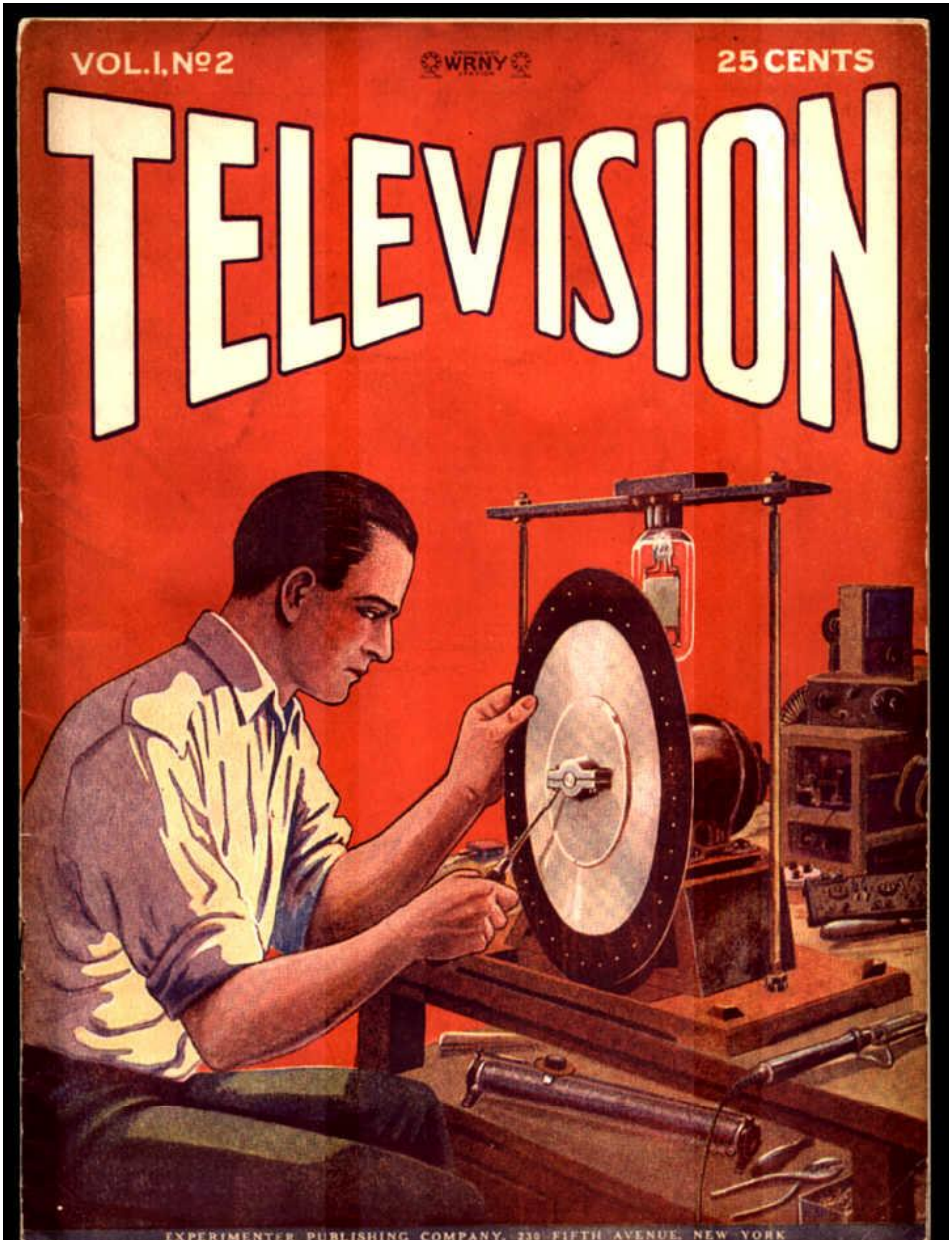
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Editorial and General Offices - - - - - - 230 Fifth Avenue, New York

Television Means Instantaneous Sight at a Distance

Television IS Here

By HUGO GERNSBACK

WHEN we brought out the first issue of this magazine in the Fall of 1927, it was thought in many quarters that we were rushing a new art unduly. At that time, it should be remembered, no broadcast station was transmitting television impulses.

In the first issue of the TELEVISION magazine, we were careful to call attention to the fact that everything contained in that issue was of an experimental nature, and that we were fully aware that there was nothing tangible as yet; but the point was stressed that a beginning had to be made somewhere.

When I started MODERN ELECTRICS, the first radio magazine, in April, 1908, amateurs had not as yet started to transmit, and it is to be doubted if there were more than one thousand amateur receivers in the country at that time; but a start had to be made in order to encourage the amateurs. Again, when I started RADIO NEWS in 1919, there was no broadcasting, there was only "wireless"—nothing but code with its dots and dashes. Broadcasting did not come along until 1921, two years later, when the public took radio to its heart and went wild over it; but RADIO NEWS, which became—and still is—the largest radio publication, had to make the start, and it has contributed not a little to radio's success.

The case of TELEVISION is very similar. We made the start last Fall when there was no television broadcasting; everything was of an experimental nature.

But we have progressed rapidly since that time. It is evident that television has arrived, for the simple reason that a number of stations at this minute are broadcasting television signals.

True, this is but the beginning. True, also, that what we are doing today in television runs parallel to what we were doing in 1908 in the coherer-and-spark-coil era. Television, admittedly, today is in a very crude state. Frankly, it is not as yet intended for the public at large and any statements to the contrary are simply misleading, and will create mischief and harm to the new art.

At the present time, television is for the *experimenter* only. By experimenter, we mean the serious-minded research student who fully appreciates the difficulties of the new art and thoroughly understands its present limitations. Unless the television experimenter is well versed in mechanics, electricity, radio and optics, he had better keep his hands off even the most up-to-date television equipment that can be bought today. If he is not so equipped, television will most likely lose a booster and will gain a knocker.

It may take many months before television has been simplified so well that anyone with a pair of pliers and a screwdriver can construct a good set which will give a clear image, whereby you can recognize a man's face from that of a woman when broadcast from a rather distant radio station.

The point is, that the start has been made and that television really is here; and that thousands of serious-minded experimenters are now sufficiently interested in it to spend their good money, even if the results obtained are, frankly, mediocre.

But television experimenters know in their hearts that they are the pioneers and that twenty years hence they can point with pride to the fact that they constructed a television set in 1928 when the art had just begun. And that will be worth while.

And don't forget that, the more people who are working along these lines, the faster the new art will progress, and the quicker we shall get results.

The experiences of experimenters are especially valuable in a new art. The American experimenters have usually shown themselves capable of simplifying and suggesting improvements. It was so with radio, and will be so with television. This publication has been created as a furtherance for the new art. At this moment the time is not ripe to bring it out every month, because sufficient material is unavailable, but we hope to present it soon as a monthly.

Television Experimenters

THIS issue of TELEVISION contains the first clear directions as to how to build a Television set, written by a Television experimenter.

This magazine will shortly come out as a monthly, and the Editor solicits good articles from those who have actually completed Television receiving sets. Photographs and full descriptions are particularly desirable.

Please address all correspondence and articles to the Editor of this publication.

TELEVISION, Vol. I, No. 2, July 16, 1928. Title registered U. S. Patent Office. 25c per copy. Published by Experimenter Publishing Co., Inc., 230 Fifth Ave., New York, N. Y.; copyright, 1928, by them in United States. H. Gernsback, Pres.; S. Gernsback, Vice-Pres. and Treas.; C. E. Rosenfelt, Sec.

Sanabria-Hayes Televisor

THIS LATEST TELEVISION TRANSMITTER AND RECEIVER WAS RECENTLY DEMONSTRATED AT THE SECOND ANNUAL RADIO TRADE SHOW IN CHICAGO

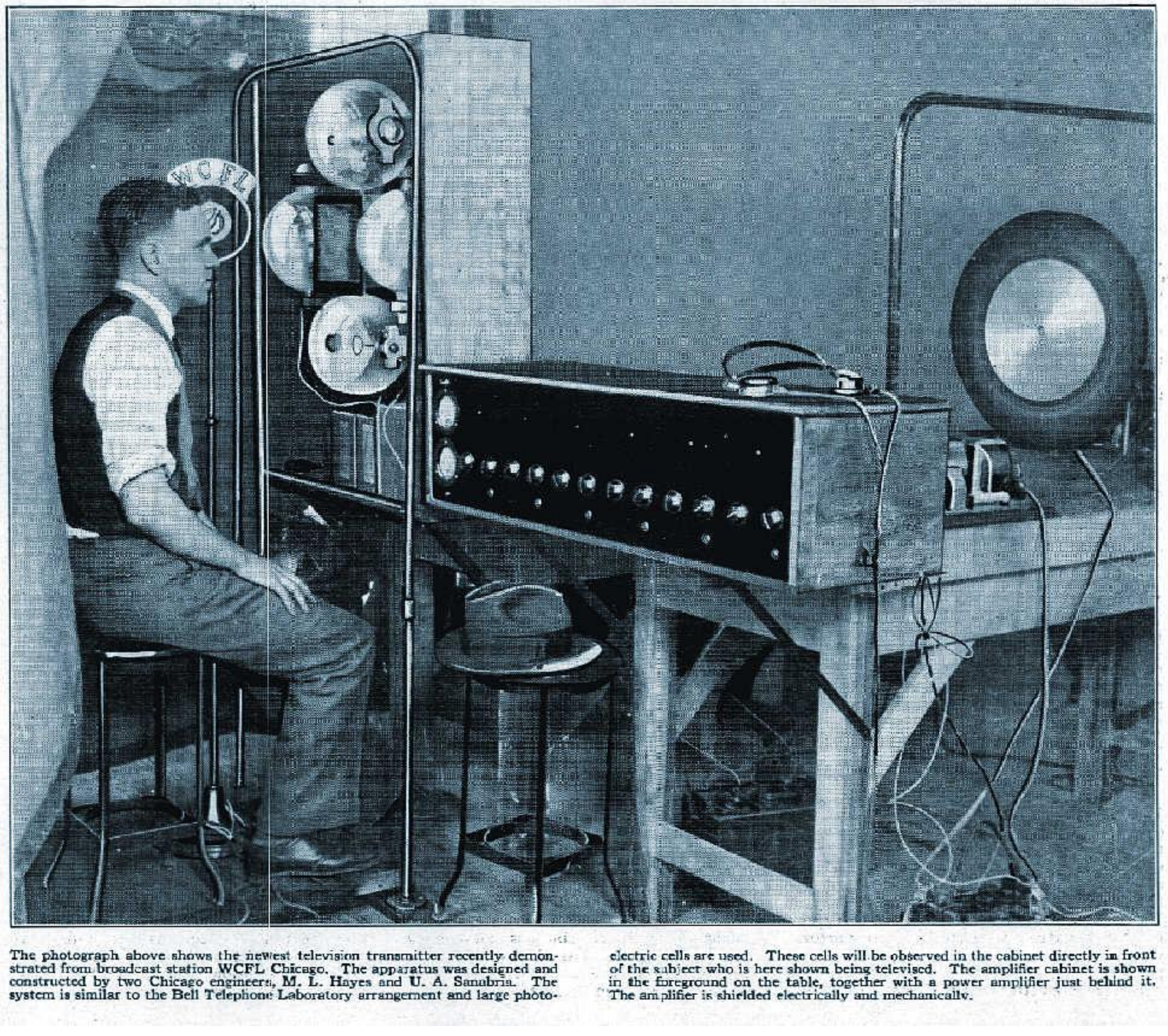
THE photograph herewith shows one of the newest television transmitters and receivers which was successfully demonstrated at the recent Radio Trade Show in Chicago. The managing editor of *Radio News Magazine* saw the apparatus in operation and stated that the reproduced image was very clear and brilliant. In general, this newest television system designed and built by two Chicago engineers, Mr. M. L. Hayes and U. A. Sanabria, is based on the Ives system demonstrated about a year ago by the Bell Telephone Laboratories in New York City. Those interested in the details of this television system will do well to read the description of the Bell Telephone Laboratory televisor described in Vol. I, No. 1, of *Television*.

Looking at the photograph we see that an intense beam of light from an arc or incandescent lamp passes from right to left, through a whirling perforated disc, the successive beams of light falling on the subject's face. As the reflected light beams fall on one of the four huge photoelectric cells, observed in the cabinet directly in front of the subject, minute photoelectric currents are produced by the cell or cells affected by the reflected light beam at any particular instant. These weak currents from the photoelectric cells are then highly amplified by the vacuum tube amplifier shown in the center of the picture. Eight stages of resistance coupled (thoroughly shielded) amplification are available in the amplifier, and jacks are provided so that any number of stages may be used as occasion requires.

When the amplified photoelectric cell currents emerge from the last stage of the amplifier, which should preferably be a power stage, this current is connected to a neon tube, which is placed behind a second revolving perforated disc. This receiving disc is rotated at exactly the same speed as the transmitting disc by a synchronous motor. The reproduced image is observed by looking through a diaphragm in front of the whirling perforated disc at the spot where the neon tube light is situated. As the constantly changing picture image currents arrive at the neon tube, the latter instantly regulates the amount of light given off in simultaneous fashion. The transmitting and receiving disc each have a similar spiral of holes on them so that when a disc makes one revolution, the spiral of perforations has succeeded in completely scanning the image to be transmitted.

One of the newer developments of these enterprising inventors takes the form of specially perforated discs, each disc containing three spirals of holes. In this fashion each disc scans the picture three times in one revolution and the scanning is not in the usual sequence one, two, three, four, etc., but one, four, seven—for example. The second spiral of holes scans paths two, five, eight, etc., the third spiral three, six, nine, etc. It is claimed that much better definition and detail are obtained in this way.

The large photoelectric cells here shown were constructed at the University of Illinois by a research scientist and their performance is similar to that of the large Ives cells used in the Bell Telephone Laboratory demonstrations last summer. Television amplifiers require the use of resistance coupling to avoid distortion and the cutting off of certain frequencies, which would happen if ordinary transformer coupled amplifiers were used.



The photograph above shows the newest television transmitter recently demonstrated from broadcast station WCFL Chicago. The apparatus was designed and constructed by two Chicago engineers, M. L. Hayes and U. A. Sanabria. The system is similar to the Bell Telephone Laboratory arrangement and large photoelectric cells are used. These cells will be observed in the cabinet directly in front of the subject who is here shown being televised. The amplifier cabinet is shown in the foreground on the table, together with a power amplifier just behind it. The amplifier is shielded electrically and mechanically.

Special Details on Jenkins Radio Movies

ADDITIONAL DATA ON JENKINS TELEVISION RECEIVER AND MOVIE REPRODUCTION SYSTEM GIVEN BY HIS RADIO ENGINEER, MR. THORTON P. DEWHIRST

BY H. WINFIELD SECOR

THIS data concerns the article on a new Jenkins movie transmitter and receiver described in the August, 1928, *Radio News*, excerpt of which appears on page 28 of this magazine.

At the transmitter Mr. Dewhirst stated that the Jenkins Laboratory was using a Sperry arc with the carbons at a 90° angle to each other, the arc drawing about thirty-eight amperes at 110 volts pressure. The positive carbon is the horizontal one, and the glowing crater of this positive carbon was picked up with a lens and passed through the revolving 48 lens disc. The concentrated powerful beam of light passes through the revolving lenses, mounted in a concentric circle (not a spiral) on to the rapidly moving, motion-picture film, which is driven by a motor in a continuous (not intermittent) movement downward behind the revolving lens disc. Asked if the scanning *pencil of light* in each case travels across the downward moving film in such a fashion as to leave the film 1/48th of an inch higher than at the spot where it started, Mr. Dewhirst said this was correct. This is due to the film continuously moving downward, while the scanning light pencil is moving across the film.

Lens Disc Details

With regard to the revolving transmitter disc for movie film image transmission, the disc being fitted with 48 lenses, Mr. Dewhirst stated that the disc, with all the mechanical work of accurately aligning and mounting the lenses cost about $9,000. These lenses were first purchased optically perfect and matched, and cost $42.50 each, he stated. Optically matched, however, was not perfect enough, and further optical correction had to be made.

The interviewer asked Mr. Dewhirst why an ordinary metal disc with small holes was not used in place of the round lenses, and he stated that a more powerful and accurately controlled beam was focused on the moving film by the use of the lenses. Apparently a disc with pin (small) holes could be used in its place, at least for experimental work by the amateur.

Transmitter Amplifier

Mr. Dewhirst stated that a three-stage resistance coupled amplifier, carefully designed, was used to first amplify the photoelectric cell current, and that this was then sent into a six-stage specially shielded, resistance coupled amplifier. For radio transmission the output from the ninth stage is connected with the grid of the modulator tube, which in turn controls the transmitter tubes of the radio station. Where the apparatus is demonstrated inside the laboratory, all in one room, the output from the ninth stage can be connected either directly, or preferably through a single stage of power amplification, to the neon tube placed inside of the Jenkins revolving quartz rod drum.

The Jenkins Quartz Rod Drum Receiver

Mr. Dewhirst stated that when using a 10-inch diameter plate glass lens, of the plano-convex type, with the plano flat side toward the mirror, that an image filling this lens was satisfactorily reproduced, the image having a brilliancy even better, he thought, than that obtained on the Bell television receiver. The 10-inch lens mentioned has a focal length of 21 inches (that is, to the 45 degree mirror, this mirror being simply a good quality plate glass mirror).

In the demonstration which Mr. Hertzberg, managing editor of *Radio News*, and a number of government representatives saw in Washington during May, 1928, at the Jenkins Laboratory, the movie film used at the transmitter was a specially selected one, having black silhouette images, such as dolls, fairies, etc. The reason for using this silhouette film with solid black images, was that with the particular design and adjustment of the amplifier stages employed at present, a much sharper and more satisfactory (contrasty) image was reproduced on the receiving mirror and lens.

Mr. Jenkins' expert explained that the Jenkins quartz rod drum receiver can be used perfectly well for half-tone reproduction of a television image, transmitted by a disc or other type transmitter, such as the Bell, Nakken, etc. It is important, of course, to use only resistance coupled stages of amplification in a radio receiver, beyond the detector, for half-tone reproduction such as Bell obtains; no audio frequency transformers being permissable, if anything like satisfactory results are to be obtained.

Asked if they had tried picking up television images from the regular orthodox television transmitter, such as the Bell type, and an attempt made to reproduce it on the quartz-rod-drum mirror lens arrangement of Mr. Jenkins, the expert stated that they had done so satisfactorily, with proper adjustment of the C bias on the receiving power stage and special attention to other details.

The engineer explained that the receiving quartz rod drum rotated four times as fast as the lens disc at the transmitter, for the reason that each one of the four, exactly identical, spirals of quartz rods comprising twelve rods to each spiral, had to complete their rotation four times in the scanning of each motion picture frame. While the first quadrant of the lens disc is moving over the film image, the first spiral row of twelve quartz rods is making one complete revolution at the receiver. When the lens is passing through the second quadrant movement, the second twelve quartz rod spiral on the receiving drum is completing its revolution. As the transmitter lens disc moves through the third quadrant, the third spiral of quartz rods on the revolving receiver drum is completing its revolution, and when the fourth quadrant of the lens disc is completing its movement, the fourth and last spiral of 12 quartz rods is completing its revolution. Thus the whole action becomes quite clear. The reason why the commutator is used at the receiving instrument to flash on successfully Nos. 1, 2, 3 and 4, one-quarter-inch square metal electrodes in the special Jenkins neon tube, is for the reason the interviewer suspected—to wit: To give more than four times the brilliancy of illumination from the neon target at any particular instant. This is so for the reason that the total available energy from the power tube, for example, is used to charge or excite one of the small targets in the neon tube. Naturally with a small target and a given amount of power, the illumination will be greater than when the same amount of power is sent to a large single plate, as in the Bell arrangement. It is interesting to note, in passing, as this expert pointed out also, that shiny hollow tubes could be used in place of the quartz rods in the receiver drum, but the quartz rods are preferable, as they transmit the light with no appreciable loss; not obeying the inverse square law loss which would occur if ordinary glass was used. Lenses would also be poorer than quartz rods, as they would have an appreciable loss, due to poor light transmission through them.

Battery Versus B-Eliminator

It was stated that very good results had been obtained in the Jenkins Laboratory with a standard power amplifier, utilizing a 210 power tube, together with a 281 half-wave rectifier tube, with a dry battery C bias carefully adjusted, so that when no image current is coming into the receiver, the neon tube is dark. This amplifier is generally used with three stages of resistance coupled amplification ahead of it after the detector. The detector can be backed up with two or three stages of tuned radio frequency, preferably with each stage tuned separately according to this expert, so that the resonance curves of each stage could be juggled to give the widest frequency band possible in tuning in the station wave.

An important thing brought out was that if a grid leak and grid condenser are used in the detector circuit, the phase relation will be markedly changed and the number of resistance coupled stages of amplification used after the detector should then be an odd number, such as three, five, or seven; otherwise, the image will be reversed (that is, the image would be like a photo negative instead of a positive). If C bias rectification on the detector is employed, then the number of resistance coupled stages to be used after the detector is an even number, such as four, six, eight, etc.

Another very important point asked Mr. Dewhirst was that concerning the use of B-eliminators versus dry B-batteries. He stated that they were at present using in the Jenkins laboratories, B-eliminator plate supply, and also at times dry battery B supply. Mr. Dewhirst said that for the reception of silhouette images, as in the case of Jenkins radio movies with silhouette image reproduction, B eliminators were satisfactory; but that where half-tone television reproduction, such as the Bell and other systems involved, dry battery or storage battery B supply was preferable. This opinion concurs with that given the writer by the Bell Telephone Laboratory engineers.

If a power stage of amplification, such as a power pack giving 375 volts on a 210 power tube is used, with a measured potential drop of about 200 volts across the neon tube (Jenkins in this case) the experimenter should not connect this power stage into the output jack of a receiving set, so as to include transformer coupled audio stages. Due to the phase shifting and frequency cut-off characteristics of such transformer stages, the image at the television reproducer would most likely be considerably weakened, and also shifted on the viewing window or mirror, causing trouble in readjusting the receiving mechanism, so as to frame the picture squarely at the start of reception from each station. Resistance coupled amplifier stages are necessary beyond the detector. The power amplifier is best made of the resistance coupled type also.

Stations Broadcasting Photos

The Rayfoto system of picture broadcasting and reception is being extended nationally. Photos are being transmitted by this system from WMCA between 11 and 11:30 A.M. on Mondays, Wednesdays and Fridays and between 9:30 and 10:15 P.M. on Wednesdays. The system is also being used by radio stations in Philadelphia, Detroit, St. Louis, Milwaukee, Scranton, Toronto and Winnipeg, and is to be used soon by other broadcasters.

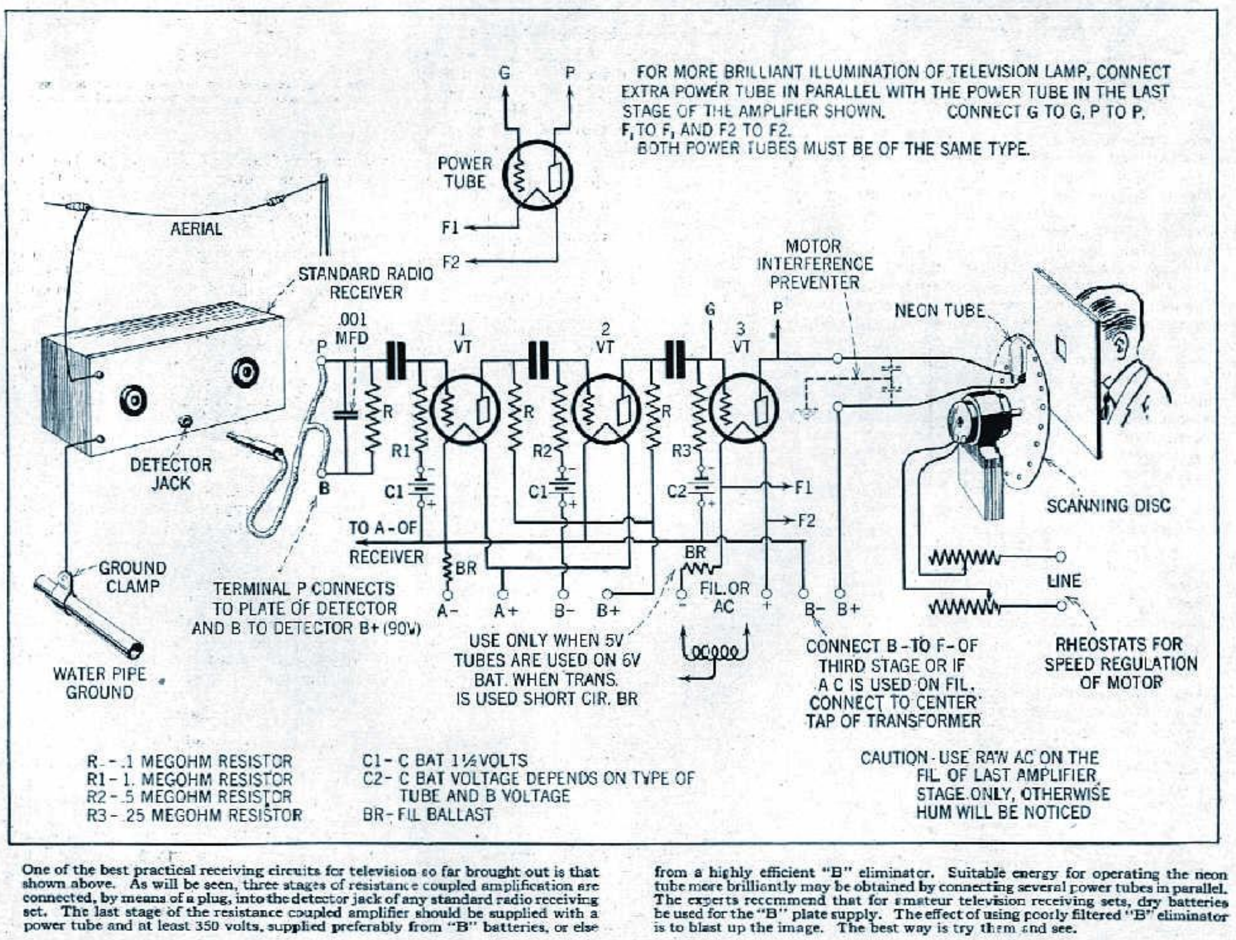
Hints To The Television Enthusiast

THE tel vision receiver hook-up shown below is that furnished by the manufacturer of a well-known resistance coupled amplifier and allied apparatus. This concern is also supplying a television kit complete with perforated discs containing different numbers of holes for receiving pictures from the different stations. Through the kindness of this corporation, the diagram below has been furnished to the editor and the television enthusiast will find it very useful indeed. It should be said in passing that those having the time and the inclination can build up the resistance coupled amplifier, as here shown in the diagram below; while those who do not have the time or the patience may instead buy this special television resistance coupled amplifier complete.

The electric motor used for driving the perforated scanning disc in this television receiver kit is of the 110 volt A.C.-D.C. universal type. In other words it is a series wound D.C. motor with the electrical windings so designed that it will operate efficiently on either A.C. or D.C. The two rheostats shown in either side of the motor control circuit, comprise a fine and a coarse adjustment. That is, the experimenter may build these, one resistance coil being wound with coarse wire, and the other with fine wire. These rheostats are easily made by winding German silver or other resistance wire over a layer of asbestos which has been wrapped around a piece of iron pipe. If A.C. is used brass pipe, split longitudinally, should be used, or porcelain, glass, etc., can be employed. A piece of pipe about 1½ inches in diameter and 12 to 16 inches in length will do. For the fine wire rheostat, about No. 24 to 26 wire may be used, depending upon what kind of resistance wire is employed. A little experimenting with the length of the resistance wire stretched across the room and connected in circuit with the motor will enable you to find out the proper size of the particular resistance wire you have at hand, and how many feet of it you will need. For the coarse wire rheostat, about No. 18 to 20 size wire may be used. Bare wire is the best to use, spacing the turns by winding the coils in a lathe. The wire can be spaced the thickness of the wire apart, by winding on a piece of cord alongside the wire, afterward removing the cord. Be sure to wind on the resistance wire tight enough so that when a phosphor bronze or German silver spring slider is slid along a brass or other bar mounted parallel with the coil, that the turns of wire will stay in place. The wire expands quite a little when heated up and this must be kept in mind also. The above considerations presuppose that you are using the universal motor on D.C. If you are using the motor on 110 volts A.C., 60 cycles, then you may control the motor speed by a simpler mechanism. In this case it is the most efficient method to employ an adjustable impedance or choke coil in series with one of the motor feed wires.

Such a variable impedance may be constructed simply by winding several layers of insulated copper magnet wire, about No. 16 gauge, on a fibre or other insulating tube. A brass or other non-magnetic tube may be used if it is slit lengthwise. For the winding, it is best to use about 6 to 8 layers of No. 16 to No. 18 enameled or double cotton covered magnet wire. Tap leads should be brought out from the third and the following layers and these taps brought to a multi-point switch. This switch will give the coarse adjustments of the motor speed. The fine adjustments of the speed are produced by moving an iron core in and out of the impedance coil. This iron core may be composed of either a bundle of annealed iron wire, or else a core built up of sheet iron strips, such as used for transformers. Stove pipe iron will do for the purpose. The coil may be wound on a round tube having an inside diameter of about one inch, if the iron wire core is to be used; if a laminated or built up sheet iron core is to be employed, then the winding or coil may be wound on a square tube bent from a piece of fibre, or brass slit longitudinally, the size of the tube being about one inch inside. A rod and a handle are mounted on the iron core so that it can be moved in and out easily, and a scale may be mounted so that the handle moves over it. In this way, you can always reset the impedance to a value previously determined for a certain set of conditions.

With the television kit shown below, the manufacturer recommends that the power stage tube be so adjusted with regard to its C bias, etc., that the neon tube behind the scanning disc glows when no signal is coming in. If the neon tube does not glow when you hook up the circuit, and with a sufficiently high plate voltage on the power tube, then the C bias battery, C2, will have to have its voltage reduced until it does glow. The other method of adjusting the neon tube as followed in the Bell system, calls for the C bias on the amplifier tube to darken the neon tube.



One of the best practical receiving circuits for television so far brought out is that shown above. As will be seen, three stages of resistance coupled amplification are connected, by means of a plug, into the detector jack of any standard radio receiving set. The last stage of the resistance coupled amplifier should be supplied with a power tube and at least 350 volts, supplied preferably from "B" batteries, or else from a highly efficient "B" eliminator. Suitable energy for operating the neon tube more brilliantly may be obtained by connecting several power tubes in parallel. The experts recommend that for amateur television receiving sets, dry batteries be used for the "B" plate supply. The effect of using poorly filtered "B" eliminator is to blast up the image. The best way is try them and see.

The Problem of Synchronism in Television

IN television, both mechanisms are running continuously, and sixteen complete pictures are transmitted per second. Under these conditions it is possible that both mechanisms may run at the same speed and still the image will be incorrectly received at the distant receiver, says A. Dinsdale in an article appearing in *Radio News* for January, 1928.

Results of Imperfect Synchronism

This difficulty has given rise to a common misunderstanding, prevalent even in technical circles, which, in turn, has caused the difficulty of synchronism in television to be, to some extent, overrated.

Quite commonly the statement has appeared that a difference of phase of only one per cent between the transmitter and the receiver is sufficient to spoil the definition of the received image. Were such a statement true, the problem of synchronism would indeed be one of almost insurmountable difficulty.

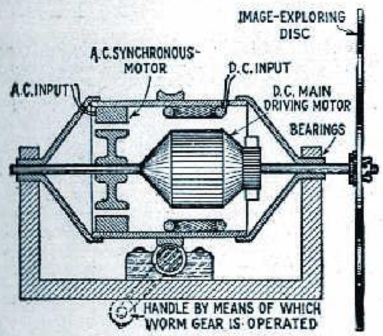


Fig. 1

A cross-sectional view of the motor, showing the relative position of the D.C. and A.C. units.

Fortunately, however, an analysis of the facts shows that if the transmitting and receiving mechanisms are out of phase the image is not blurred, but merely displaced; the clearness is not altered. The effect is that the image of a man's face, instead of being visible squarely in the center of the receiver screen, is displaced to right or left, so that his face appears to be cut off vertically, say, by the nose. On the other side of the screen the other half of his face is visible, also cut off by the nose. In the center of the screen his right and left ears will almost touch each other.

The distortion, or blurring of a television image is caused only by different speeds prevailing at the transmitter and receiver, that is to say, by lack of *isochronism*. The problem of isochronism is much simpler of solution than that of synchronism. Possibly these words are not familiar to readers, and it is not out of place to define them here.

Isochronism and Synchronism Defined

When two mechanisms are said to be running in *isochronism*, what is meant is that they are running at the same speed, but are out of step. For example, two clocks which are running at the same rate would be in exact isochronism, although the hands of one might point to 2.30 and the hands of the other to three o'clock. To be in *synchronism*, the hands of both clocks must indicate exactly the same hour.

When the first efforts were made to achieve television, attempts were made to obtain isochronism by means of the methods used in phototelegraphy; *i.e.*, by means of pendulums and tuning forks. Such methods, however, do not lend themselves to television, for they are not sufficiently accurate.

By using synchronous motors, however, perfect isochronism can readily be obtained, and the mechanical and electrical arrangements involved are not so complicated as is the case with the other methods. It was with the aid of such motors that the first successful results in television were achieved by John L. Baird, the British inventor.

One of these motors comprises, essentially, an armature, or rotor, supplied with an alternating current, and a stator supplied with direct current. Or the rotor may be supplied with D.C. while the stator takes the A.C. The speed at which such motors run is dependent entirely upon the periodicity, or frequency, of the alternating-current supply, and upon the number of poles in the rotor or stator, whichever is receiving the A.C.

At first glance it might be supposed that synchronism between two television mechanisms could be obtained by using two exactly-similar motors, controlled by rheostats and run at exactly the same speed, as indicated by a form of speedometer. This can not be done, however, for ordinary electric motors continually vary in speed, due to small variations in the supply current and other reasons. This habit of variation is known as "*hunting*," and, before television can be successfully achieved, the hunting propensities of at least one of the motors must be brought under exact control. The task of the synchronous motor is to act as controller.

How Isochronism is Obtained

At the transmitting end the image-exploring mechanism is driven by an ordinary electric motor, either A.C. or D.C., depending upon the supply available. Mechanically coupled to the same shaft is a small A.C. generator. The periodicity of the output of this machine may have any convenient value; but the higher it is, within very reasonable limits, the better are the results.

This A.C. output is then conveyed (as will be discussed later) to the receiver, where it is caused to drive a synchronous motor which is mechanically coupled to the same shaft as the main driving motor which operates the image-exploring mechanism of the receiver. This main driving motor, like the main driving motor at the transmitter, is an ordinary electric motor operating off any convenient supply.

The main driving motor at the transmitter has the usual tendency to "hunt," and it is allowed to do so unchecked; the periodicity of the A.C. generator coupled to it varies in accordance with its speed wanderings.

At the receiver, however, the main driving motor is not allowed to hunt independently. Its speed is under the absolute control of the synchronous motor coupled to it; and as the speed of the latter varies in exact sympathy with the periodicity changes of the distant A.C. generator, it follows that the main receiver motor must at all times be revolving at exactly the same speed as the main transmitter motor. The fact that they both hunt slightly does not matter, for they hunt in unison. Therefore, isochronism is achieved.

There remains now the question of synchronism. That is to say, although we have the two machines running at exactly the same speed, we have, as yet, no means for keeping them in the *same phase relation*.

Obtaining Synchronism

As stated previously, a difference of phase does not cause blurring or loss of definition. It merely causes a shift of the image as a whole, and this image shift is very simply rectified by the expedient of rotating the receiver's driving mechanism as a whole about its spindle until the picture comes into view in its proper place.

The action may be compared to that performed by the operator of a moving picture projector when the picture appears with people's feet at the top of the screen and their heads at the bottom, with a dividing line across the middle. All that is required is simply an adjustment to bring the picture properly into its "frame." The descriptions given above will be understood more clearly if reference is made to the accompanying diagrams.

In Fig. 1 a cross-sectional view is given of the receiver's driving mechanism. At the extreme right-hand end of the shaft is the image-exploring disc. Further to the left,

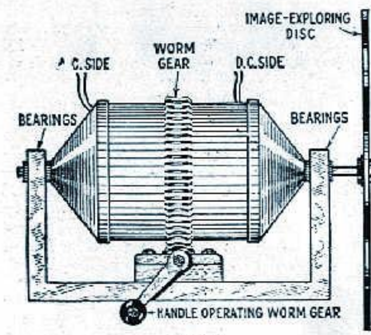


Fig. 2

The outer view of the driving motor and synchronous motor, which can be adjusted by means of the worm gear.

within the "carcase" (frame) is the D.C. main driving motor. To the left of that is the synchronous motor, which controls the speed of rotation of the D.C. motor, giving isochronism.

The carcase of these motors is mounted on bearings, so that it can be rotated bodily by means of a handle operating through a worm gear. This feature is more clearly shown in Fig. 2.

It will be seen that this mechanism has the merit of extreme simplicity, and it seems to work extremely well in practice; for it is essentially the method used not only by Mr. Baird, but also by the American Telephone & Telegraph Co. in their recent demonstration of television between Washington and New York.

Mr. Baird's British patent (No. 236,978, of March 17, 1924) describes this device for rotation of the mechanism; although it is questionable if any patent involving the use of a synchronous motor as a means of obtaining synchronism can be considered valid, because the synchronizing principle, to use the phraseology of the Patent Office, has been "long known to the art." However, to Mr. Baird belongs the credit of being the first successfully to apply this principle.

The Transmission Medium

It has been mentioned that the output from the A.C. generator at the transmitter is "conveyed" to the receiver.

It is, of course, impossible at the present time to transmit power by radio or over a telephone line. Therefore, some other means must be provided to supply the A.C. impulses to the receiver. This is done by causing the A.C. to modulate either the carrier current, in the case of wire communication between the two points, or the carrier wave, in the case of radio communication. This modulation, of course, takes the form of a continuous note of audible frequency, corresponding to the periodicity of the generator output. It can, without difficulty, be carried over the same channel which carries the television impulses, filter circuits being used at the receiver to separate the two sets of impulses.

At the receiving station the synchronizing note, after being filtered out from the transmission channel, is amplified and used to control the supply of the A.C. synchronous motor.

To make the operation clear to our readers, we will describe the exact apparatus used at one of Mr. Baird's first public demonstrations, given in London in April, 1925. At this demonstration, which was an early effort with crude apparatus, only silhouettes were shown, and two separate channels were used, one for the television impulses, and one for the synchronizing impulses. However, the method of synchronism employed was essentially the same as that described above.

The transmitter was connected to two small loop antennas, one of which transmitted the television signals, while the other transmitted the note caused by the A.C. generator. At the receiving station, which was at the other end of the same room, two similar loops were employed to pick up the two sets of impulses.

Baird's Original Apparatus

The note, after being picked up by the loop and its associated tuning apparatus, was passed through a 3-tube A.F. amplifier, the output of which was connected to a telegraph relay. The amplified alternating current caused the reed of the relay to make contact first in one direction and then in the opposite direction. That is to say, the reed was caused to vibrate, or oscillate, between the two fixed contacts set on either side of it. The output of the relay was therefore an alternating current, directly in phase with the alternating current generated at the transmitter.

In order to synchronize the two machines, the receiver's main driving motor was first run up to speed, under the control of a rheostat. The input to the synchronous motor was controlled by means of a double-pole switch, which connected it to the output of the relay. Across the poles of the switch were connected two little lamps.

As the synchronous motor and the output of the relay came into phase the lamps flickered, the flickering becoming less and less as the speed of the synchronous motor (driven by the receiver's main driving motor) approached that of the generator at the transmitter. When the speeds became exactly isochronous, the flickering ceased and the lamps went out entirely. At that instant the switch was closed and the current from the relay fed to the synchronous motor. This current was sufficient to prevent the synchronous motor creeping out of phase, which, in turn, prevented the main driving motor from hunting.

The above method is essentially similar to that used by Baird at present, with the exception that the telegraph relay is, it is understood, no longer employed. The output of the last tube of the amplifier is now applied direct to the synchronous motor.

It will be understood, of course, that the synchronizing current is almost infinitesimally small; but where well-balanced mechanisms are used, only a very small synchronizing current is necessary to keep the main driving motor of the receiver from hunting.

As already explained, any convenient supply may be used to run the main motor. Mr. Baird uses D.C. motors, because the current supply to his laboratory happens to be direct. The A. T. & T., whose synchronizing methods are essentially the same as Mr. Baird's, used A.C. motors, simply because the power supply was in that form.

During the course of his original experiments, Mr. Baird used a synchronizing frequency of 60 cycles; but, as already mentioned, the higher the periodicity used, within limits, the better the results; and I understand that at present Baird is employing a synchronizing frequency in the neighborhood of 200 cycles. The employment of this frequency enables him to obtain a much finer degree of synchronism, and this improvement, in conjunction with greatly-perfected and better-finished mechanisms, has resulted in a vast improvement in the quality of the received image.

Whereas his original television images were somewhat lacking in detail and marred by a constant flicker, his present-day results are remarkable for their improved detail and the almost complete absence of visible "grain" and flicker. To these improvements the writer can personally testify, having witnessed both the earliest and the most recent demonstrations given in Mr. Baird's laboratories.

How Photo-Electric Cells Work

The Photoelectric Effect

THE photoelectric cell itself is a converter of light intensities into electric currents which may be amplified and employed in accordance with ordinary electrical practice. The conversion of light into extremely minute electrical impulses is brought about by what is known as the photoelectric effect, says John P. Arnold in *Radio News* for December, 1927. This effect is due to the fact that an *insulated metallic conductor loses negative electricity when illuminated.* The loss of negative electricity is caused by the emission of electrons from the conducting surface. Moreover, the quantity of electrons emitted varies with the intensity of the light which influences the action. Thus, stated in the form of a rule, we say that *the photoelectric effect is proportional to the intensity of the illumination and to the time during which it acts.*

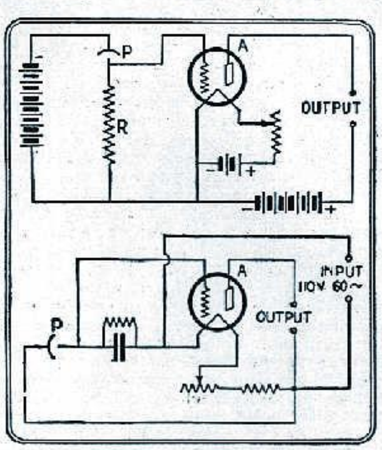


Fig. 2

Two methods of connecting a photoelectric cell in the grid circuit of an amplifier tube, which is necessary in advance of a mechanical relay. One draws its current from a battery, and the other from the lighting mains.

This proportionality between the intensity of the illumination and the electronic emission is strictly true; and whatever apparent departure from this law is noted may usually be attributed to incorrect design or to certain conditions of ionization which are especially characteristic of the gas-type cell.

Investigation has shown that, for whatever metal is used as a conductor, there is a definite wavelength at which the photoelectric effect takes place. The minimum frequency required to produce this phenomena shifts continuously toward the red end of the spectrum as the light-sensitive material is made more electro-positive. (See *Radio News* for June, 1927, page 1422.) As the "alkaline" metals (sodium, potassium, lithium, caesium and rubidium) respond to radiations in the visible part of the spectrum, these substances are used in cells for visual communication.

The loss of electrons which a photoelectric body undergoes when illuminated may be observed to take place either in a vacuum or in gases. This has led to the development of two general types of cells, both using for the conductor or plate one of the alkaline metals in the form of a hydride (a compound of the metal with hydrogen), which is more sensitive than the pure metal. They differ mainly that in one the plate is placed in a highly-evacuated tube; while in the other it is contained in an inert gas such as argon at low pressure. In the construction of such cells great care is take to prevent oxidization of the plate and, for this and other reasons, they are more thoroughly exhausted than the ordinary vacuum tube.

Construction of the Cell

To illustrate more clearly photoelectric action, it is useful to describe the modern cell. The PJ-1 and PJ-5, gas-filled and vacuum types respectively, are taken as examples. These cells are 5½ inches long and the glass tube has a maximum diameter of 2½ inches. The light-sensitive material is deposited on a silvered surface, on the inside of the tube, with a connection leading out

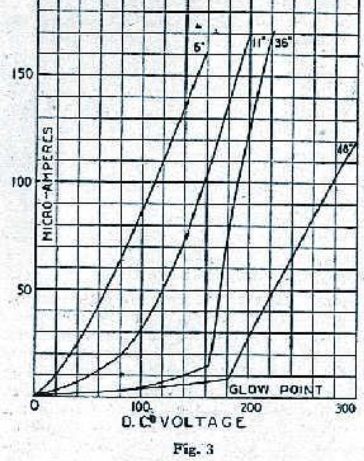


Fig. 3

The characteristic curve of a photoelectric cell. As it approaches a given source of light, proportionately less voltage is required to produce unit flow of "plate" current. The "plate" in this tube, however, corresponds electrically to the filament of the ordinary tube.

through the glass. The only other element is the anode, or filament, which has a lead also brought out of the tube. A small aperture of clear glass allows light to fall on the plate. When a potential is applied and the plate illuminated, a current flows from the latter to the filament.

Two methods of connecting cells to the input of the familiar three-element tube, using either a direct or an alternating potential across the terminals of the cell, are shown in Fig. 2. Either the gas-filled or the vacuum types may be used with these circuits; the essential difference being that the gas-filled cell, because of ionization, passes a greater current. In the diagrams P indicates the conventional symbol for the cell. In order to minimize the effect of tube leakage, the value of R lies between one and ten megohms. Theoretically, however, the higher the resistance used, the more sensitive the circuit will be.

Fig. 3 is a graph showing the current-voltage characteristic curves of a gas-type cell with direct current applied across its terminals. These curves were taken at the distances indicated from the source of illumination, which was a 250-watt Mazda lamp.

In operation these cells will glow under excessive potential and while glowing, of course, are not sensitive to light variations. Efficient operation is secured somewhat below this point. If the rated voltages of the cell are exceeded, its life is considerably shortened. The manufacturers of the above-described cells specify that they should not be operated at a temperature above 30 Centigrade, which is 86 Fahrenheit.

To those familiar with the action of the thermionic tube, the application of the photoelectric cell to visual communication is not hard to understand. The current through the cell rises and falls with the varying intensities of the light directed on the plate. This current may be made to influence the grid of a sensitive vacuum tube, as shown in the circuit diagrams; and the output of the latter is fed into an amplifier.

Practical Difficulties

This description of the way of handling the output of cells sounds simple enough on paper; but the fact of the matter is that difficulty is often experienced in designing amplifiers which will give an adequate response to the extremely minute impulses involved and to the rapid fluctuations necessary to transmit pictures or, especially, scenes of motion. This provides radio experimenters with a problem which is definitely within their province to solve, in addition to those questions of static elimination and fluctuations of signal strength, which must be answered before radio will become a practical channel for such communication.

It is fortunate for the progress of visual communication that the photoelectric cell, although it has some disadvantages, is a device of great speed and precision. Cells of the better type are capable of translating extremely rapid fluctuations of light and shade without appreciable lag or "hang-over," for the emission of electrons is practically instantaneous.

Importance of Synchronism

THE problem of synchronization is to run these two discs—the scanning and the receiving discs—not only at identical speeds, but always in exact step; *i.e.*, if the tenth aperture of the transmitting disc be allowing the light to pass through and fall on the sitter's face, the eye at the receiver will be looking at the high-frequency lamp also through the tenth aperture, and so on. Otherwise the photoelectric cell may be "seeing" the eye of the sitter, while the eye of the receiver is looking at the position of the viewing screen where the nose and chin ought to be, states Mr. T. Thorne Baker in the English publication, *Amateur Wireless*, for June 2, 1928.

The means adopted by Baird and other workers has been to employ synchronous motors, or motors the speed of which can be controlled by an applied pulsating current. The simplest form of synchronous motor is probably that depending for its control on a tuning fork. A heavy fork is kept in vibration by means of an electro-magnetic impulse, and vibrates at, say, 240 periods a second. On one limb of the fork is a contact, K1 (see diagram), which at each vibration touches another contact, K2, thus completing a circuit including a battery, E, and the winding, W, of one of the magnets of a multi-pole electro-motor.

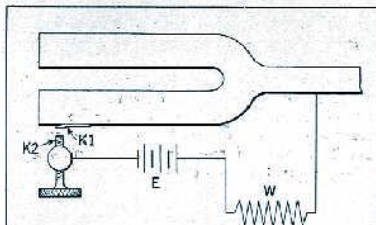


Diagram showing the principle of tuning-fork control.

In this way regular impulses are applied to the motor, which, of course, fix the rate at which it revolves. If the same fork be made to control the impulses of two such motors, then both motors will run in exact synchronism.

Radio Control

Great refinements have been made in the design and construction of synchronous motors, and special types of motor, the speed of which can be easily regulated by amplified wireless signals sent out from the transmitting control, have been designed. A particular part of the design is a second controlling device which ensures that each motor will begin its revolution at the same instant, apart from equal rate of running. If one motor were 180 degrees, that is to say, half a revolution, out of step with the other, then the receiver would see the picture cut in half, the top half of the image being at the bottom and the bottom half of the image on top, and so on.

Even the best regulated synchronous motors get a little out of step in semi-rhythmic fashion at times, and Mr. Baird has told me that the effect is that of the whole image swaying slightly, although definition is not impaired.

It is really perfect synchronization that has solved the problem of telegraphing single pictures. I do not suppose that any more elegant or perfect method of receiving a telegraphed picture will be invented than that devised by Professor Korn, in 1908, using a spot of light falling upon a revolving photographic film, the light of which was controlled by the movements of a wonderfully designed form of Einthoven (string) galvanometer. This galvanometer is substantially the same as that used by Dr. Ives today in the famous Bell system of phototelegraphy.

But faulty synchronization prevented the success of the Korn telautograph system, just as it did all other attempts at phototelegraphy for the following twenty years. And synchronization still remains the biggest problem in television.

"Looking In"—Hints for the Amateur

AT the present time the television experimenter is most interested perhaps in knowing what stations are transmitting the image signals. The following station data will aid him in this respect.

WGY—24 hole disc—disc speed 900 R.P.M.

WRNY—36 hole disc—disc speed—600 R.P.M.

WLEX—48 hole disc—disc speed—1,080 R.P.M.

The latter station is in Boston.

At the present stage of the experimental television game, the amateur may purchase scanning discs from several manufacturers, the discs being available in various diameters and with different numbers of holes. The manufacturers are supplying a separate disc for each station reception so far, but later a single disc, drilled with several spirals of holes, each spiral containing a different number of perforations, will undoubtedly be made. This means that for the present the person desiring to pick up television pictures from different stations will have to purchase several discs, and when through "looking in" at one station's pictures, they will have to stop the motor and replace the old disc with another one containing the proper number of holes to pick up the television image from the newly selected station.

Having done this, the amateur televisionist must, or at least should know the speed at which the station transmission disc is being operated. If this is not known, the experimenter will simply have to use the cut and try method; that is, he will be obliged to change the speed of his disc driving motor until he picks up the image, all this, providing, of course, that he is utilizing the disc with the proper number of perforations.

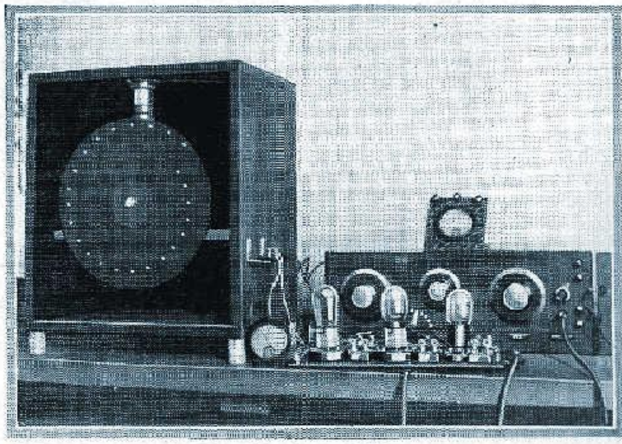
Probably the best all-around motor to use is one of the universal 110 volt A.C.-D.C. types. This motor can have its speed lowered by simply placing a rheostat or else a variable impedance (choke coil) connected in series with the motor. This will give any speed lower than the manufacturer's rating. In selecting the motor, care must be taken to see that its normal speed rating is a little higher than the maximum at which the disc must rotate. The disc can be driven by means of a belt or otherwise, of course, and in this way any speed desired can be readily obtained by changing the sizes of the belt pulleys. A round or preferably a V-shaped leather belt with suitably grooved pulleys will give a very good transmission arrangement.

A few words concerning the adjustment of the neon tube will probably be of interest. There are two ways in which the neon lamp may be used for television reception. By the first method, the "C" bias on the last amplifier tube is raised until the neon tube doesn't quite light. Under these conditions, with an incoming television signal, the plate current increases and the neon tube glows. With the second system, wherein the neon tube is allowed to glow when no signal is coming in, an incoming image signal causes a decrease in the plate current through the neon tube. Dry "B" batteries are recommended for amateur television reception, the potential varying from 180 volts up to 350 volts. The higher the voltage, the brighter the image created by the neon tube and the whirling disc in front of it. A milliammeter should be connected in series with the neon tube and the current kept within the limits specified by the manufacturer.

How to Build a Television Receiver

THE ARRANGEMENT OF THE SCANNING DISC AND RESISTANCE COUPLED AMPLIFIER HERE DESCRIBED IS VERY COMMENDABLE

BY FRED H. CANFIELD



Here we see the disc cabinet at left with cover removed. The neon tube can be seen directly behind the disc. The amplifier appears at right.

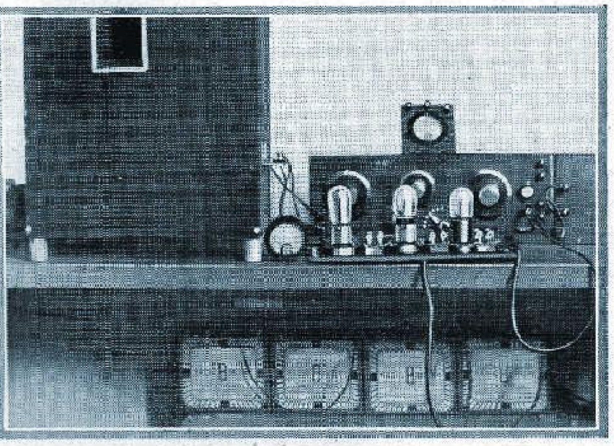
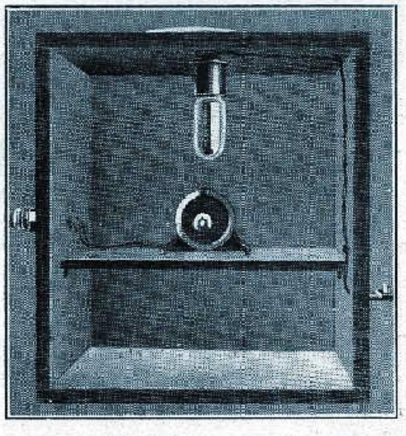


Photo above shows neat arrangement of amateur television receiving apparatus. The resistance coupled amplifier is shown at right and the disc cabinet at left.

LESS than two years ago it was rumored in engineering circles that television might be practical within a decade or so, but much doubt was expressed as to whether it would ever be developed to a practical basis. It was said that hundreds of photoelectric cells would be required at the transmitting station to "pick-up" the picture and that an equal number of neon lamps would be needed at the receiving end to reproduce the image. This system, of course, would make both the receiving and transmitting installations very expensive, and the use of television broadcasting for home entertainment would be entirely out of the question.

Today conditions are very different. Greatly simplified systems for the transmission and reception of television have been discovered, and the public is now anxiously awaiting the day when *home television* will be declared an established fact. Already broadcasting stations are placing television programs on the air on a regular schedule, and many experimenters throughout the country have built television receivers. The signals which are being transmitted and received are far from perfect, but the progress which has been made in this direction during the past two years greatly exceeds the most enthusiastic predictions which were recklessly made in previous years.

When contrasted with yesterday's conception of television apparatus, the modern television sending and receiving stations will be found absurdly simple. At the transmitting end a single photo-electric cell (or else 3 to 4 large ones) is used to pick-up the picture, and the output of this cell is connected with an audio-frequency amplifier which amplifies the current from the cell before delivering it to the transmitter. A device known as a scanning disc makes it possible for the single photo-electric cell to do the work which would require hundreds of cells with other systems. This disc is punched with holes in a spiral path, and it allows the cell to photograph all parts of the picture fifteen times each second. At the receiving end the apparatus is similar to the transmitter but it operates in the reverse order. A standard broadcast receiving set followed by a high-quality audio amplifier is employed, and the output is connected with a single neon lamp. Also, a scanning disc, exactly the same as the one used at the transmitter, is placed between the eye of the observer and the neon lamp. The chief problem in receiving the image is to have the scanning disc revolve in exact synchronism with the disc at the transmitter.



The picture above shows the interior of the cabinet with the motor and neon tube in place.

With apparatus of the type described in the above paragraph an image approximately one inch square is received. The image is a half-tone in character, and when distortion has been reduced to a minimum, and the discs are in perfect synchronism, the definition of the picture should be very satisfactory as it is composed of from 24 to 50 lines per inch. The average newspaper half-tone has 50 to 60 lines per inch, and, therefore, under ideal conditions television may be practically the same in quality.

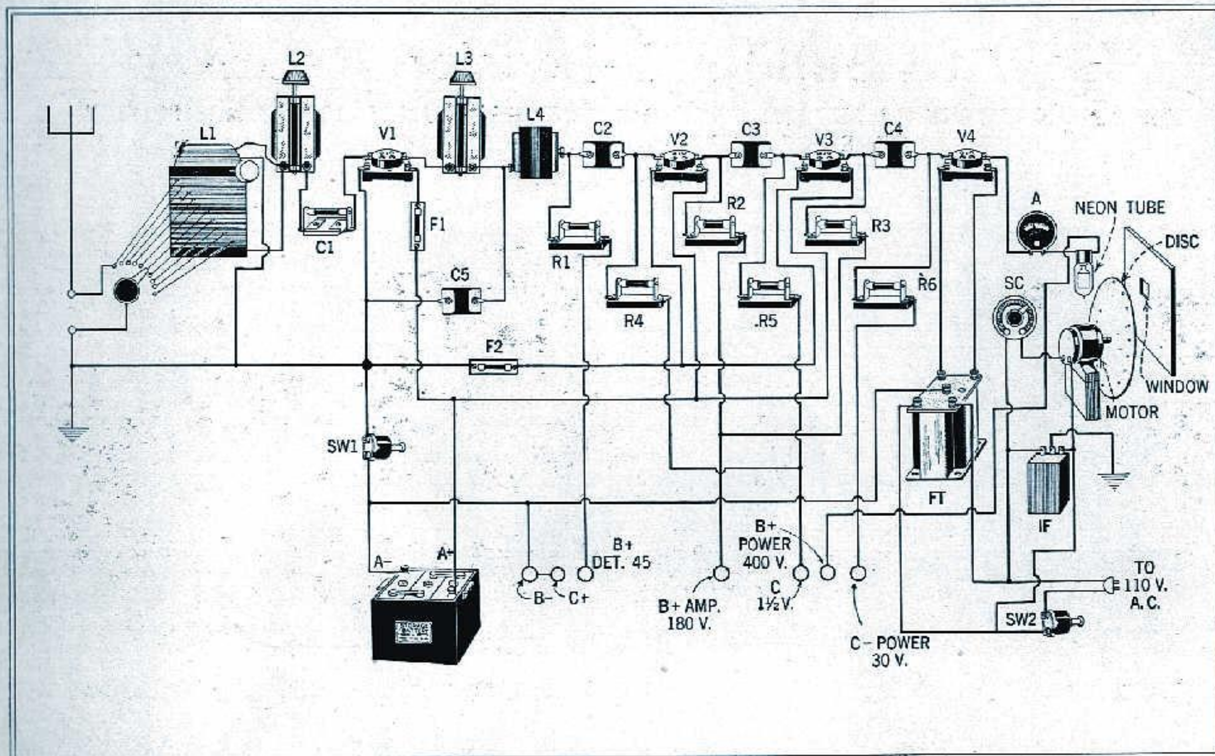
A Typical Amateur-Built Televisor

THE pictures which appear on this page provide an example of the average amateur television receiving installation. This station is owned by a New Jersey experimenter and is entirely home constructed. The owner is Mr. Albert E. Sonn, 66 Yantacaw Ave., Bloomfield, N. J. Mr. Sonn is well known in amateur circles as operator of station 2GC, and his name is also familiar to many broadcast listeners who have heard his informative talks on radio from various New Jersey stations.

An interesting feature of the station shown in the picture is that it is of very simple construction and it is very inexpensive to assemble. Both the receiver and audio amplifier are of more or less standard construction, and the only special parts required are the neon lamp, the scanning disc and a small universal motor. The radio receiving set shown in the picture is an early design of broadcast receiver, yet it is entirely satisfactory for the purpose. It happens to be a two-variometer-type regenerative set, but any standard tuned R.F. tuner would work just as well, provided it did not distort the incoming signals. However, it would be inadvisable to use a superheterodyne receiver for television reception, as the usual intermediate-frequency amplifier will cut sidebands sufficiently to cause serious distortion of the image.

The audio amplifier in a television receiver is a very important consideration as distortion must be reduced to an absolute minimum, and at the same time the output must be comparatively high. It has been found that a resistance-coupled amplifier is the only type which provides entire satisfaction, and at least three stages are needed. Also, the tube in the last stage should be a 210- or a 250-type in order to provide the neon lamp with enough energy to produce a good picture. The amplifier used with the receiver shown in the above pictures consists of a standard resistance-coupled unit which has been rewired for power-tube operation. Two 240-type hi-mu tubes are used in the first two stages and a 210-type tube is used in the output stage. Maximum plate voltage is used on the first two tubes and 300 volts is applied to the plate of the power tube. The grid bias of all tubes is adjusted carefully to prevent distortion.

The pictures clearly show the simplicity of neon tube-scanning disc combination. A box slightly larger than the scanning disc is employed and this is painted black both inside and out in order to reduce reflection.



This picture diagram shows the wiring of a complete television receiving set. It consists of a standard regenerative tuner, followed by a resistance-coupled A.F. amplifier, with the usual neon tube in the plate circuit of the power tube. A rheostat in series with the motor serves as a synchronism control for the disc.

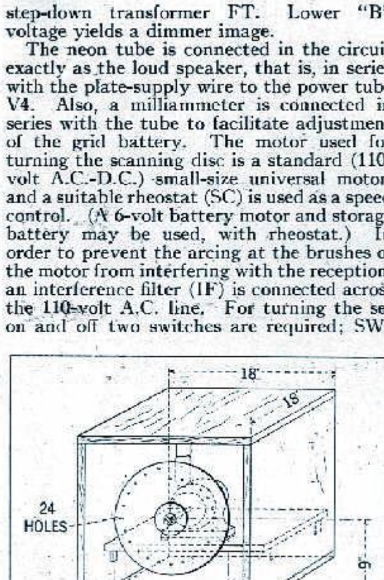
For the benefit of those who are contemplating the construction of experimental television receivers, the diagrams on this page give details of the set pictured in the illustrations. It is not essential that these drawings be followed exactly, as many variations are possible. However, they show the exact circuit which was selected by Mr. Sonn.

The receiver is a standard three-circuit regenerative set of the double-variometer type. L1 is a variocoupler with a tapped primary and a rotating secondary winding. L2 and L3 are variometers of identical design. These are the type ordinarily used in broadcast receivers and are designed to cover the wave band of 200 to 600 meters. L4 is a standard R.F. choke coil, which is employed to prevent R.F. current from entering the audio amplifier. The grid condenser C1 has a capacity of .00025 mf., and the resistance value of the grid leak R7 is selected after experimenting with leaks of various values. F1 is a 5-volt, ¼-ampere filament-ballast unit and C5 is a .002 mf. by-pass condenser. All of the parts mentioned in the above are housed in the receiver cabinet.

The audio amplifier is a standard three-stage resistance-coupled unit. V2 and V3 are HiMu amplifier tubes of the 240 type, and V4 is a 7½-watt power amplifier tube of the 210 type. C2, C3 and C4 are coupling condensers, having a capacity of approximately .01 mf. each. R1 has a resistance of .1 meg., while R2 and R3 have a resistance of 250,000 ohms each. The value of the resistors R4, R5 and R6 must be determined by experiment, but usually it will be approximately 250,000 ohms for R4 and R5 and 100,000 ohms for R6.

The "B" power for the entire receiver is provided by batteries. Four hundred volts of dry cells are required for the power tube and taps at 180 volts and 45 volts are needed for the amplifier and detector tubes, respectively. Thirty volts of "C" battery is required for the power tube and 1½ volts is needed for the first two audio tubes. The filament of the power tube is heated with 7½ volts of A.C., which is provided by a step-down transformer FT. Lower "B" voltage yields a dimmer image.

The neon tube is connected in the circuit exactly as the loud speaker, that is, in series with the plate-supply wire to the power tube V4. Also, a milliammeter is connected in series with the tube to facilitate adjustment of the grid battery. The motor used for turning the scanning disc is a standard (110-volt A.C.-D.C.) small-size universal motor, and a suitable rheostat (SC) is used as a speed control. (A 6-volt battery motor and storage battery may be used, with rheostat.) In order to prevent the arcing at the brushes of the motor from interfering with the reception, an interference filter (IF) is connected across the 110-volt A.C. line. For turning the set on and off two switches are required; SW1 closes the storage-battery circuit and SW2 connects the 110-volt supply with the filament transformer and motor.



These drawings clearly show the construction of the scanning disc cabinet.

A box 18 inches square, as shown, provides ample space for the 12-inch, 24-hole scanning disc. However, if larger discs are to be used, the size of the cabinet must be increased proportionally.

After setting up the receiver, the first problem is to make sure that the set operates at maximum efficiency. It is best to disconnect the neon tube temporarily, and in its place connect a standard loud speaker. Now, use the set as a broadcast receiver and make the necessary adjustments until the most perfect voice reproduction is obtained; that is, adjust the grid-bias voltages and experiment with various size resistors in the audio circuits. When the set is performing properly, the neon tube may be connected into the circuit.

Before it is possible to receive television signals, it is necessary to know whether sufficient amplification is being obtained to properly operate the neon tube. With the neon tube connected and the scanning disc revolving tune in the signal of a broadcasting station and note the results. If the station has a strong signal, the music and voice should cause the appearance of distinct geometric designs in the observation window. Also, when a signal is not being received, the tube should give off a steady glow; and when looking through the window, the screen will be perfectly clear, with the exception of fine parallel lines which are hardly noticeable.

The receiver is now ready to pick up the television picture. When a television program has been tuned in the only problem is to adjust the speed of the disc to synchronism with the disc at the transmitting station. This is accomplished with the motor speed-control rheostat (SC). It may require considerable experimenting before the speed of the receiving disc is brought into synchronism; but after a little practice, it will not be found so difficult. In this connection a revolution counter is valuable as the disc should revolve at approximately 900 R.P.M.

Latest Data on Photo Transmission

ALEXANDERSON PHOTO TRANSMITTER AND RECORDER

THE apparatus demonstrated by Dr. Alexanderson is far from complicated, yet it does not seem quite as simple as the receiver for picking up television broadcasts. The transmitting apparatus was installed in a studio of the National Broadcasting Company, at 55th Street and Fifth Avenue, New York City. A photograph is clamped around the cylinder of the transmitter, as shown below and described in *Radio News* for April, 1928.

As the cylinder is turned by a synchronous motor at a constant speed, a photo-electric cell, contained in the box next to the wall, transforms the light energy into electrical energy. The light is reflected to the cell from the surface of the photograph and is broken up by the revolving disc, which has a slotted edge. The output of the photoelectric cell is amplified and is connected to the regular broadcast transmitter, in this case at Bellmore, L. I., by means of land lines. At the WEAF transmitter the picture was put on the air, and received in the home of Dr. Alfred Goldsmith at 82nd St. and West End Ave., New York, a distance of approximately twenty-five miles.

The Photographic Pick-up

In the figure above is a schematic diagram of the apparatus. As the diagram shows the synchronous motor turns the cylinder at a constant speed, properly reduced by the gears. A source of light is concentrated on a small portion of the photograph, this small area reflecting the light through a lens and the scanning disc to the photoelectric cell. (See Fig. 1.) The diagram makes this clear.

The rapidly-revolving disc, at the front end of the case containing the photoelectric cell, has around its circumference a series of indentations or notches. These notches interrupt the light rays at a certain frequency and the photoelectric cell is energized, every so often, by a reflected ray of an intensity which depends upon the depth of shade in the minute area of the photograph then being reflected. These variations of light are translated into electrical impulses by the photoelectric cell and after being amplified are put on the air as a modulation of the carrier wave.

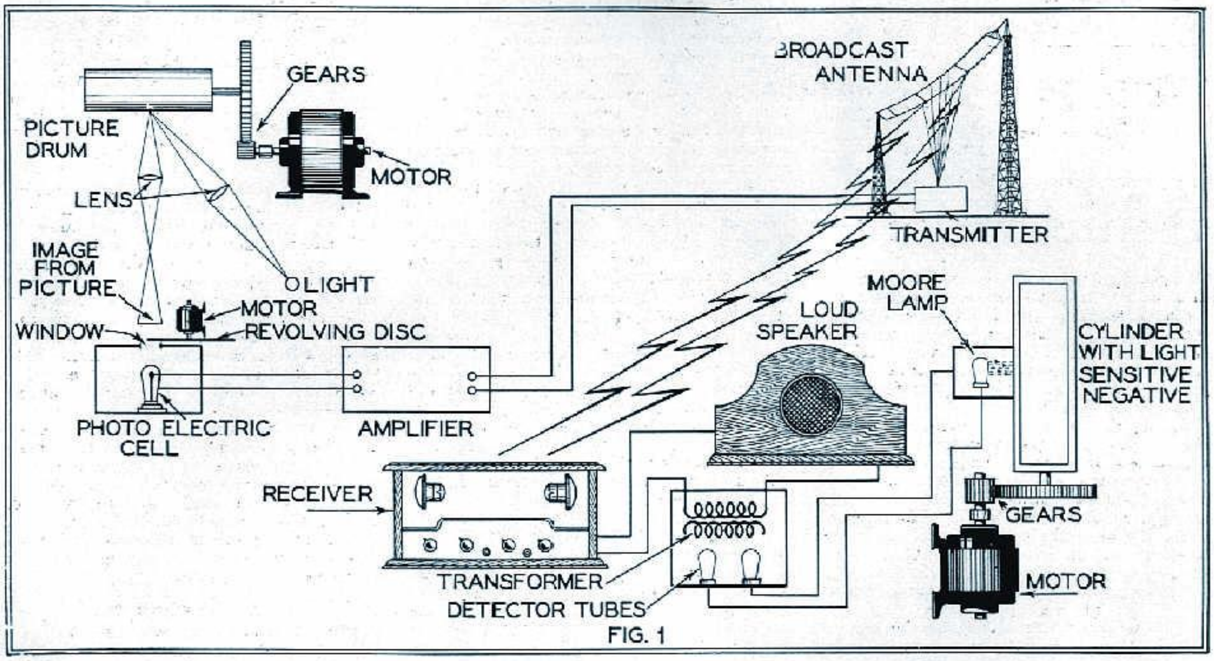
The ordinary transmitting equipment of the station is used, the only substitution being that of the photoelectric pick-up for the microphone. Ordinary land-line, or "remote control," is employed as usual. One of the most important things that Dr. Alexanderson has done, besides simplifying the apparatus, is the speeding up of the entire process. The picture was transmitted in about one minute and a half, a rate about twenty times as fast as that of other processes.

The Receiving Equipment

One of the first requirements for receiving pictures from the air is an ordinary broadcast receiver. This is tuned to a station which is transmitting the pictures, in the same manner as though music were to be heard. Instead of the loud speaker the apparatus shown in diagram is connected to the output terminals of the set. A sheet of bromide photographic paper is wrapped around the cylinder, preparatory to receiving a picture. This paper must, of course, be protected from the light of the room, until after its exposure to the light controlled by the incoming radio signal; this protection is afforded by a light-proof cover. A shielded box contains the amplifier, which strengthens the impulses before they are sent to the neon lamp.

This lamp, which operates on the same principle as the one used in the television apparatus, was also developed by D. McFarlan Moore. Instead of the tube's having a plate on which the images are built up, its central electrode is a rod, in which there is a small crater. By the variations in light intensity produced by the neon lamp the light and dark portions of the photograph are faithfully printed on the sheet of photographic paper, on which they are focused by a lens.

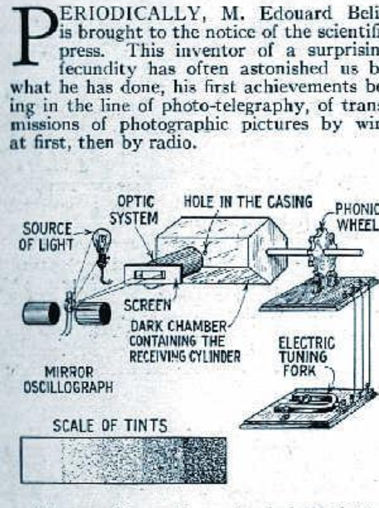
The cylinder is driven by a synchronous motor and gears, similar to those at the transmitter. As the cylinder revolves, it also moves along a threaded rod, thus exposing the entire sheet of sensitive paper to the light rays. Before the actual transmission of the photograph takes place, instructions from the transmitting station are broadcast and received through the regular loud speaker at the receiving end. A milli-ammeter on the box containing the amplifier indicates to the receiving operator when his receiver is properly "framed" and set to the correct intensity strength for tone shades. These adjustments are easily and quickly made. After the entire surface of the paper has been exposed to the rays of the Moore lamp, the picture is developed and fixed, just as in the case of an ordinary photographic contact print.



The diagram illustrates the process through which a photograph goes when being transmitted through the ether. When it is finally received on the cylinder on the right, it must be "developed" and "fixed" as with an ordinary print.

New Belin Photo-Transmitter

PERIODICALLY, M. Edouard Belin is brought to the notice of the scientific press. This inventor of a surprising fecundity has often astonished us by what he has done, his first achievements being in the line of photo-telegraphy, of transmissions of photographic pictures by wire at first, then by radio.



A diagram of the receiving system is shown above. An ordinary sheet of sensitized photographic paper is rolled upon the cylinder, which is placed in a dark chamber. All tints of the transmitted photograph are received in their exact value.

How the Transmitting Set Operates

ON a cylinder driven by a phonic wheel, which is regulated by a tuning fork, driven electrically, an ordinary photograph is rolled, face outwards. This cylinder, during its rotation, is given a helicoidal motion. If in place of a photograph, an ordinary telegram, written with any ink is placed on it, the system still operates. It transmits one or the other document without their having to receive any modification, as explained in *Science and Invention* for June, 1928, by Lucien Fournier.

Facing the cylinder is a small dark chamber, containing a photo-electric tube; it is terminated by a cone, pierced with a hole, which faces the document to be transmitted. Every light ray passing through this hole reaches the photo-electric tube, which represents in a sense the seat of a current, whose intensity will be proportional to that of the light.

In the new system, the luminous ray which enters the dark chamber is a reflected ray, not by a mirror, but simply by the photographic image or by the ordinary white paper, if handwriting is to be transmitted. The process employed is the following:

An ordinary electric lamp contained in a tube sends out a luminous beam to a prism, which reflects it upon the cylinder at a point exactly in front of the hole in the dark chamber, and appears as a luminous spot upon the document. When a white surface comes under the luminous spot, it reflects a great part of the light received, but if the white surface gives place to a black surface, the light is practically completely absorbed, and no reflected ray penetrates the dark chamber. In this case we will obtain a total emission of light, followed by a total interruption. And the photo-electric cell will be first traversed by a current of maximum intensity, and then will cut off this current sharply. And this is the phenomenon which is produced when an autographic dispatch written in black ink on white paper is to be transmitted; total emission under the action of the reflected ray and total interruption when a spot of ink comes in front of the dark chamber.

The system will operate the same way in the case of photograph transmissions with this difference, that the image is formed by tints, more or less accentuated. The reflected ray will be subject to the influence of the various tints and the action on the photo-electric cell would be modified in consequence. This will then become the seat of variable current more exactly of a modulated current, whose strength is precisely proportional to that of the reflected ray.

But this current, being very weak, it has to be amplified for its transmission whether by telegraph or telephone wires, or by the use of transmitting radio sets. This amplification is facilitated by the transformation of this current, modulated but continuous, into a periodic current which is developed by simply acting on the ray as it leaves the lamp.

For this purpose there is interposed in this ray a wheel driven by an electric motor, whose periphery is perforated by a certain number of holes. We thus obtain a current modulated periodically, that is to say, with rapid breaks 800 to 1000 periods per second, reproduced by the reflected ray and accentuating the amplification.

As the cylinder has a helicoidal motion, all points of the image attached to its surface are explored by the direct ray, and give rise to a reflected ray, whose intensity will depend on the tint of each one of these points. The electric current emitted by the photo-electric cell under its influence, undergoes the same variations which will be conveniently amplified before being used as active transmitting currents.

You must remember *en passant*, that the photo-electric cell carries a potassium cathode and a tungsten anode. If a negative charge is applied to the cathode, there is an emission of electric corpuscles between it and the anode, when a light ray, however feeble it may be, reaches the system. This cathode current permits the working current applied to the plate to cross over the vacuous space between the two electrodes. (The Edison effect.) The photo-electric cell becomes then a conductor of current and closes the electric circuit. It is opened automatically when luminous emission ceases to affect it, and its conductivity is proportional to this intensity. So that if we modulate the luminous beam, the current passing through the tube will also be modulated.

Reception and Transmission

IN the receiving system we find again the same cylinder as that used in transmission, driven always by a phonic wheel motor but enclosed in a dark chamber; this too is pierced by a small hole to permit the entrance of the "receiving" ray of light.

It is enough now to retransform the electric modulations caught by the receiving antenna or else by the ordinary telegraphic wire so as to get luminous modulations therefrom.

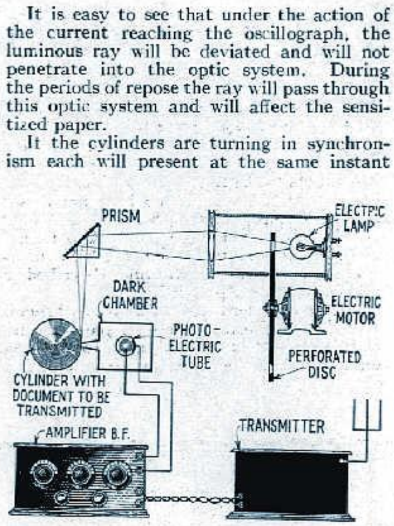
On the cylinder there is rolled a sheet of ordinary photographic paper, its sensitized surface being outside, so that the luminous ray entering the dark room leaves its trace upon this paper.

The currents are first received by an amplifier which sends them finally into a reflecting oscillograph set. This last, whose inertia is almost zero, is subject to these currents making slight horizontal oscillations. If a luminous ray touches it, the reflecting ray will increase its oscillations which are received on a glass screen before penetrating into the optic system, which causes the ray to penetrate into the dark chamber through the hole made in its face.

Now suppose that a manuscript is being received. The mirror will cause a slight displacement to right or left upon the screen of the ray. This has a very narrow slit through which the ray passes when at rest, the opaque portion of this screen cutting the ray off when it moves away from the slot.

It is easy to see that under the action of the current reaching the oscillograph, the luminous ray will be deviated and will not penetrate into the optic system. During the periods of repose the ray will pass through this optic system and will affect the sensitized paper.

If the cylinders are turning in synchronism each will present at the same instant



The above illustration shows clearly the arrangement of the apparatus and how it is coupled to the radio transmitter.

the same points of the same generatrix before the luminous rays, and the point touched by the ray from the transmitter will take the same position on the receiving cylinder. All the points will succeed each other regularly, the reproduction of the writing will be obtained on the sensitized paper.

In the transmission of a photographic image, the same phenomena occur but the mirror will be actuated by variable oscillations. The opaque screen will then be replaced by a screen of graduated transparency,—already utilized in the former apparatus—and the light ray which penetrates into the dark chamber will find itself modulated exactly in the same conditions as those of the reflected ray from the transmitter.

The sensitized paper will register these modulations to reproduce all the tints of the original photograph in their exact value.

Now a few words regarding the maintenance of synchronism.

Synchronization

THE synchronism is ensured in an absolutely perfect manner. In order that the desired result shall be attained, it is absolutely necessary that the two cylinders, transmitting and receiving, start at the same point and turn with a rigorously identical speed.

The speed of rotation is obtained very simply by means of the well-known phonic wheel motor of Paul Lacour. It is a little electric motor driven by intermittent currents from a tuning fork, driven electrically by an electro-magnet placed between its legs, and it is these last which send and shut off alternately the currents. As the legs of two tuning forks giving the same note produce exactly the same number of vibrations per second, it is easy to see that the two motors receiving these vibrations will turn at the same speed, though they may be 500 or more miles apart. Here we have one condition realized—perfect synchronism of the two cylinders.

We need only say that the two cylinders emit at the beginning luminous spots which appear upon the screen placed in front of the transmitting system and the spots approach nearer and nearer until they blend. At this moment the cylinders are at the same point or synchronized, and the two apparatus are allowed to operate normally.

How to Build a Radio Photo Recorder

ONE of the most important considerations in picture transmission and reception is that the both systems operate in absolute synchronism. In this case, it is necessary to have the receiving cylinder turn over at the same rate of speed as the sending one, i. e.—100 revolutions per minute.

The method is simply to have the receiving cylinder travel at a slightly higher rate of speed than that of the sending station. A spring stops the receiving cylinder automatically at the end of each revolution, and a separate but distinct impulse from the transmitter reacts on a relay that permits the receiving cylinder to begin its next revolution at exactly the same time that it does. Thus, the two cylinders begin each revolution on exactly the same instant, and the receiving cylinder is synchronized at every revolution as the article in *Radio Listeners' Guide and Call Book* (Summer Edition), points out.

Putting together the mechanism that will enable any amateur that can tune in to a picture broadcast to record his own photographs by radio is not complicated. In fact, anyone that can build any of the standard types of multi-tube sets can construct a radio picture receiver.

Standard parts are used throughout. With the exception of the special recorder, and one or two additional parts, all of the apparatus may be purchased from your local radio dealer. The character of parts needed are given as follows:

- 1 Variable gain control resistance, 10,000 ohms, R1.
- 1 Potentiometer, 200 ohms, high current capacity, R2.
- 1 Filament rheostat, 10 ohms, high current, with filament switch, R4, S.
- 1 Fixed condenser, 0.1 mfd., C4.
- 2 Fixed condensers, 0.0005 mfd., C1, C2.
- 1 Variable condenser, 0.0005 mfd., C3.
- 1 R.F. choke, 85 millihenries, L1.
- 1 Switch, filament circuit type, S1.
- 3 Jacks short circuiting short jacks, double contacts, J1, J2, J3.
- 2 Filament ballast resistances, R3, R6.
- 1 Phone plug, P.
- 1 Milliameter 0 to 25 mils, MA.
- 2 Tube sockets, V1, V2.
- 14 Binding posts.
- 1 Panel 16½x7 in.
- 1 Binding post strip 16½x2 in.
- 1 Wood Baseboard 10½x16½ in.
- 1 Grid leak.
- 1 Corona coil, L2.
- 1 Low ratio audio amplifying transformer, T1.
- 1 Modulation transformer, T.
- 1 Relay, K.
- 1 Recording machine, M.

With a view to minimizing as much as possible any bad feed-back effects that are most undesirable in this machine, and also, to give maximum room for adjustment, wiring, and replacement, a large board is used for the base. The panel is of standard size, and will accommodate all of the controls that are of immediate importance in the working of the machine.

Much of the success of the picture set will depend on the way it is assembled. First, the audio and modulation transformers are located and fastened down with large screws. Then, the sockets, fixed condensers, choke, filament controls, and the coil. The suggested layout can be followed. Experienced amateurs only will attempt to change it greatly.

Work on the panel can now be started. On it are placed the filament and gain controls, several jacks, the special relay, and a variable condenser. Any symmetrical arrangement can be designed for the panel. A convenient and practical layout is the one suggested here in the model.

A binding post strip, with the binding posts readily accessible is screwed on the rear end of the baseboard. The preliminary wiring can now proceed.

First, it is suggested that the filament circuits be tackled. The grid, and then, the plate circuits can be done in succession. Before this is done, the front panel should be mounted on the front edge of the baseboard with wood screws.

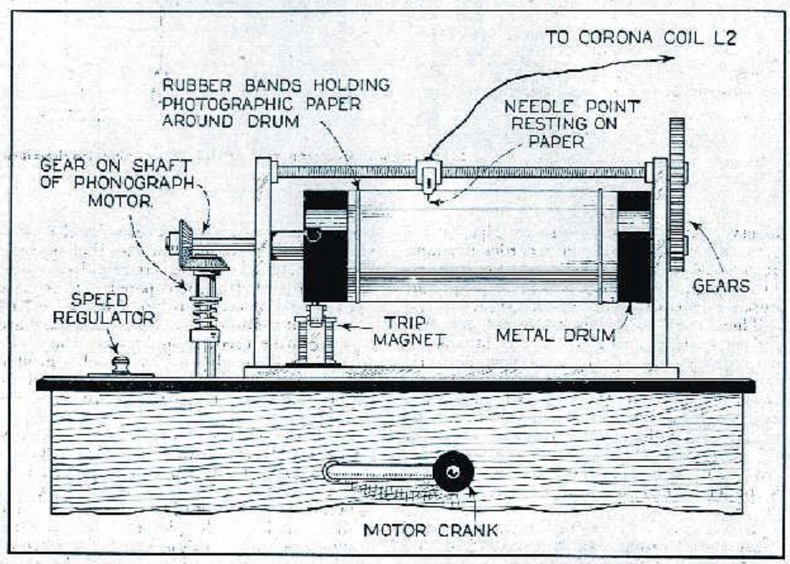
Every circuit should be checked over carefully. Specially is it important that the relay circuit be watched. Notice the numbers on the transformer terminals, and connect them to the correct jack, relay, and other points in the modulation and oscillating circuits.

six inches long. It is driven, through a gear arrangement, by a spring motor. An ordinary phonograph motor, or an electric one that has the same speed can be used. A commercial recorder is made so that it can be placed in a standard phonograph for driving.

By means of a train of gears, a carriage moves along the cylinder axially at the rate of about 80 lines to the inch. A sharp stylus, such as a phonograph steel needle, is attached to it. This is the terminal electrode of the high voltage corona coil. At this point, a brush discharge of varying intensity takes place, which records the picture on a photographic paper wrapped around the metal cylinder.

There is a stop-start spring arrangement, together with a release magnet, which stops, and again starts the cylinder, according to impulses received and directed through the relay, as explained above for the synchronization process.

The entire recording mechanism looks very



Details of the recorder. A device of this type is available completely assembled, or it can be built by the experienced machinist.

Modulation transformer posts are numbered 1, 2, 3 and 4 in the accompanying schematic diagram. The input goes to terminals 1 and 2. The first terminal connects with the winding of the relay, which in turn, goes to the plate of the first tube. The second post connects with a jack, and to the B plus post on the rear strip.

Then, secondary connections are made, for post three, to the choke coil feeding to the plate of the oscillator; post four goes to high plate voltage terminal on the strip, through a jack. Although the connections from the receiving set into the input transformer are not of prime importance as to direction, they may be reversed if necessary.

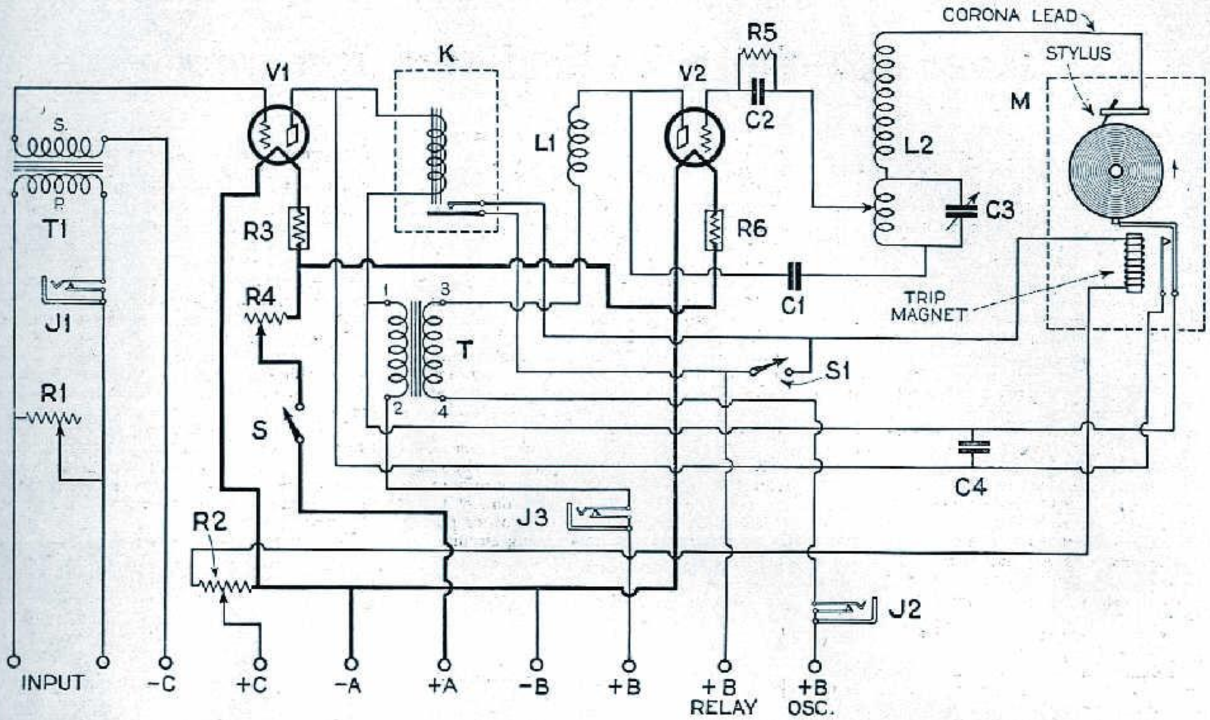
To produce a neat wiring job, wires may be cabled, in the telephone manner, and carefully tied together. Needless to say, all connections should be soldered, and individually tested. All parts should be inspected before using in the circuits. This work may save hours of time later, when it is found that trouble has developed.

Attention may now be given the recorder shown in a sketch herewith. It consists of a cylinder, about two inches in diameter, and

much like an old cylinder phonograph, except that it has in addition the synchronizing apparatus. It would be possible to convert such a device into a recorder, but providing the synchronizing means, as in the commercial product. It would, however, be necessary for the amateur to have an elaborate machine shop equipment to do this.

After the final assembly of the picture machine, and the good working of the recorder, either spring or electrically driven, the picture set should be tried out. Tubes of the usual amplifier type are placed in the sockets, the V1, V2, and batteries connected, and a milliameter handy. It is very desirable to use individual batteries for this apparatus. Eliminators are best used with the receiving set to be connected to the picture machine. Of course, the ideal experimental set-up is where the entire arrangement is operated from individual sources of current supply.

Certain adjustments will have to be made to the picture set before it will be ready for operation. There is apparatus adjustment, and a bit of tuning. The relay contacts will have to be carefully brought into place, and the tension on the armature regulated to a



Schematic wiring diagram of the radio picture apparatus described in the article.

nicety. Every time this relay trips, it will actuate the magnet of the recorder machine. It must be balanced so that only the synchronizing signal, which precedes each picture impulse once a revolution, will trip it.

Then, the biasing resistance R2, must be judged best, so as to give the right amount of negative bias on the amplifier tube grid in order to swing the plate current to the operating point of the relay winding. The best way to adjust this resistance value is by means of a milliammeter reading, when the relay and recorder magnets are energized. A reading of 15 mils in the plate circuit of the amplifier tube show a healthy operating condition.

This relay, as explained previously, will cause the recording cylinder magnet to stop its revolving once a revolution, in synchronism with the sending impulse. There may be some sparking at the contacts, which may be minimized by placing a large fixed condenser across them, or by increasing the space between contacts. The relay will trip at approximately 100 or more times a minute. The speed of the phonograph motor, governing that of the recording cylinder will have to be adjusted to strictly that of the sending station, plus a little advance. The revolutions can be readily counted by the tick produced by the trip magnet when it works.

To receive a picture, it will be necessary to see that a corona discharge is actually taking place at the stylus end. The oscillating circuit must perforce be working. A milliammeter reading in its plate circuit will determine this. The recorder depends upon the voltage generated in the step-up radio frequency transformer for the spark discharge.

By darkening the room, and placing the stylus on a dark piece of paper, its glow may be seen. By adjusting various parts of the circuits, such as the variable condenser, the intensity of the spark can be regulated. A better method would be to insert a piece of photographic paper on the cylinder, and "expose" it to the spark. After developing, dark spots will indicate the action of the spark. The oscillating circuit should be regulated so that there is just a visible discharge when there is no modulated picture signal coming through. The intensity of the discharge will vary with that of the picture impulse.

Ordinary photographic paper can be used with the recorder. Azo No. 2 has been suggested, but Velox, or any of the other standard makes can be used. Simply wrap the sheet, which should be about 5 by 7 inches around the cylinder, holding it in place by means of rubber bands, or, if desired, paste along the long edge.

After the picture is run off, it should be developed in the regular way, with a developing and fixing bath. As skill is gained with the apparatus, more sensitive or contrasty papers can be tried, until the best combination is discovered. If the pictures are too dark, it is because the spark discharge is too strong, or the paper too rapid. Adjust the input resistance of the picture set to the amount given above, or use a slower grade of paper, or, again, readjust the oscillating condenser so that the discharge will be smaller.

If the pictures are weak, boost the signal, or use faster paper. Careful adjustment of the oscillating circuit should be made also.

Static and other interference may cause some difficulties in the manipulation of the picture machine. These generally show up in the shape of streaks in the photographs. The skill of the amateur constructor will enter here, to eliminate much of the troubles, and to obtain the finest picture.

If, some day while tuning idly around, you pick up peculiar signals that sound like a badly greased grindstone turning over at a fairly rapid rate, let your curiosity find out what it is all about. The chances are that you accidentally tuned in a radio photograph transmission broadcast. There are several stations in the United States and in Canada that are "on the air" with radio pictures. Now, the sport is building a special set that will pick these up, and enable the amateur to receive his own radio-photos in his home.

Radio pictures are being broadcast within the wave bands assigned by the Government for program and entertainment use. This means that the receiving set now ordinarily employed for the reception of broadcast programs can be used to pick up picture impulses without any change. To operate various devices that make it possible to record the picture transmitted, some additional material, already described, will be needed.

Receiving a radio picture is practically reversing the process of transmission. At the sending station, an original photograph is wrapped around a cylinder that turns over at a very definite rate of speed, say, 100 revolutions per minute. A beam of light is made to strike the surface of the photograph, the reflected ray being directed against the aperture of a photoelectric system, connecting to the transmitting apparatus. The mechanism is so arranged that the entire photograph will be scanned by this narrow beam, revolving and progressing axially before it.

As the beam meets different values of light and shade on the photograph, a greater or lesser amount of light will be reflected to the photoelectric cell. This device, in turn, regulates the intensity of the picture impulse sent.

At the receiving end, the wave is tuned in, and the impulses amplified as though they were ordinary broadcast signals. Then, they are fed into a special amplifying and oscillating arrangement, and after reaching high voltages, are led to a stylus, or recording point on a traveling carriage that is part of a recording cylinder mechanism.

In regard to the high frequency coil L2 here employed, to supply the corona discharge at the stylus, this may be experimented with by the amateur. Offhand a primary and secondary coil such as those used in tuned radio frequency receivers may be employed. In general, both for photo transmission as well as television transmission it will be found the best practice to use B batteries instead of a B eliminator. Shielding of the individual apparatus is also recommended both in photo and television transmitters and receivers. In using photoelectric cells it is particularly important that the cell itself be placed in a grounded metal shield or box, leaving only a small hole as a window through which the light ray can pass.

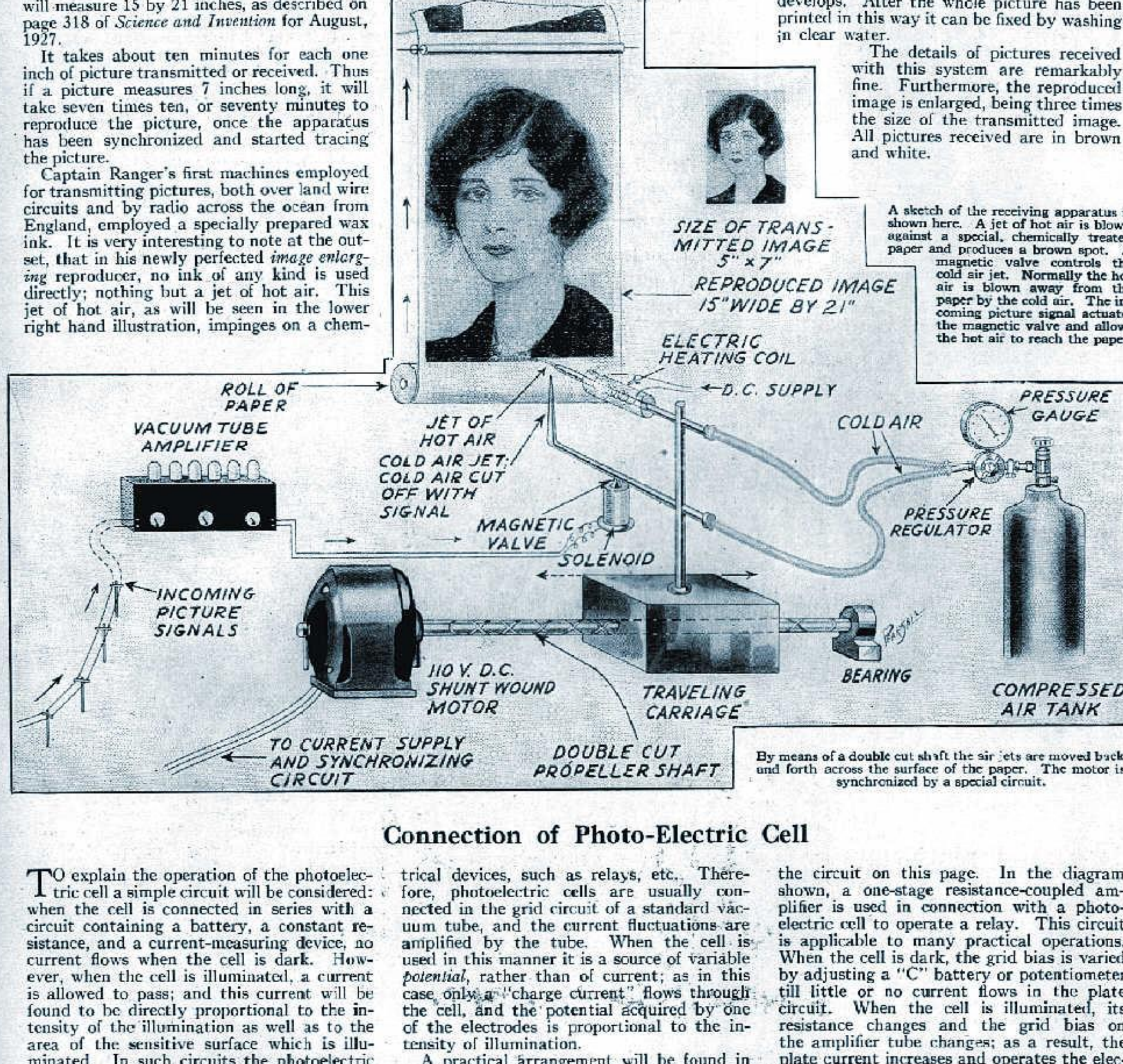
Recording Picture with Air Jet

CAPT. R. H. RANGER'S highly improved and ingeniously constructed photo reproducing machine enlarges the image nine times, i.e., if a 5 by 7 inch photo is placed on the transmitting machine at one end of the circuit, the picture reproduced at the receiving end of the circuit will measure 15 by 21 inches, as described on page 318 of *Science and Invention* for August, 1927.

It takes about ten minutes for each one inch of picture transmitted or received. Thus if a picture measures 7 inches long, it will take seven times ten, or seventy minutes to reproduce the picture, once the apparatus has been synchronized and started tracing the picture.

Captain Ranger's first machines employed for transmitting pictures, both over land wire circuits and by radio across the ocean from England, employed a specially prepared wax ink. It is very interesting to note at the outset, that in his newly perfected *image enlarging* reproducer, no ink of any kind is used directly; nothing but a jet of hot air. This jet of hot air, as will be seen in the lower right hand illustration, impinges on a chemically treated paper, which unreels from a roll in a progressive and systematic manner line by line. Where the hot air strikes the paper, a remarkable chemical change takes place and a brown tint instantly appears. When an incoming signal arrives from the machine at the transmitting end, an electromagnet or solenoid connected with the radio receiver for example, causes the deflecting jet of cold air to be cut off; in consequence the hot air is allowed to strike the paper and a brown line of certain intensity instantly develops. After the whole picture has been printed in this way it can be fixed by washing in clear water.

The details of pictures received with this system are remarkably fine. Furthermore, the reproduced image is enlarged, being three times the size of the transmitted image. All pictures received are in brown and white.



A sketch of the receiving apparatus is shown here. A jet of hot air is blown against a special, chemically treated paper and produces a brown spot. A magnetic valve controls the cold air jet. Normally the hot air is blown away from the paper by the cold air. The incoming picture signal actuates the magnetic valve and allows the hot air to reach the paper.

By means of a double cut shaft the air jets are moved back and forth across the surface of the paper. The motor is synchronized by a special circuit.

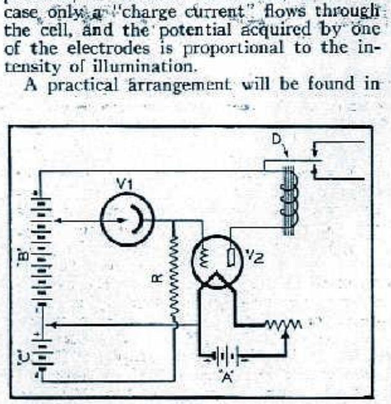
Connection of Photo-Electric Cell

TO explain the operation of the photoelectric cell a simple circuit will be considered: when the cell is connected in series with a circuit containing a battery, a constant resistance, and a current-measuring device, no current flows when the cell is dark. However, when the cell is illuminated, a current is allowed to pass; and this current will be found to be directly proportional to the intensity of the illumination as well as to the area of the sensitive surface which is illuminated. In such circuits the photoelectric cell acts as a variable resistor, the value of which is determined by the illumination of the cell, as stated on page 597 of *Radio News* for December, 1927.

In the electrical operation of the cell the sensitive surface is the negative terminal, and the grid (or anode) is the positive terminal. When the cell is connected properly and light shines upon the sensitive surface, electrons are emitted from this surface and are attracted by the grid. The number of electrons emitted in any unit of time is proportional to the area and intensity of the illumination of the sensitive surface, and is also dependent upon the color of the light.

In actual practice the photoelectric cell does not pass sufficient current to be of much importance in the direct operation of electrical devices, such as relays, etc. Therefore, photoelectric cells are usually connected in the grid circuit of a standard vacuum tube, and the current fluctuations are amplified by the tube. When the cell is used in this manner it is a source of variable *potential*, rather than of current; as in this case, only a "charge current" flows through the cell, and the potential acquired by one of the electrodes is proportional to the intensity of illumination.

A practical arrangement will be found in the circuit on this page. In the diagram shown, a one-stage resistance-coupled amplifier is used in connection with a photoelectric cell to operate a relay. This circuit is applicable to many practical operations. When the cell is dark, the grid bias is varied by adjusting a "C" battery or potentiometer till little or no current flows in the plate circuit. When the cell is illuminated, its resistance changes and the grid bias on the amplifier tube changes; as a result, the plate current increases and operates the electromagnetic relay. This relay circuit can be used to regulate artificial illumination—that is, to close the lighting-circuit switch when the intensity of the natural illumination falls below a predetermined value. Another interesting and useful application is its use as an optically-controlled counting device. With this simple mechanism it is possible to record accurately the number of times a shadow is cast upon a given point.



Circuit showing arrangement for connecting the photoelectric cell V1 with a resistance-coupled amplifier for the operation of a relay (D).

An approach to an electric eye is found in the alkaline-hydride photoelectric cell. This device, which is extremely sensitive to light, and to variations in intensity and color of light, transforms optical effects into variations in an electric circuit. Furthermore, the cell responds to these effects with extreme rapidity and a high degree of precision. The result is that the cell has a wide range of application.

Television's Newest Developments

COVERING IMPROVEMENTS
by
BELL TELEPHONE LABORATORY
BAIRD SYSTEM
ALEXANDERSON
NAKKEN SYSTEM (WRNY)
VALENSI
CLARKSON
CAMPBELL SWINTON
JENKINS

Television Demonstration

IN ONE corner of a vast room in the General Electric Company's research laboratory at Schenectady, N. Y., during February, 1928, were set up an arc light, a rapidly-revolving metal disc, four photoelectric cells in a frame, and several boxes. Just around a corner a group of men were gathered in a room totally dark, save for two squares of pinkish light about three inches square.

A young woman was seated before the bank of photoelectric cells, with narrow bands of light and shadow playing across her features. She smiled, frowned, rolled her eyes, and smoked a cigarette—and all these actions were instantly and faithfully pictured in the little squares of pinkish light in the adjoining dark room. At the same time, the conversation which she kept up with one of the operators came into the dark room through a loud speaker, says the author of an article in *Radio News*, for April, 1928, page 1098.

The question will present itself naturally to the reader's mind: "*How well* did these faces come over the air?" It was possible to see every detail in the features, the individual teeth, for example; when the eyes were rolled, one could follow with ease the movement of the pupils. In short, the transmission of faces by radio can be compared in quality to moving pictures in their earliest days.

In three homes in different sections of Schenectady, similar television receivers had been installed to show that reception in the home is possible and practicable. A short antenna was employed to pick up the 37.8-meter wave on which the television impulses were broadcast. The results obtained in the homes were of the same excellence as those demonstrated in the laboratory.

The Electric Eye

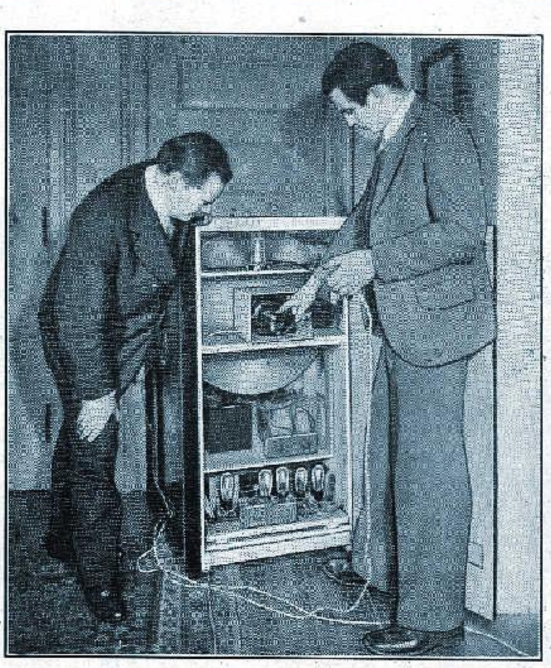
The transmitting apparatus for broadcasting television is not very complicated. The rays from a powerful arc light are broken up by the spirally-arranged holes in the disc, which is rotating at the rate of eighteen revolutions per second, being driven by a small motor. The light rays are concentrated and focused on the face of the girl by means of the lens held in a square wooden support.

After the rays of light from the arc have been broken up by the revolving disc and focused on the face of the subject (where they appear to the camera as a series of grid-like light and dark lines; they are reflected from the surface of the face to the four photoelectric cells in the thick, square frame of galvanized iron. These possess the property of changing light energy into electric energy. (These cells were described on page 640 of the December, 1927, issue of *Radio News*; previous television experiments will be found described in the June, 1927, issue.) The output of these cells after being amplified, modulates the carrier wave of the 37.8-meter transmitter, the antenna of which is located on the roof of the research laboratory. A condenser microphone picks up the voice, which was simultaneously broadcast on WGY'S regular wave of 379.5 meters. A very short wavelength was chosen for broadcasting these "pictures" because a channel 40 kilocycles wide is needed; this is because of the depth of modulation necessitated by the great range of differences in shading, which must be reproduced in the transmission of vision.

The Electric Paintbrush

The average radio enthusiast is most likely much more interested in the apparatus for reception than in that just described. Compared with the television receivers that have been described in this magazine previously, the latest one is simplicity itself. In place of the loud speaker, a Moore neon tube is connected in the output of a short-wave receiver of the regenerative type. The most interesting property of the neon lamp, which was invented by D. McFarlan Moore (as related in Mr. Moore's biography, "Thirty Years in the Dark Room," which appeared in *Radio News*, from December, 1925, to May, 1926), is that it responds to the changes in intensities of the current and causes fluctuations in the intensity of the emitted light; just as the diaphragm of a loud speaker produces pulsations in the air in response to alternating-current impulses. It is said that this lamp will go on and off in a millionth of a second; so that in its use there is none of the "time lag," which is the greatest problem those working in television have had to meet.

The plate of the Moore tube, on which the image is built up, is about 1½ inches long and 1 inch wide. The scanning disc, which can be seen in front of the lamp in the rear view of the apparatus, is of the same size as that used in the transmitter, 24 inches in diameter. The 48 holes (which have a diameter of 35 mils each—or about 1/30-inch) trace successive lines on the picture, literally "painting" it in one revolution. The disc is turned by a standard "universal" motor; which is to say that it can be operated from either direct or alternating current. The speed of this motor and, therefore, of the disc, is controlled by a push-button. In order to enlarge the image as much as possible, a magnifying lens is placed between the scanning disc and the observer's eye; thus bringing the image up to 3 inches square.



At the left, shows the rear of the receiver; one man is pointing out the universal motor, which drives the scanning disc. Above the motor is the Moore neon lamp. On the lower shelves are batteries and the amplifier and rectifier tubes. Dr. E. F. W. Alexanderson is seen at the left.

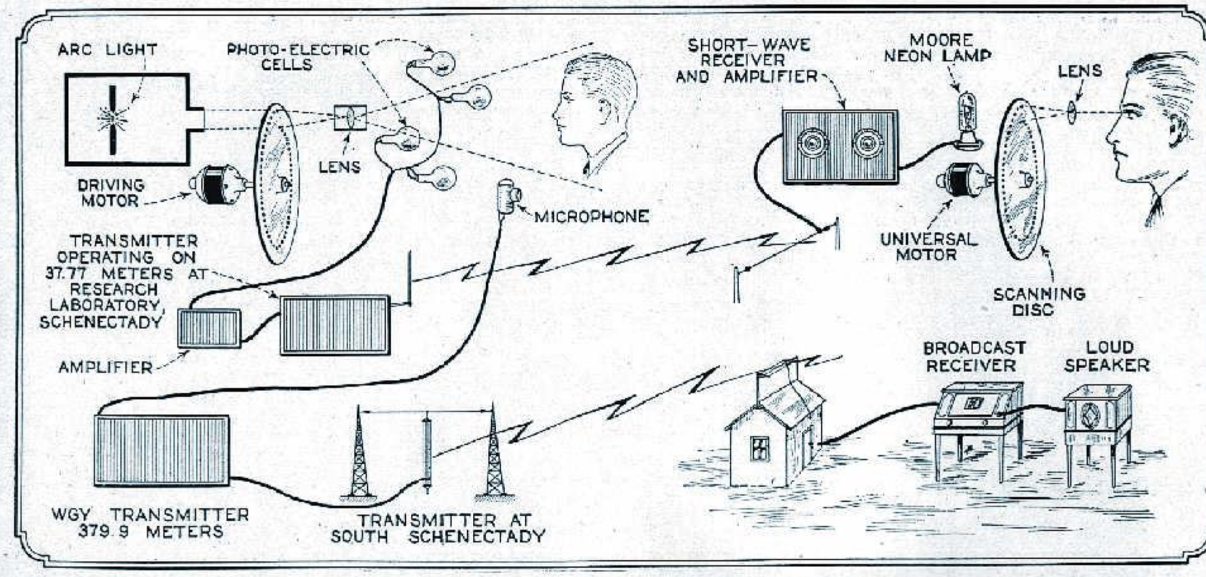
Synchronization by Hand

In Dr. Alexanderson's system no such complicated method of synchronization is employed; the simple and only speed control is a push-button that varies the speed of the universal motor turning the disc.

When the receiver is first started the speed of its motor is far below that of the one at the transmitter, and the resultant image is a straight line of light. As the motor is brought nearer and nearer to synchronous speed, this line of light breaks up into a series of parallel lines, slanting first one way and then the other. Then there appears a distorted image of a face, again breaking up into splotches of light and dark. Finally, when the two motors are running in synchronism, a true image may be seen on the lens. This image constantly shifts from one side to the other, as the speeds of the two motors vary; but this shifting from side to side does not interfere with the reception, as the movement can be made to be very slow.

Here it is that the operator must exercise his skill, in keeping the received image as near the centre of the lens as possible. This is done by "whipping" the motor; *i.e.*, sending an electric impulse to the motor by means of the push-button, and thereby increasing the speed. This is far from being a difficult feat, as it requires no more skill than steering an automobile along a road. Sometimes, when the two motors get slightly out of synchronism, the lower half of the image may be above the upper; so that a man's collar and tie may be seen above his head. This condition can be easily adjusted, however; just as a like condition is remedied by the motion-picture operator when the picture gets out of its "frame."

In the lower part of the cabinet, which (as may be seen) is about the same size as that which houses an ordinary talking machine, is an amplifier with two rectifier tubes. A storage battery and dry-cell "B" batteries for the short-wave unit are on a shelf over this amplifier, which utilizes A.C.



A diagram of the Alexanderson method of operation in the transmission and reception of television. At the upper left are the transmitter for the image and the microphone for the voice, which is broadcast on a different wavelength. At the right are the receivers for television and speech.

house current. By the use of a universal motor and the rest of the equipment as mentioned above, it may be easily seen that the television receiver is one that can be used in almost any home; the only provision being that 110 volts of either A.C. or D.C. be available.

Of course, there are still a number of "bugs" that have to be eliminated before the apparatus can be put on the market for general use; but, considering the rate at which television engineers are progressing in their work, the time is approaching rapidly when it will be possible to see as well as hear the artists as they appear in the studio.

Although the picture as seen in the television receiver appears no more than three inches square, and there are instants when it is obliterated by static or some other interference, the remarkable part of the story is that the device worked at all. Every so often, during the last few years, enthusiastic articles have appeared, telling how television is rapidly becoming a reality instead of an engineer's dream. But these fulfillments of dreams were in laboratories; now television has been carried to the home.

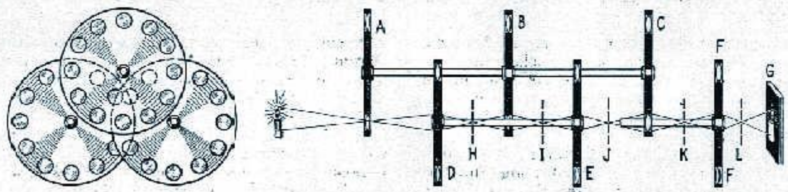
Baird Optical Lever Increases Scanning Speed

Latest Design of Mechanism

IN another part of his laboratory, however, Mr. Baird has erected another and more modern machine, which is at present undergoing test. This new machine makes use of the principles involved in one of Baird's latest master patents, called the "optical lever." Briefly outlined, the object of the optical lever is to increase the speed of an image passing across the light-sensitive cell, without increasing the speed of rotation of mechanical parts, according to an article on page 1232 of *Radio News* for May, 1928.

This object is achieved by mounting, on two parallel shafts, two sets of lens discs. The first pair of discs, at the end of the shaft, overlap one another and move in opposite directions at the point of overlap. The distance between the two discs is so arranged, however, that they overlap at a point where their focal points coincide.

Further along the shafts other pairs of discs can be added, and the principle of the arrangement is such that, for every extra pair of discs, a doubling of the speed of the image is obtained.



The Baird "Optical Lever" is composed of lens-studded discs on common shafts, shown in cross-section at the right, and in end-view at the left. The illuminated image cast through A is moving at an apparent speed which is doubled by the lens in D, and so on to any desired rapidity of horizontal "scanning." The focal points of the lenses are represented at H, I, J, K, L. The disc F causes the transmitted image to move perpendicularly back and forth across the window of the photoelectric cell G. (British patent 265,640.)

There is no limit to the number of discs which may be added, by suitably lengthening the parallel shafts, so that there is virtually no limit to the number of image, or light impulses, which may be flashed per second upon the light-sensitive cell; and this phenomenal result is achieved without in any way speeding up the mechanism, which may rotate at any speed at all which may be prescribed by good engineering practice for the weight of revolving material concerned.

Valensi Television System

M. VALENSI, chief engineer of the French Post Office, is one of the first inventors who had the idea of utilizing the cathodic ray for television apparatus, says an article on page 204 of *Science and Invention* for July, 1927.

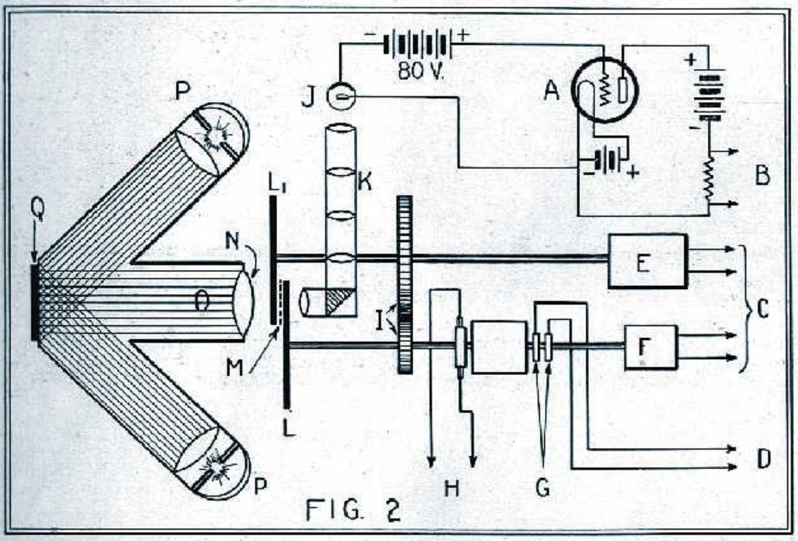
Exploration of the Image

The image to be transmitted may be a lantern slide in a lantern, or an opaque subject, drawing, postal card, watch, etc., placed in an "opaque object" lantern. There is nothing special about the projecting lantern. It contains two arc lamps which can be made as powerful as desired, casting the greater part of their light on the object whose image is to be transmitted, and this image strongly illuminated is formed at an exact place between two stroboscopic discs.

These discs are shown in Fig. 1-A. It will be seen that one carries a wave line made up of arcs of spirals of special form, while the other carries one single line eccentric to the disc. The two are connected by means of gears which give to the first disc a rate of rotation of 2,400 turns a minute, and to the second a rate of 480 turns. As our diagram shows the two discs are so placed with relation to each other, that any point on one of the discs is always opposite one point of the second disc. A ray of light can then constantly pass through a point of intersection of the two curves.

Under these conditions the image is not explored or traced over by a double sine curve, but by a series of straight lines uniformly switching over it from left to right, and from right to left; not parallel but at an extremely acute angle with each other. The following advantages are incident to this arrangement. In the tracing by double sine curve, the ray of light reduces its transverse velocity as it approaches the extremities of the image it is tracing, so that these parts are better lighted than is the central part. To understand this phenomenon it is enough to think of a pendulum in oscillation, its speed is greater at the central part of the oscillation than at the extremities. M. Valensi, on the contrary, gets a uniform tracing or exploration of constant speed represented in a diagram by the figure shown, it being clearly understood, that each of the lines which form it, is to connect in some way with the preceding one, to obtain very close synchronism between two shafts.

It now appears that each station, transmitting or receiving, depends directly on an alternating current motor, in central position, which governs on one hand by means of the stroboscopic discs the transmission of photoelectric currents; and on the other hand by means of alternators, one of 800 and one of eight cycles, the magnetic fields of deviation of the luminous point of varying brightness upon the receiving screen.



The diagram of the televisor is shown here. The various components of the circuit are as follows: A, amplifying tube; B, circuit to the amplifying battery; C, circuit of the coils of the magnetic reflecting fields; D, lines to the telephone circuit; E, 8-cycle alternator; F, 800-cycle alternator; G, rings connecting to the two points of the motor field coil; H, 110-volt circuit; I, gearing; J, photoelectric tube; collimator; LL1, discs; N, lens; O, beam of parallel light rays; P, arc light; Q, object to be transmitted.

It is important to understand this feature. Each station has the transmitting and the receiving apparatus mechanically coupled on a single shaft of the central motor; a single synchronic current carried by the telephone line completely synchronizes the two corresponding television stations.

The Receiving Apparatus

Mr. Johannes of a Paris instrument firm has constructed for M. Valensi a Braun tube characterized by this feature; that with a very feeble modulation energy factor, (a few micro-amperes at about 12 volts), it was possible to light and extinguish a brilliant luminous point of a fluorescent screen. The concentration of the electrons is there produced in a very simple way by means of traces of a neutral gas acting by their positive ions. The electrons formed by the incandescence of a filament (Wehnelt's cathode) are put in motion by a perforated plate anode facing the filament. Between filament and anode is found a group of small auxiliary electrodes acting as the grid of a triode tube.

It will be seen on the diagram that the currents coming from the radio receiver act upon the cathodic emission between grid and filament; a grid battery keeps said grid always negative as referred to the filament. These two elements can be very near together, without the filament being in danger of change by positive ions precipitating themselves upon it. The cathodic emission is then greatly influenced by currents acting upon the grid and coming from the radio receiver, and which it will be remembered are due to waves emitted by the photoelectric current at the transmitting station.

The perforated plate of the Braun tube, the anode, is supplied by a continuous current generator at 800 volts potential; the beam of electrons passes out through the canal tube belonging to this plate and impinges upon the fluorescent screen. On the other hand, the eight cycle and 800 cycle currents generated by the two alternators are passed through four coils, situated on a core of square sections, which surround the extremity of the Braun tube very near to the fluorescent screen. The wave profiles of these alternators is made up of isosceles triangles; the intensity and phase of the eight cycle and 800 cycle circuits can be governed by rheostats and other appliances acting on the fields of the alternators.

The diagram of the receiving instrument shows how the coils of the magnetic fields are associated to give very regular fields of force, which produce the same phenomenon which we have already explained; that is to say, a deviation or movement of a cathodic ray in perfect synchronism with the photoelectric emission currents, and having exactly the same form as that of the explorer or image tracer, and operated at a uniform rate.

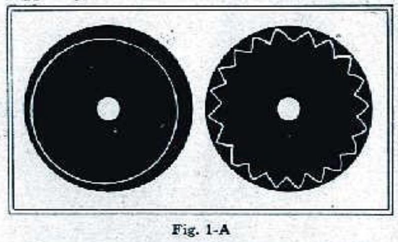
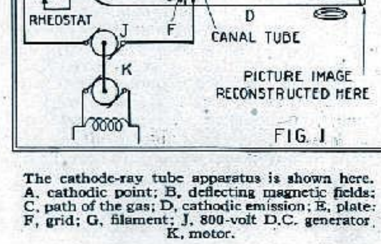


Fig. 1-A

This illustration shows the two discs of the stroboscope. One of them carries a wave line of special form, while the other carries a single line.



The cathode-ray tube apparatus is shown here. A, cathodic point; B, deflecting magnetic fields; C, path of the gas; D, cathodic emission; E, plate; F, grid; G, filament; J, 800-volt D.C. generator, K, motor.

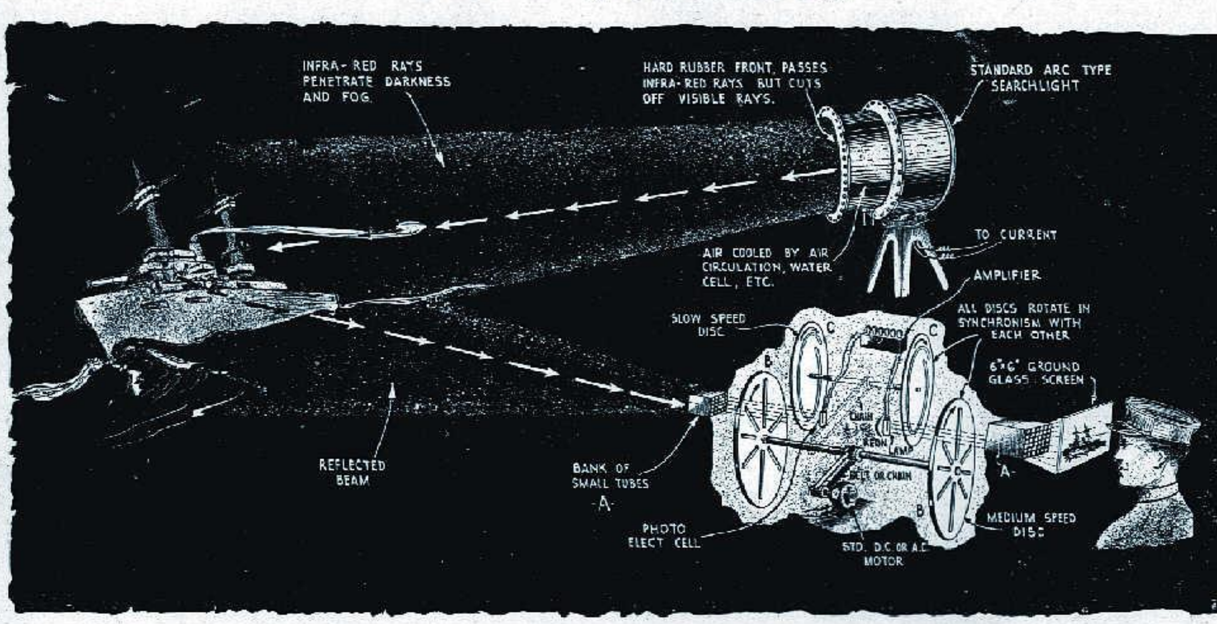
Infra-Red "Eye" Sees at Night

VISION in total darkness and fog is now made possible through the recent invention of J. L. Baird, of London, England, who has completed the "Noctovisor," which is the name given to his new device. The apparatus makes use of infrared rays, those invisible heat rays which are found beyond the red end of the spectrum. Recently heat rays have been measured which have a wavelength of .0107 centimeters, or 160 times as long as the wavelength of the red end of the spectrum, and from this limit there is an unbroken series to the end of the visible spectrum, as stated on page 213 of *Science and Invention* for July, 1927.

What might be termed the transmitting portion of this device consists of an infra-red ray projector. A standard arc type search light is used with a hard rubber front which cuts off the visible rays but allows the invisible ones to pass. A special type of filter glass, which serves the same purpose as the hard rubber, may also be used. The rays emanating from the projector strike upon some invisible object and are reflected back to the receiving apparatus. The receiving portion of the "Eye" consists of first an analyzer, a bank of small tubes which subdivides the scene or picture into minute areas and transmits it to the light sensitive cell. Directly in back of this analyzer is a rotating disc, which is slotted and at regular intervals varies the amount of the ray which is received by the photoelectric cell. The photoelectric cell itself is placed behind a disc revolving at a relatively low speed, which is spirally slotted, thus the cell receives different portions of the reflected beam at a set time. The photoelectric cell converts the energy received into an electric current which is amplified by means of a bank of vacuum tubes. A neon lamp is connected to the output of the amplifying unit and two other discs, as previously described, are placed in front of the lamp. In front of the last disc another analyzer is arranged with a ground glass screen, upon which the image appears. The rapid movement of the spot of light builds up and makes visible to the naked eye the scene revealed by the infra-red searchlight. All the discs are rotated in synchronism with each other, the two sets being joined by a chain or gear drive.

The "invisible search light" has 200 to 300 times the penetrating power of ordinary light through darkness, fog or smoke and consequently will find many uses in our present day existence. Two-thirds of the energy in the search-light beam resides in the infra-red component.

How J. L. Baird, Television Investigator, Utilizes Infra-Red Beam and Photo-Electric Cell to See Through Darkness or Fog



The apparatus used to receive the view illuminated by the invisible beam of the infr-red searchlight and render it visible to the eye of the operator, is shown in the above illustration. The infra-red rays have the property of penetrating darkness and fog and thus lend themselves to use during war time and also in locating ships lost at sea during a storm.

The infra-red rays, striking the invisible object are reflected back to the receiving apparatus. As the angle of incidence equals the angle of reflection, it is possible to determine beforehand the exact position which the receiver must occupy. The details of the invisible ray projector and the receiving mechanism are further described in the accompanying text.

Quartz Crystals Synchronize Television Sets

The Properties of the Crystal

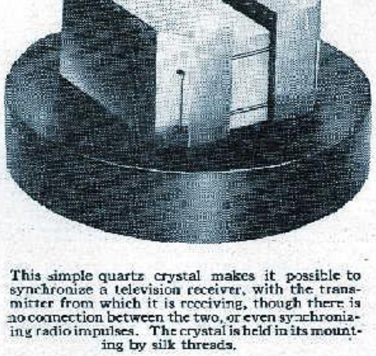
AT LAST, however, the famous quartz crystal has stepped out in a new spring dress and hat, so to speak, and has bestowed a priceless boon on the television engineers, by solving the bugaboo over which they had spent so many sleepless nights. Their endeavor to simplify and eventually commercialize the "seeing over a wire" idea, first demonstrated last summer, has been facilitated by putting the crystal to work at keeping the discs revolving with *exactly the same speed at both transmitter and receiver.* This is accomplished by the use of a quartz-crystal-controlled oscillator and a two-stage amplifier at both ends of the line, says H. W. Secor on page 1230 of *Radio News* for May, 1928.

It is a peculiar property of quartz and some other crystals, and an extremely valuable one, to have fundamental frequencies at which each responds to electrical vibrations. The effect is called *"piezo-electric"*: the molecules of a crystal acquire, apparently, an electric charge when the crystal is twisted or pressed out of shape, without breaking it. It would seem as if the internal arrangement of a crystal is in some ways like that of a magnet.

So also, when we apply a difference of potential, or a voltage, across a crystal we cause a disturbance, of the arrangement of the crystal's particles, which slightly deforms the crystal. When we cause this voltage to alternate rapidly, we cause very slight twistings and untwistings of the crystal, and these are most effective at *a certain frequency, depending on the size of the crystal.* This adjustment is very critical, and renders possible a remarkable degree of accuracy in the regulation of oscillating radio circuits.

The crystal of quartz occurs, in nature, in the shape of a six-sided prism, with two pointed ends; something like the glass pendants which are often hung from chandeliers. In order to make it suitable as a "piezo-electric" governor of the frequency of electrical apparatus, it has to be cut down; the more it is reduced in size, the lower the wavelength corresponding to its fundamental frequency. The preparation of a crystal for use in this manner is shown in one illustration, and the cut-and-tested crystal, mounted for use in its oscillator, in another. The crystals are carefully ground to size on special grinding wheels, and are checked in the laboratory before being mounted.

A second important thing is that the frequency which the crystal will pass is controlled by temperature changes. Therefore, as may be seen from the accompanying view of the quartz-crystal-oscillator set-up, the crystal is mounted in a wooden box, in which the air is maintained at a constant



This simple quartz crystal makes it possible to synchronize a television receiver, with the transmitter from which it is receiving, though there is no connection between the two, or even synchronizing radio impulses. The crystal is held in its mounting by silk threads.

temperature by means of thermostats. When the temperature rises, say above 70 degrees, inside the crystal cabinet, thermostats cause the temperature to be lowered by connecting in circuit an electric fan, which lowers the temperature; if the temperature drops below 70 degrees, the thermostats connect electric heating coils in the circuit, and thus the air is warmed to the proper degree. The two meters at the left of the panel of the oscillator indicate the currents passing in the tube circuits; while the two dials at the right of the panel are for adjusting the frequency of the oscillator.

Independence of Synchronization

For the purpose of a television-frequency control, as the pictures and diagrams herewith illustrate, a quartz crystal is connected to a vacuum-tube oscillator, together with a suitable vacuum-tube amplifier; the "sine-wave" alternating-current output of this set-up is fed into a high-frequency synchronous motor, mounted on the disc-driving shaft beside a 60-cycle synchronous motor. As the reader will probably recollect, in the Bell television system each disc-driving shaft carries a 60-cycle synchronous 110-volt A.C. motor; and also a special high-frequency A.C. motor; the high-frequency motor is used to improve the synchronism or constancy of revolution of the disc, because a slight slippage or variation in the speed of the high-frequency motor will not be so noticeable as a corresponding variation in the case of a low-frequency motor. Between the two motors a very accurate constancy of rotation is maintained.

In fact, the writer is informed by the engineers who have perfected the quartz crystal for use with the television apparatus, that the accuracy of the speed as related to perfect synchronism has reached *the order of one part in a million.* This means that the discs of the transmitter and the receiver, respectively, may rotate one million

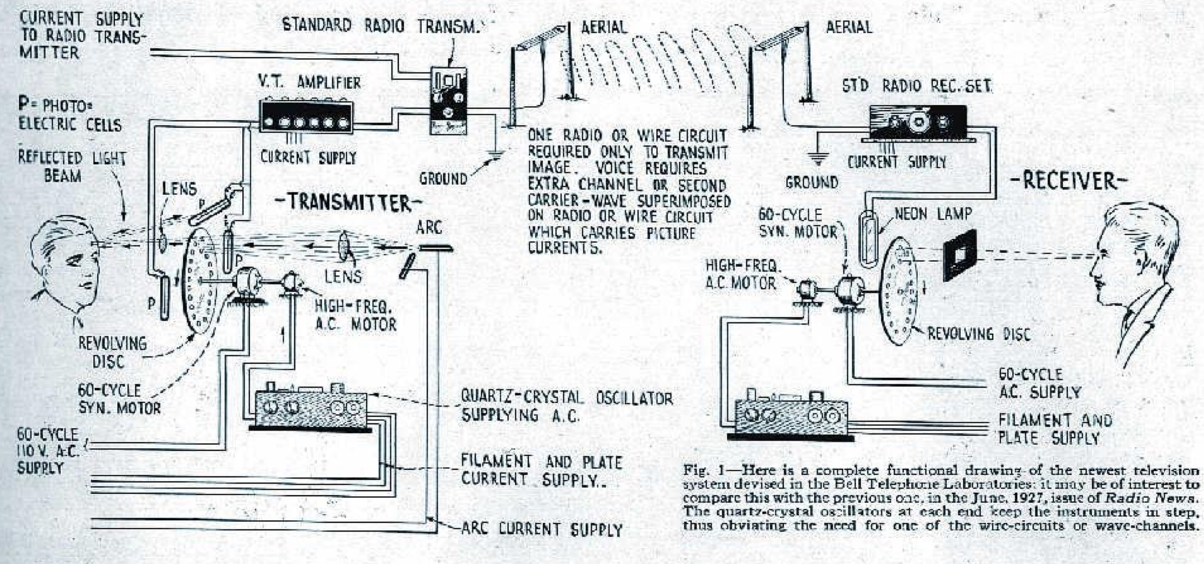


Fig. 1—Here is a complete functional drawing of the newest television system devised in the Bell Telephone Laboratories: it may be of interest to compare this with the previous one, in the June, 1927, issue of *Radio News*. The quartz-crystal oscillators at each end keep the instruments in step, thus obviating the need for one of the wire-circuits or wave-channels.

times and not be out of step, during that time, more than one revolution. A correcting button, however, is placed on the television machine cabinet, so that in the event that the picture should "drift" or become distorted, once in a great while, perfect synchronism can again be established by simply pressing a button.

Hook-up of Crystal

In Fig. 2 we have the electrical connections of the quartz crystal, in the oscillator-amplifier hook-up used in the latest Bell television system. As will be seen, the quartz crystal, a given size of which passes only a single definite frequency at a certain temperature, is connected in series with the grid of the oscillator and the tuned inductance "L" of the oscillator circuit. In the quartz-crystal oscillator illustrated here, one of the tuning dials at the right of the panel controls the variable condenser VC2, which is shunted across the oscillator inductance "L," functioning in the well-known Hartley fashion. Of course it is understood that VC2 is so adjusted that the closed resonant circuit L-VC2 is tuned to the same frequency for which the quartz crystal has been ground. Whenever the condenser VC2 is changed, in order to tune this circuit to a frequency in a different band, another quartz crystal, calibrated for the approximate value of the new frequency or wave-length, is placed in the temperature-controlled receptacle housing the crystal.

The second variable-condenser dial, appearing at the right of the panel, is used for the purpose of tuning the quartz crystal; and certain "plus" or "minus" corrections or adjustments in the frequency to which the crystal responds are thus made by means of this dial. In other words, the quartz crystal is ground and "lapped" in the laboratory until it is brought to the proper size, corresponding to the desired frequency. But, if it does not respond naturally to that exact frequency, it may be made to do so by carefully adjusting the variable condenser dial VC.

As the diagram shows, the output of the amplifier may be taken from either the first or the second stage. A "C" bias is placed on the grids of both amplifier tubes, as indicated; and the grid circuits of these tubes are coupled to the Hartley-oscillator inductance "L," by the coil L1.

The output of either of the amplifier stages of the oscillator set-up, is in the form of a "*sinusoidal*" or alternating current, the frequency of which is maintained to an astonishingly high degree of accuracy. One of the problems met, in maintaining constant the frequency with such a quartz-controlled oscillator, lies in providing a very stable and constant grid-leak resistor; for this particular circuit there has been developed a resistor of new type which will not vary as much as 0.1 per cent. Fluctuations or variations in the battery voltage are an important source of trouble; but these voltages are now maintained sufficiently constant, with a plus or minus variation of about 2 per cent. The variation in the oscillator's frequency from this cause is only about three parts in 10,000,000. It is also possible to compensate the circuit; so that variations in voltage will result in offsetting a change in frequency in one direction by setting up an equal and opposite reaction.

Regulating the Heat

Referring to the detailed illustration of the quartz crystal and its mounting, the crystal vibrates along the longitudinal axis, or line of its greatest length. It is separated from the metal plates by silk threads, which also support it. Within the balsawood box which houses the crystal, the temperature must be kept the same at all times, within 1/20th of a degree (F.), in order to reduce frequency variations due to the heat of the crystal (and its consequent changes in size) to *one part in ten million.*

(The frequency of the crystal is affected also, slightly, by changes in atmospheric pressure; as explained in a paper presented to the Union of Scientific Radio Telegraphy at Washington, Oct. 13, 1927, by J. W. Horton and W. A. Morrison.)

The quartz crystal in its mounting (as shown in the picture) is placed within a steel cylinder which (see Fig. 3) has hollow walls within which mercury is placed. Whenever the temperature rises it causes the mercury to expand into a "capillary" (very fine-bore) tube which contains an electrical contact of tungsten wire. At the predetermined point, the mercury reaches the tungsten wire and operates a relay, opening the circuit through a heating coil wound around the outside of the steel cylinder. When the temperature falls sufficiently, the heating circuit is again closed. By this means the temperature in the cylinder is kept very uniform.

The cylinder with the mercury-filled wall has lids at top and bottom; and this miniature "safe" with its crystal, which may be indeed called a precious stone (it is "rock crystal," the same mineral of which many of the "diamonds" you see in cheap jewelry are composed; but the value is in its careful cutting and adjustment) is placed in a balsa-wood box for protection against external changes of temperature. The box is visible, in the panel view of the oscillator apparatus, as the square object above the panel in the center of the apparatus. The entire assembly, with the oscillator-panel, inductance, amplifying tubes, ventilating fan, etc., is in turn placed within a larger closed cabinet; the air in which is regulated to a constant temperature by a thermostatic apparatus.

From Fig. 2 it will be seen that a resistor is connected in series with the "B" plate supply to the oscillator tube, to keep the plate voltage on this tube at a low value. This is for the reason that some energy is dissipated within the crystal; and the energy dissipated

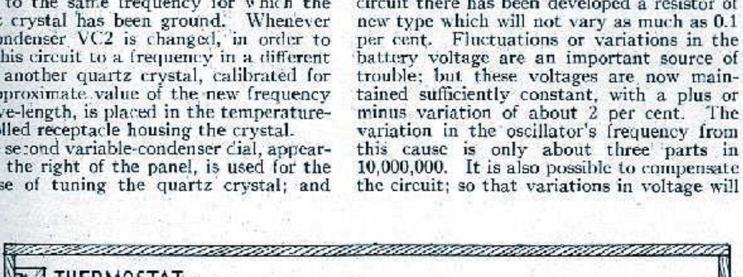


Fig. 4—Elaborate precautions are taken to keep the crystal at an even temperature, by a double system of thermostatic control.

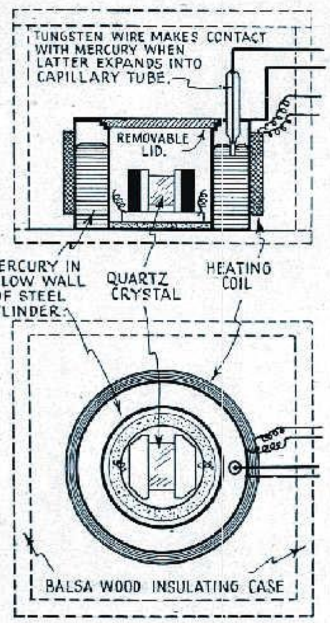


Fig. 3

The quartz crystal is kept inside a jacket of mercury; the slightest change in the temperature of which makes or breaks the electrical circuit of the heating coil, and thus keeps the temperature even.

The schematic hook-up of the crystal-controlled oscillator circuit and the amplifier which it regulates; the condenser, VC, permits very slight changes in the adjustment of the oscillator's frequency. VC2 tunes the principal inductor of the Hartley circuit, which is coupled to the amplifier-tube grids through the pick-up, L1. The output is a true alternating current of very constant frequency.

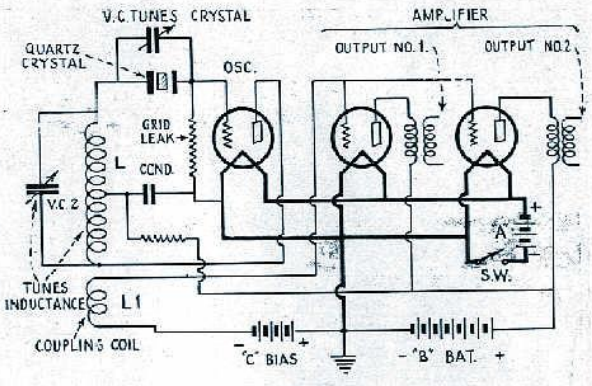


Fig. 2

varies approximately as the square of the plate voltage. This phenomenon is important with regard to the system maintaining constant the temperature of the crystal when in operation; for it will now be seen why the temperature of the crystal is not exactly that of the air surrounding it.

Recently, Dr. E. F. W. Alexanderson and his associate engineers of the General Electric Research Laboratories have demonstrated a simplified form of television apparatus, which comprises practically the same photoelectric cells, revolving perforated discs, etc., that are used in the Bell system, but with the advantage that the need of a synchronizing circuit or wave-channel has been eliminated. (See April, 1928, *Radio News*.) The synchronizing problem, in this case, is solved (or rather obviated) by utilizing an ordinary 60-cycle A.C. motor; and, whenever a variation in the motor's speed or any change in the alternating current's frequency occurs, the speed of the motor and its attached disc is corrected by simply pushing a button, which accelerates the motor. As the motor speed must be corrected continuously, this is evidently not the ideal solution of the synchronization problem in television.

Vacuum Cameras to Speed Up Television

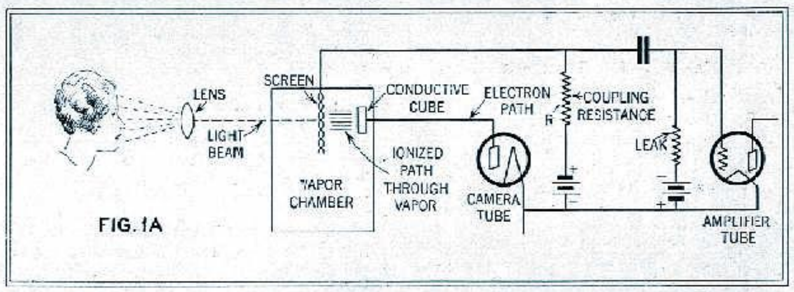
Fast Work

SUPPOSE, for example, we wish to send an image 10 inches square, which contains, of course, 100 square inches. To have the detail of the resulting image of an ordinary printed magazine quality, there must be provision made for, say, 14,000 variations per square inch in light and shade to be changed into electrical impulses. That means 1,400,000 impulses per picture, or at least 14,000,000 impulses per second for a moving picture; each impulse resulting in a light flash for *one fourteen-millionth part of a second.* The eye wouldn't see this flash at all and, although the pictures were faithfully sent and recorded, to the eye the screen would be perfectly blank. In recording a "fast-motion" picture, such as requires a 1/100-second exposure instead of 1/10, the condition would be the same—only more so! says R. P. Clarkson in *Radio News*, page 22, for July 1928.

How can this apparent stumbling-block be overcome. My suggestion, in the apparatus described in this article, is to use for the light-flash, not a neon lamp or anything of the sort, but the impact of a stream of electrons on a screen of material which is *not only "fluorescent," but also "phosphorescent."* In other words, to use a screen which not only glows when struck by electrons (as in an oscillograph) but one *which will continue to glow* after the stimulus has ceased. Not only will this make visible a short impulse but, also, it makes possible the use of less intensity of the glow in order for the eye to be stimulated. It will also lend itself to the blurring of the successive dots of light into each other to imitate more nearly a photograph.

Scanning Apparatus

Now, as to dividing the image up into 1,400,000 dots or impulses in one-tenth of a second, no device yet suggested can begin to approach that task. The Nipkow disk with its spiral openings (patented by the inventor in 1884) whether of the original form as used by Alexanderson, with lenses in the openings as used by Baird, with slits as suggested by Rothschild, or in the form of whirling optical plates as Jenkins makes it, is perfectly useless for this purpose; not only because of the limitation on the speed of mechanically-moving parts, not only because of the limitations of size to make room for enough holes, but also because of light limitations, as sufficient light won't pass through the holes. Last, but not least, there is the impossibility of synchronizing the transmitting and receiving disks at that speed.



Simplified schematic drawing, showing arrangement of the various components of the television apparatus proposed by the author.

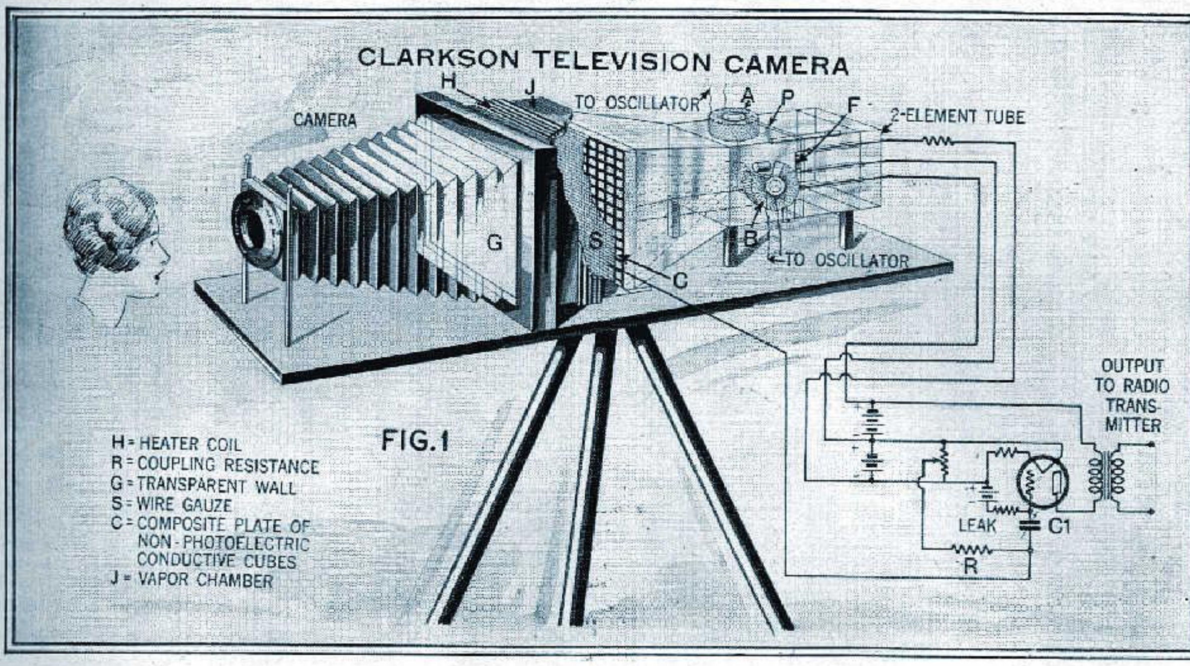
The only answer I know to this problem is the use of a *weightless beam of electrons moving under the influence of a changing magnetic field.* This is the type of image-scanning device I have suggested in the television camera and projector. To secure a changing magnetic field of any frequency is a simple problem, readily solved by means of a generator or an audio-frequency oscillator.

The Clarkson Camera

The theory is simple. Certain vapors and certain liquids, too, are more conductive in light than in darkness. One of these fluids is sodium vapor, familiar to all by having been used in the Donle tube. In the vapor chamber of the television camera (Fig. 1) we may have sodium vapor, and the temperature of the chamber may be regulated by the heating coil H. The wall G of the tube is of transparent material, preferably quartz, and an image may be at will focused on the composite plate C, which is simply a number of insulated, conductive wires or cubes. It may be a bakelite plate in which are embedded small conductors.

In front of the composite plate is a screen S of metal wire, which not only divides the light into rays when an image is projected on the plate, but acts also as a terminal in contact with the vapor.

At the other end of the camera tube is a concentrated filament, or cathode F and a plate, or anode P, which has a tubular opening. With proper plate voltage a flood of



What the television "camera" of the future may look like. P and F are plate and filament, respectively, of the electron-projecting tube. A and B are the coils whose magnetic fields influence the electrons which stream through the opening in P.

electrons shoots from the cathode to the plate a stream of them passes at high speed through the tubular opening, creating a narrow beam which impinges on the back of the composite plate C. This beam is really a flexible, weightless conductor, *an electric current without a wire*. It has around it a magnetic field, like any other conductor, and any magnetic field of the coil A will attract or repel the field of the electron beam, thus moving the beam itself.

The Pencil of Electrons

If we put an alternating current in coil A the weightless beam will move back and forth vertically in unison with the coil frequency, as it has no inertia. This coil frequency is, say, only 5 cycles per second. Then the beam will go back and forth across plate C five times a second or, in other words, will cross plate C ten times per second.

In the same way, and at the same time, coil B is moving the beam horizontally, say, 1,000 times a second, or across the plate C up and down 2,000 times in each second.

The distance moved horizontally or vertically depends only on the *strength* of the coil field, which may be changed by moving the coils towards or away from the tube, or by changing the current in the coils.

Now, with arrangements of the frequency stated, the beam will go up 100 times and down 100 times for each trip across plate C. If the distance across the plate is 8 inches, the beam will, in effect, draw 25 vertical lines on plate C for each inch of width. If the conductive portions are properly divided and positioned, the beam will hit each one of them once in this journey across the plate.

The Circuit

Suppose the beam strikes a conductive portion of the plate C which happens to be strongly illuminated by the rays of light falling through the screen S upon the other side of C. Then some of the electrons will travel along the ionized path of the light ray in the vapor, from that conductive section of C to the screen S; and a current will flow around through the resistor R and back to the cathode F along the filament wires, the beam itself and the conductive path in the plate completing the circuit. The screen S may have a positive potential bias to aid this action.

The current which flows around this path is determined by the conductivity of the vapor path along the light ray between plate C and screen S at each conductive point. This, in turn, will depend on the intensity of the light ray at that point. Thus, as the electron beam sweeps over or "scans" plate C, there is created a varying current through resistor R depending on the intensity of the image at different points. This variation in current will cause a varying potential across resistance R and this is the potential applied to grid and filament of the amplifying tube. The condenser C1 permits the grid circuit of the tube to be adjusted to its best operating point. The output of the tube may be amplified and used to modulate a carrier wave. (See Fig. 1a for details of the circuit.)

The Projector

Then, at the receiver, the amplifier output goes into the projector tube (See Fig. 2) which operates like any radio vacuum tube. The grid G is heavily biased negatively. Thus no electrons escape through the tubular opening in the plate P. When the varying signal impulses come through, however, this bias is counteracted and through the tubular opening passes an electron beam varying in intensity with the received signal.

Here again we have two coils at right angles, having the same frequencies as the coils of the camera tube and in phase with those frequencies. When the camera beam is at the top, the electron beam of the projector is at the top. When one is at the left, the other is at the left also. The relative position of the end of the projecting beam on the phosphorescent viewing screen of the projector is the same as that of the camera beam on the plate C in Fig. 1.

This viewing screen is phosphorescent and is swept or "scanned," just as plate C is scanned. When the electron beam strikes this phosphorescent screen, it "luminesces" or lights up at that point and the path of the beam on the screen becomes visible; the light and shade from instant to instant depending on the intensity of the beam. This instantaneous intensity is proportional to the received signal and, therefore, proportional to the intensity of the light and shade of the image points on plate C of the camera. Thus an image is projected, point by point and line by line, on the phosphorescent screen in the projector.

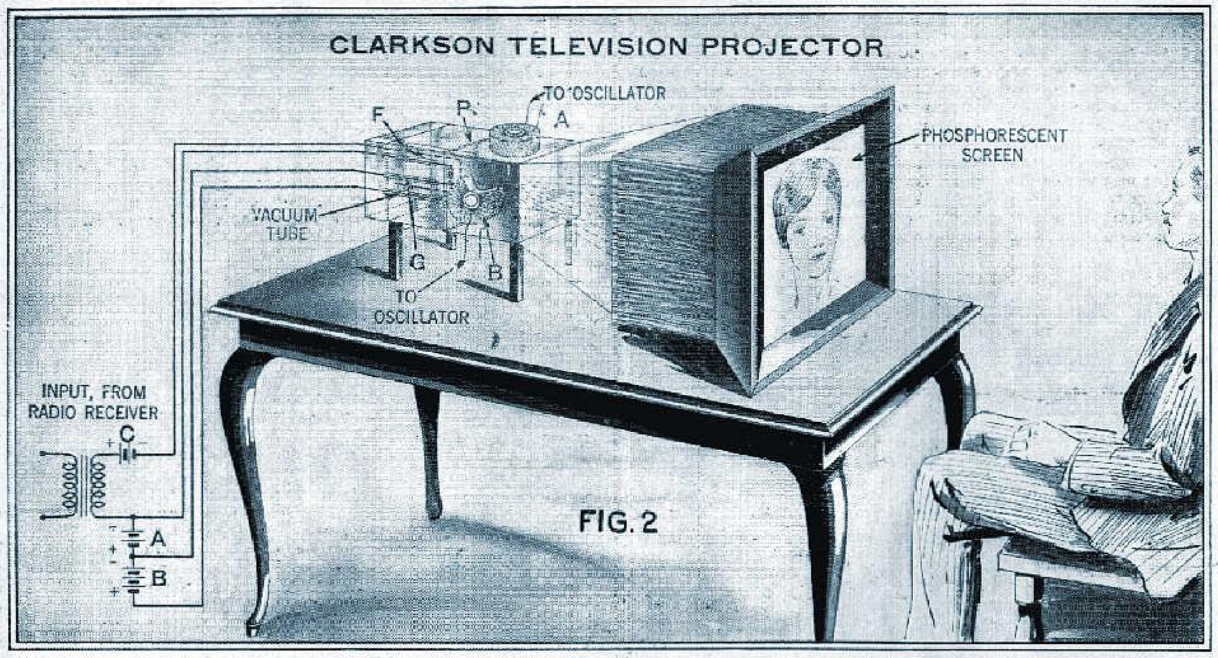
This image is readily visible in the partial darkness caused by the hood over the screen and may be larger or smaller than the original image; one way of changing the size being to move the phosphorescent screen in or out. The image may be applied to a film running through the vacuum tube by means well known in the oscillographic art; or it may be projected by prisms from the luminescent screen upon the wall of the room.

Speed of the Electrons

The electron beams may be moved at any speed and have been known to record a frequency as high as 220,000,000 cycles per second. Thus any speed of transmission is possible. Any sluggishness in the passage of the current through the vapor will have no effect on the image; as it will be uniform sluggishness all over the plate C. In fact, selenium may be used for the conductive portions of plate C (though not when potassium vapor is used) and thus an added variation in the current impulses produced by the effect of light and shade on plate C, will be obtained.

There are many incidental advantages in the apparatus which has been described but, in one particular, it gives rise to hopes that have never been dreamed of before; and that is, of a reproduction comparable to a "half-tone." In no other method is this even conceivable; for the reason that, while gradations of light and shade may be obtained, all of the dots reproduced are of the same size and shape. With the projector shown in this article, the reproducing beam varies in intensity, in number of electrons, *and thus in size*, under proper conditions. Intense beams will cause large dots and less intense beams small dots, and thus a graduation of the pictures may be expected.

It is the feeling of the editors that this idea of using a stream of electrons will one day be perfected by some genius. It is not the most perfect nor the most desirable method which involves the use of motors and revolving perforated discs. In the first place the picture is not perfect and the apparatus is limited to the transmission and reception of small images.



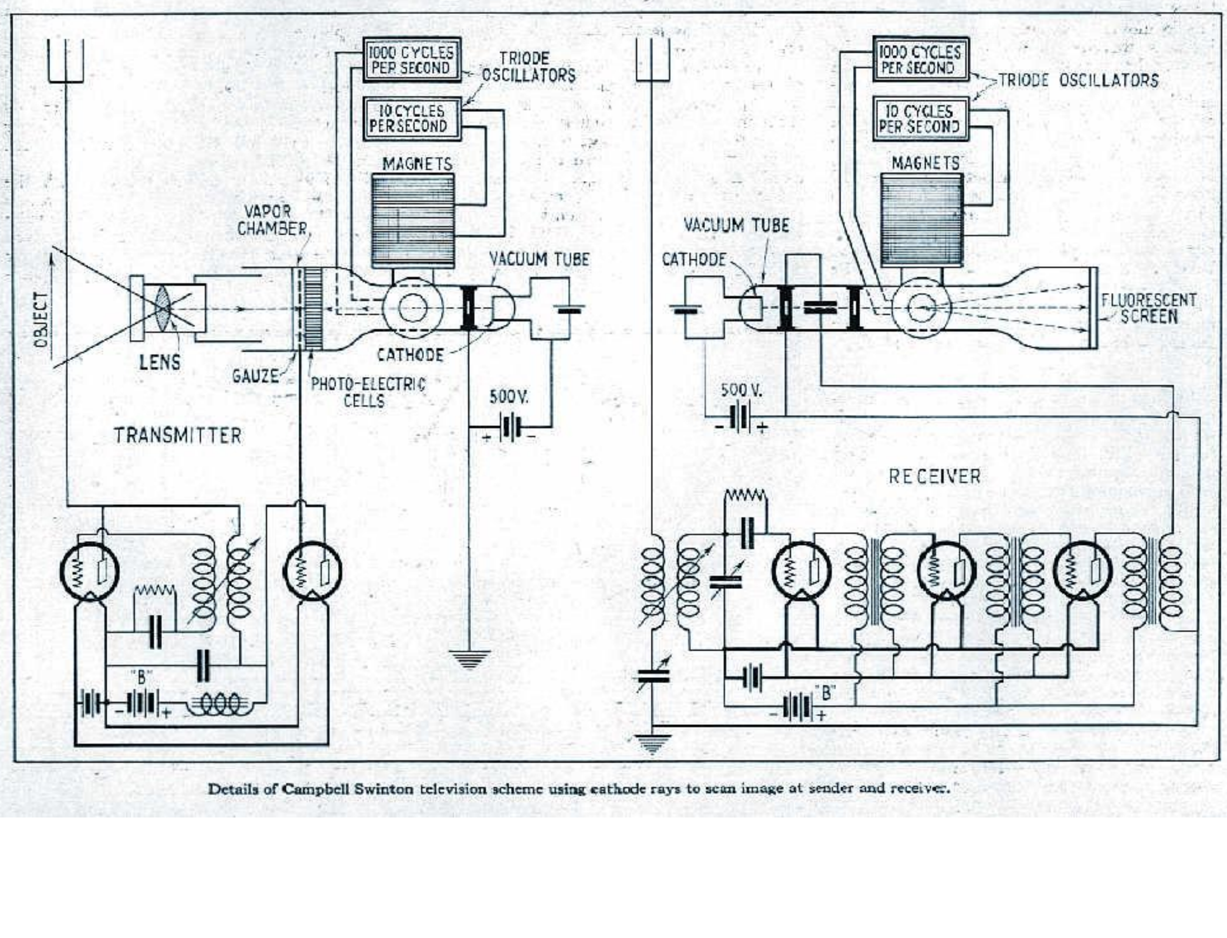
The receiving televisor, similar in construction to the transmitter, makes use of an identical two-element electron-projecting tube. The image will appear on a phosphorescent screen. There are no moving parts at either end, except the electrons. The idea seems very promising indeed.

Campbell Swinton Television System

THE diagram shows my apparatus, both for transmitting and for receiving, as figured in my paper of 1924, but modified as employing triode thermionic oscillators instead of rotating dynamo machines.

At both ends the two cathode-ray beams impinge on screens, which they are caused by the deflecting systems to sweep over rhythmically and in complete synchronization in parallel lines backwards and forwards from end to end.

The Photo-electric Screen. In the transmitter the screen is composed of a very large number of minute photo-electric cells which are each activated, more or less, by the amount of illumination each receives from the image thrown upon the whole screen by the lens. The end of the transmitting cathode beam explores each of these cells in turn, and as to whether it finds it illuminated and thus activated or not, an electric impulse of varying intensity, proportional to the amount of local illumination, is transmitted to the neighboring gauze grid.



Details of Campbell Swinton television scheme using cathode rays to scan image at sender and receiver.

The varying electric current thus originated, after amplification and conversion into wireless waves, is transmitted to the receiver, where after further amplification and detection, it varies the strength of the receiving cathode-ray beam, which, in turn, affects the brightness of that particular portion of the fluorescent screen on which the end of the cathode beam is at that instant impinging.

Thus on the receiving fluorescent screen a replica of the picture thrown by the lens on the transmitting screen is reproduced.

This is a patent applied for by the Westinghouse Electric & Manufacturing Company, of the U. S. A., the convention date of which is July 13, 1923, and the complete specification of which was accepted on March 31, 1927. In this, where a gauze grid is employed, and a large number of very small photoelectric cells, similar to my suggestions of 1911 and 1924, the cells are composed of minute globules of specially prepared potassium hydride in an atmosphere of argon.

The specification, which is a very interesting one, gives full particulars, and should be studied in detail by anyone who wishes to understand Zworykin's ideas. Further, it contains the new suggestion that, by inserting both in the transmitter and in the receiver mosaic three-color screens, like those used in autochrome color photography, colored pictures could be transmitted and reproduced, this extra complication increasing the difficulty of success by three times, inasmuch as three times the number of granulations would be required to form the received image of any desired quality in color instead of in monochrome.—*Modern Wireless* (England).

New Jenkins Radio Movies

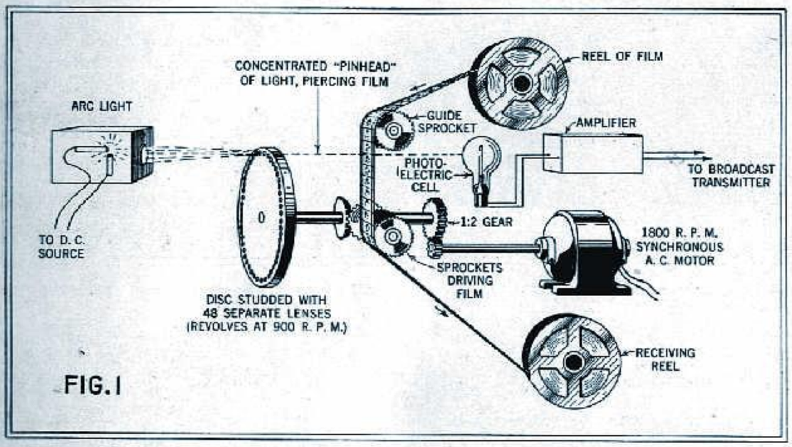


FIG. I

The transmitter of the new Jenkins Radio Movie System.

EARLY in May of this year, C. Francis Jenkins, the noted radio inventor, demonstrated in Washington, D. C., his latest system of radio photography, or rather "radio movies," as he prefers to describe it. Using a wavelength of 300 meters, in the regular broadcast band, he transmitted a number of reels of specially-prepared, standard-size motion-picture film, while members of the Federal Radio Commission and a number of other nationally prominent individuals looked on. The original film showed, in black and white silhouette, a little girl bouncing a ball, dancing and kicking into the air. It was reeled off in front of the radio-movie transmitter at the rate of 15 pictures per second, the pictures at the receiving end being reproduced at the same rate. The images seen through the observing lens at the receiver were, apparently, about six inches square, and remarkably clean cut, says an article in *Radio News* for August 1928.

The Jenkins Transmitter

In Fig. 1, the essential parts of the transmitting apparatus are shown in approximately the positions they occupy in relation to each other. The film reels are arranged on a simple framework, one above the other, in such a manner that the film is pulled vertically downward by a set of sprockets which are, in turn, driven by an electric motor. One end of the shaft which drives the sprockets is fitted with a gear meshing with another of only half its size. The small gear is attached directly to the shaft of the motor, which is a synchronous alternating-current machine developing 1,800 revolutions per minute. Because of the reducing action of the gears, the pictures are pulled past the sprockets, or past any fixed point next to the film, at the rate of 900 per minute, or 15 per second.

At the other end of the sprocket-driving shaft is a heavy metal disc, about 15 inches in diameter and about one inch thick; its edge is studded with 48 separate little lenses, each having an "optical speed" of *f.* 3.5. Each lens is designed to concentrate the light from a powerful arc lamp into an intensely-brilliant "pinhead" beam, which is caused to pierce the film as the latter travels down past the back of the disc.

Directly behind the film is fixed a sensitive photoelectric cell, so placed that it receives the "pinhead" beam of light projected through the film by each lens. The cell is connected to a three-stage resistance-coupled amplifier, and that in turn to an eight-stage amplifier of similar design. To prevent the amplifiers from picking up external disturbances of various kinds, which would be registered as part of the pictures, Mr. Jenkins has buried them under double copper shields. The photoelectric cell itself is also completely sheathed in copper, except, of course, for a small aperture which is left to admit the light beams. The eight-stage-amplifier shield is fully the size of an ordinary business desk.

Scanning the Picture

A close study of the apparatus will make its operation clear. The disc is revolving at the rate of 900 revolutions per minute, or 15 per second. The separation between the centers of the lenses is just equal to the width of the film. The film moves steadily down at the rate of 15 pictures per second (its action is not jerky, as in a moving-picture projector).

Forty-eight separate beams of light travel across each individual picture on the film, this operation consuming one-fifteenth of a second.

The Receiving End

The Jenkins receiver is altogether different from any of the other television and picture machines now in existence. It consists of six essential parts, arranged as shown in Fig. 2. The heaviest unit is a 3,600-r.p.m. synchronous A.C. motor, to the shaft of which is attached a hollow metal drum about seven inches in diameter and about five inches wide. The center of this drum is a hollow spindle with a thin wall.

In corresponding places on the drum and the spindle (both outer and inner surfaces) are four spiral rows of tiny holes, twelve holes to a row. A short piece of quartz rod between the outside and inside connects each pair of corresponding holes. The purpose of the 48 little rods is to conduct light from the inner spindle to the holes in the outer drum with as little loss as possible.

Fixed inside the hollow spindle, with the flat little plates facing directly upward, is a special four-"target" neon tube. This tube is similar in general operation to the standard flat-plate neon tubes now sold generally for television purposes, but is in reality a quad-

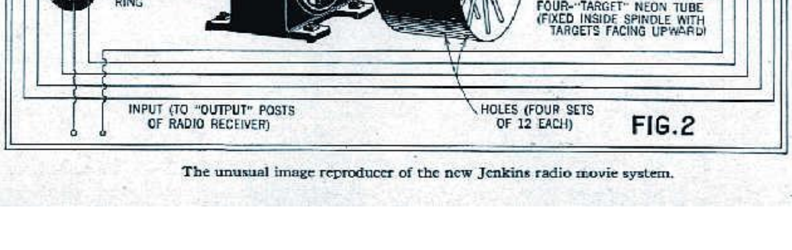


FIG.2

The unusual image reproducer of the new Jenkins radio movie system.

ruple tube. It is about four inches long and one inch in diameter, the little plates or "targets" being about ¼-inch square.

The other end of the motor shaft is fitted with a 1:4 reducing gear which drives a revolving switch. The revolving element is simply a pair of contact brushes connected together; one brush effects continuous electrical connection to a solid brass ring imbedded in an insulating disc, while the other makes a wiping contact over the four sections of a split ring. The four segments connect with the four targets of the neon tube, while the solid ring goes to one of the input posts of the machine. The common element of the neon tube goes to the other input post.

Above the top of the revolving drum is a square opening in the top of the cabinet; over this opening an ordinary mirror is mounted at an angle of 45 degrees to the top. About a foot in front of the mirror, standing upright, is a magnifying glass about ten inches in diameter.

The input posts of the picture receiver unit are connected to the last audio amplifier tube of a regular receiver. For his demonstrations Mr. Jenkins used a popular one-dial receiver with an additional power amplifier stage.

Now let us follow through the operation of the receiver: the modulated signal of the transmitter is picked up by the aerial, amplified, detected and again amplified by the receiver, and then led to the "radio-movie" projector. Let us assume that the contact brushes have just made contact with the upper right ring, as shown in Fig. 2, and that one of the quartz rods in the first (outermost circle) is pointing straight up. This condition corresponds with the start of a picture in the transmitter, just when the pinhead of light is starting to sweep across the film.

As the contact brushes have just closed the circuit to the neon-tube plate at the extreme right, this "target" lights up immediately and fluctuates in accordance with the modulation of the signal. The fluctuations of light are carried up the quartz rods and projected through the holes in the outer drum upon the mirror. The light thus produced on the mirror follows the shading of the images on the original film, so that a picture is built up in the mirror. This may be observed through the magnifying mirror.

A complete picture of 48 lines (corresponding to the rate of transmission) is built up on the mirror with every four revolutions of the drum. At the beginning of the second revolution, the contact brushes turn to the next segment of the switching ring (because of the gearing) and the second target of the neon tube is illuminated. The drum revolves the third time and the third quarter of the picture is built up, with target No. 3 lit; then the contact brushes shift to the fourth target, and the fourth and the last quarter is built up. On the fifth revolution target No. 1 is again lighted, and the first spiral of holes builds up the first quarter of the second picture. During one second the drum turns 60 times; since four revolutions create one picture, 60 revolutions create 15 pictures. This gives us the speed of 15 pictures per second mentioned in the early part of this article.

Of course, it is necessary to maintain perfect synchronism between the transmitting and receiving motors, as in all systems of television and radio photography. In the Washington demonstrations the transmitter and the receivers were on the same power line, so little difficulty was experienced in keeping the pictures steady.

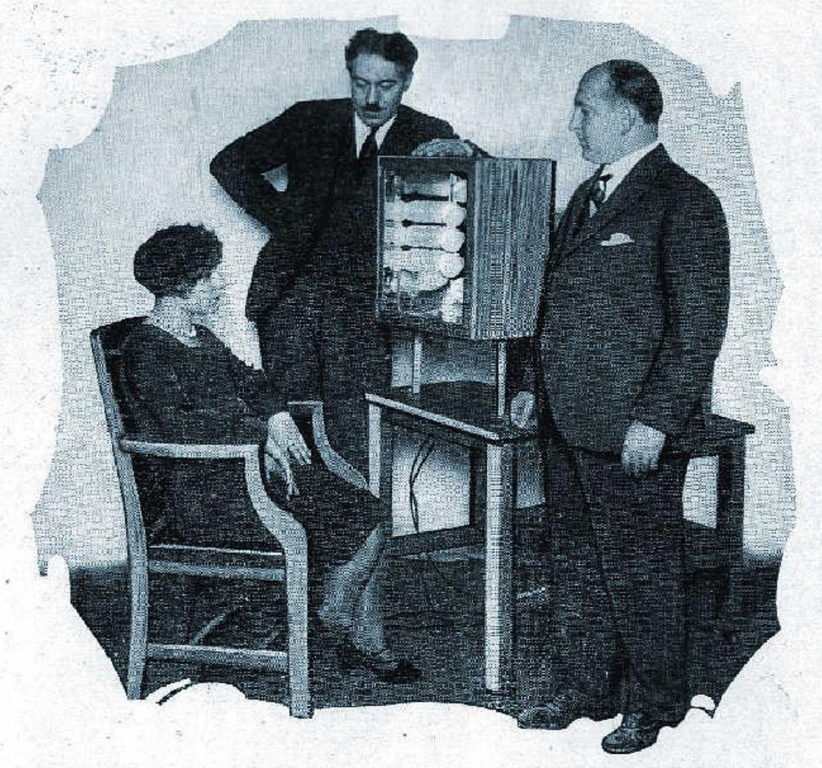
The pictures, as they appear through the magnifying lens at a distance of about ten feet, are clean-cut black silhouettes against the characteristic reddish glow of the neon tube. They possess no fine shading; as such refinement is not possible without the use of a very wide band of frequencies at the transmitting end.

Practical Demonstrations Scheduled for WRNY

WITHIN a short time after the appearance of this issue of *Television*, the first television broadcasting experiments to be conducted by an American broadcast station, on its regular wave in the 200-500-meter band, will be made over WRNY, New York City. This pioneer work will be done under the direction of the writer, Theodore H. Nakken, with apparatus of his own design and construction, according to his article in *Radio News* for July 1928, page 20. The plan is to give an initial demonstration of the system in the Hotel Roosevelt, New York, where the studio of WRNY is located. A television transmitter, or "televisor," will be installed here; and the image of a person will be broadcast on the 326-meter wave of WRNY from the transmitter proper, which is situated at Coytesville, N. J. A receiving set with a televisor attachment will be in operation in a room in the hotel, where the received images will be observed by the editors of *Radio News*, a group of newspaper men and a number of scientists.

The object of the whole undertaking is to demonstrate the practicability of radio television, on the regular broadcast channels, with comparatively simple transmitting and receiving apparatus. Although the writer does not claim he will be able to provide images of great sharpness, their definition will at least be great enough to make them readily distinguishable to the human eye. The degree of distinctness is limited by the fact that broadcast stations must keep their radiated waves within a 10,000-cycle band; which means that a carrier-wave (920 kilocycles in the case of WRNY) can be modulated by impulses up to only 5,000 cycles in frequency.

The receiving apparatus necessary for the reproduction of the televised images will be of such comparatively simple construction that any radio experimenter, given the few essential components that he cannot make himself, will be able to assemble a complete instrument in a few evenings. The receiving televisor will form an independent unit, and will be equipped with a cord which will connect to the regular output posts of the broadcast receiver.



How a person would be "televised." Mr. Nakken, the author, is standing behind his apparatus. At the right is Mr. I. Goldberg, president of the Pilot Electric Mfg. Co., makers of the televisor.

Announcements

In the present state of affairs, it will not be possible to receive both broadcast voice or music and the television images at the same time, because the electrical impulses carrying either will occupy the full legal "channel" of the transmitting system. First the WRNY announcer will speak, and then the television broadcasting will commence. There will be a slight pause between the end of the speech and the start of the televisor, to enable the listener to disconnect his loud speaker and to hook on the televisor or receptor. If the speaker is left in the circuit it will emit a confused babble of totally-meaningless noises.

To start with, only faces will be transmitted. The received images appearing on the screen of the televisor will be about two-and-a-half or three inches square, and will appear at the rate of ten per second. This speed is enough to produce the illusion of motion. The minimum number required to produce this effect is eight pictures per second. Because of the inherent limitations and legal requirements of broadcast transmitters, there is little possibility of enlarging the images with pleasing results.

Synchronism

Both transmitting and receiving televisors will employ revolving discs. The all-impor-

MR. THEODORE NAKKEN, the author of the accompanying article, is a prominent radio engineer and inventor, and the holder of what is probably the most important patent in the television field. This patent, No. 1,522,070, reissue No. 16,870 (February 7, 1928), was granted for means of transforming light impulses into electric-current impulses, and covers all practical arrangements of elements and circuits for such transformation. It will, in all probability, be the subject of a great deal of legal controversy.

This article, the first of a number by Mr. Nakken, heralds a series of practical television demonstrations through the Radio News broadcast station, WRNY, New York, on its regular 326-meter wavelength. The subsequent articles will describe the transmitting equipment in detail and will tell how the radio fan can make his own television receiver.

tant problem of synchronizing them is solved by the use of a manual control at the receiving end. In other words, the operator of the receiving set will adjust the motor by means of a simple regulator (and visible indicator), and thus attain the adjustment that gives the best results. It is not feasible to use synchronous alternating-current motors for general television work, because the motors running televisor transmitters will not be fed by the same power systems that feed receivers in distant districts.

The actual television transmitting apparatus has been practically completed, as the accompanying illustrations show. The model receiver was still in "breadboard" form when this article was being written, so it could not be photographed. However, a detailed description of it will be published in a forthcoming number of *Radio News*, after it has undergone thorough tests both in the laboratory and in practical service.

Operation

The television transmitter is made mostly of wood, and stands about five feet high, three feet wide, and about four feet deep. The legs are fitted with casters, so that the whole machine may readily be moved from place to place. As a subject prepares to be "televised," he or she merely sits down in front of the "illuminator," shown below this. It is a square box fitted with twelve 50-watt lamps and a highly-polished reflector. Directly behind an opening about six inches square in the latter is a very "fast" lens (f. 1.5) which concentrates the image of the subject on the revolving disc behind it, which is pictured separately at the lower right. The disc's driving motor, which is not shown, will be placed on the baseboard in the immediate foreground.

Behind the perforated disc is a small box containing a photo-electric cell and a three-tube amplifier. As the disc revolves and allows the reflected light from the subject's face to pass through the small holes, one at a time, into the cell, the latter translates the light impulses into electrical impulses, which are led to the broadcast transmitter. (A close-up of the photoelectric cell unit appears in the panel above; the cell is the large round bulb at the left; the square opening in the steel can allows the light rays to affect the cell in the proper manner.)

In his next article, the writer will discuss his television transmitter, the amplifier and the exact method of putting the images "on the air."

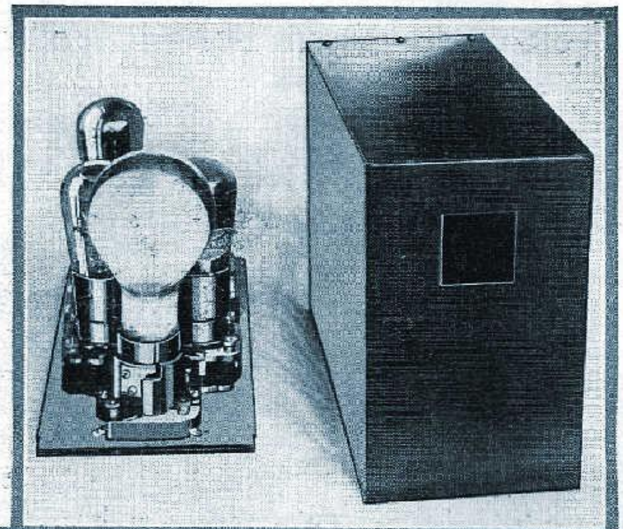
(On the very closing day of this number of Television, an announcement was made by the General Electric Company that station WGY, transmitting on its regular 380-meter wave, would commence broadcasting television programs on a regular schedule. The pictures will be sent from the WGY laboratories in Schenectady, N. Y., on Tuesday, Thursday and Friday each week, between 1.30 and 2.00 p. m., Eastern Standard Time.

Only the faces of men talking, laughing or smoking will be broadcast, the announcement said: no elaborate effects are planned at this early stage.

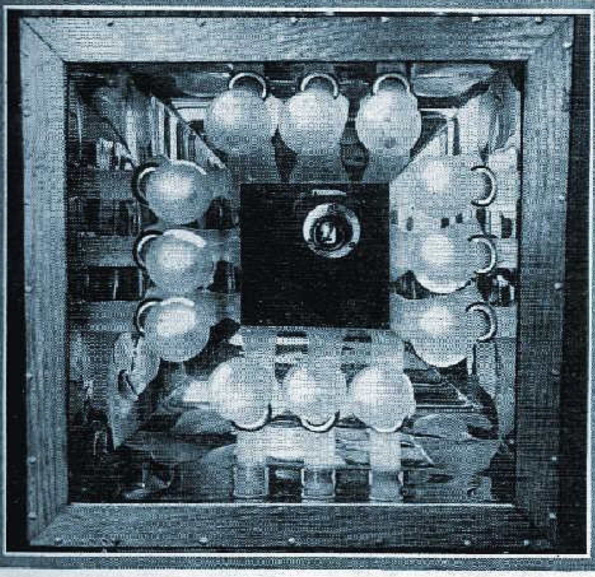
The regular schedule of transmission is designed primarily to assist engineers in the development of a reliable and complete television system; but, since the signals may be picked up with ordinary broadcast receivers, amateur experiments may readily use them for the testing of television apparatus of their own construction.

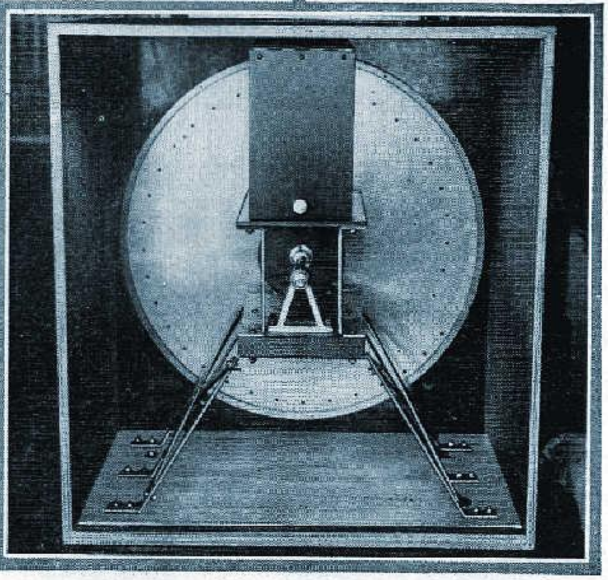
As heard from the loud speaker, the television signals have an intermittent, high-pitched whirr; the pitch varying with the action before the transmitter. This description is contained in the announcement.

The television transmitting apparatus is a modification of the Alexanderson machine described in the April 1928 number of Radio News. No information on the construction of receivers suitable for the reproduction of the broadcast images was available at the time this number of Television closed; but, as soon as the data can be presented in useful form, Television will publish them.—Editor.

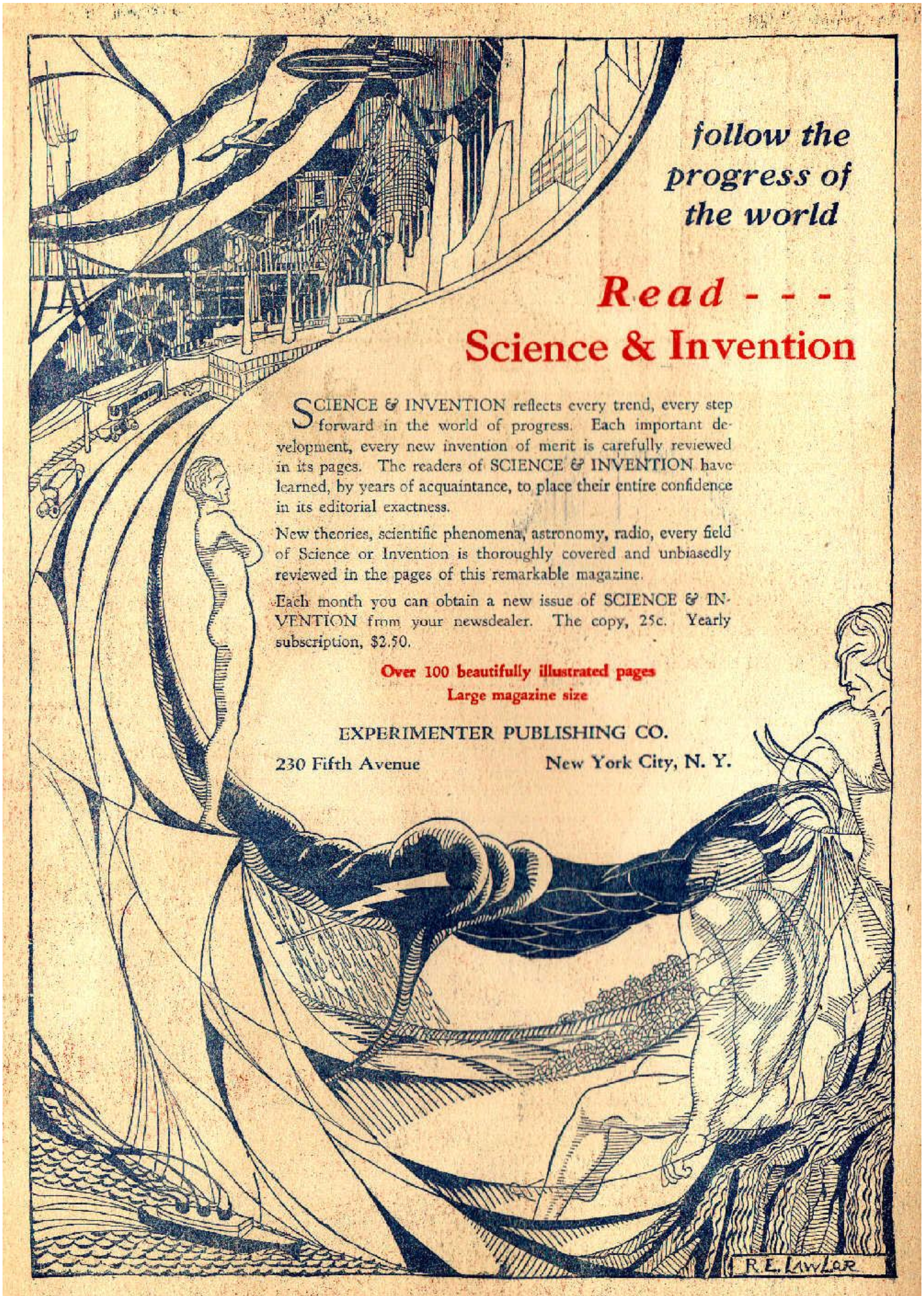


The photograph at the left shows the photoelectric cell and amplifier tubes. These are mounted upon a baseboard, over which fits a heavy metal shield shown beside the tubes. This shield is grounded and has a small opening allowing the light rays to enter and strike the cell. The photoelectric cell is the large bulb mounted on the forward part of the baseboard.





Top: The photoelectric-cell unit, removed from its metal container. The cell itself is the pear-shaped bulb in the foreground, the other tubes being A.F. amplifiers. Left: What you would look at if you were being "televised." The round object behind the reflector is a lens. Right: The back of the televisor, showing the photoelectric cell's can behind the revolving disc. The driving motor (not shown) fits on the baseboard.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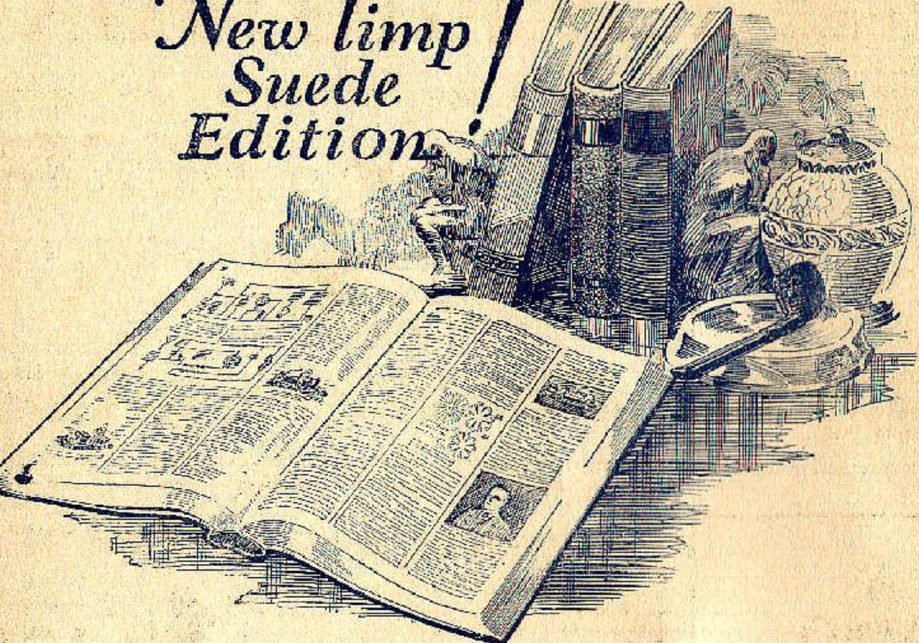

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