my wife finally shouted above the din. "Turn that thing off -it's terrible!"

Satisfied, I laughed and disconnecting the old aerial and ground wires, I then attached the lead-in wires of my new underground antenna, which I had installed just before dinner. "Now listen!" I commanded.

The Thrilling Test

As though by magic, the sweet high notes of violins, the stirring, sobbing of saxophones, the clear, pure notes of a clarinet brought Bill to his feet! Jane looked dumbfounded. Even my wife, who had not paid much attention to my preliminary tests, was amazed. "What did you do to it?" she demanded. "I think he bewitched it," Jane accused. The music went on, clear and strong, with only a long moan or slight jumble now and then to remind us of the storm raging outside. The static was so greatly reduced that we hardly noticed it. The important thing was—we were getting one of the year's best programs with scarcely any trouble on a wild, stormy night.

"You see," I explained later to Bill, "I buried my new underground aerial about two feet below the ground, where wind and storms can't affect it so easily. It has certainly been proved tonight that radio waves are just as strong in the ground as they are in the air. They call this thing "Subwave Aerial" and it's insulated some way to keep out interference and noise. It's combined with a scientific ground, so I'm sure now that I have the correct ground connection. And all this isn't costing me any more than my old aerial antenna that I've nearly broken my neck repairing after wind storms like this. And last but not least," I finished triumphantly, "I'll never need to touch it again. It's guaranteed for 25 years."

SUBWAVE - AERIAL GETS DX INSTALLED 50 FEET FROM 60,000-VOLT POWER LINE

Underground Aerial Products,
Suite 618, St. Clair Bldg.,
St. Clair and Erie Sts., Chicago, Ill.

Gentlemen: Regarding a test with your underground aerial, "Subwave Aerial." On January 27, 1929, Mr. Frank Smith and I drove out near the Sanitary District power plant in a Ford Sedan. We stopped about 50 feet distant from the plant's 60,000 volt transmission line and dug a small hole into which we dropped the Subwave Aerial. We left the two sets we brought with us in the sedan, attaching the lead in wires of the Subwave Aerial first to one, then the other. One set was a 5 tube Freshman—the other a single-dial Atwater Kent, Model, 35. We used the Ford battery.

At 15 minutes to six we got WCCO, St. Paul, Minnesota. It came in loud and clear at 27 on the dial. There was not the slightest interference from the 60,000-volt power transmission line only 50 feet away. At 20 minutes after six, we got Toronto, first on one set and then the other. We plainly heard the program which was being sponsored by a Spartan Radio dealer.

It was impossible to get reception at all with an overhead aerial under the same conditions.

Yours truly,
F. Bennett Smith.
Harry R. Jackson.

Hardly necessary to say that Bill went home with the name and address of the Subwave Aerial manufacturers in his pocket.

Test It Yourself—Free

The above story illustrates the results for which the designers of the subwave Aerial struggled for months. At last, enthusiastic reports such as this from Radio Experts reproduced here, proved that they had succeeded. Now you have a chance to prove the merits of this great new radio development for yourself. Try, if possible, to pick a night when static is bad and make the thrilling test. It's fun! And if you are not more than pleased with Subwave Aerial, the test won't cost you a cent. We feel safe in saying, however, that once you've heard the amazing difference in reception and realize the wonderful convenience of this modern combined antenna and ground, you'll wonder how you ever put up with the old fashioned, dangerous, inefficient methods. Be sure to send at once for all the interesting details on the development of Subwave Aerial. It's the newest, most thrilling thing in the romantic world of radio! Use the coupon below. Fill it in and mail it NOW!

UNDERGROUND AERIAL PRODUCTS
Suite 618, St. Clair Bldg.
Dept. 1009-C.W.
St. Clair & Erie Sts.
Chicago, Ill.

Underground Aerial Products,
Suite 618, St. Clair Bldg.,
Dept. 1009-C.W.
St. Clair & Erie Sts.,
Chicago, Ill.

Rush illustrated literature on the new Subwave Aerial and details of your Free Test Offer.

Name ....

Address ....

City .... State ....