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If you are in need of certain small radio parts that other radio and mail order houses do not bother to carry, get the Rasco Catalog and you will find the small parts there. Anything from a screw to copper ribbon, telephone diaphragms, as well as thousands of other small radio findings. Just to mention a few:

Lugs, nuts, jacks, plugs, all kinds of knobs, cords, panels, screws, slides, washers, selenium, tinfoil, switches, crystals, cap nuts, Litz wire, cord tips, brass rods, resistances, binding posts, switch parts, carbon balls, switch points, lock washers, carbon grains, ground clamps, metal pointers, insulated tubing, low melting metal, antenna connectors, as well as thousands of other articles. We carry the Largest Variety of Small Radio Parts in the World, BUT WE also carry All Standard Radio Merchandise.
I Thought Radio Was a Plaything

But Now My Eyes Are Opened, And I'm Making Over $100 a Week!

$50 a week! Man alive, just one year ago a salary that big would have been the height of my ambition.

Twelve months ago I was scrapping along on starvation wages, just barely making both ends meet. It was the same old story—a little job, a salary just as small as the job—while I myself had been dragging along on starvation wages, just barely making both ends meet. It was the same old story.

If you'd told me a year ago that in twelve months' time I would be making $100 and more every week in the Radio business—wheel! I know I'd have thought you were crazy. But that's the sort of money I'm pulling down right now—and in the future I expect even more. Why only today? But I'm getting ahead of my story.

I was hard up a year ago because I was kicking myself, that's all—not because I had to be. I could have been doing the same sort of job I'm holding now, if I'd only been wise to myself. If you've fooled around with Radio, but never thought of it as a serious business, maybe you're in just the same boat I was. If so, you'll want to read how my eyes were opened for me.

When broadcasting first became the rage, several years ago, I first began my dabbling with the new art of Radio. I was "nuts" about the subject, like many thousands of other fellows all over the country. And no wonder! There's a fascination—something that grabs hold of a fellow—about twirling a little knob and suddenly listening to a voice speaking a thousand miles away! Twirling it a little more and listening to the mysterious dots and dashes of steamers far at sea. Even today I get a thrill from this strange force. In those days, many times I stayed up almost the whole night trying for DX. Many times I missed supper because I couldn't be dragged away from the latest circuit I was trying out.

I never seemed to get very far with it, though. I used to read the Radio magazines and occasionally a Radio book, but I never understood the subject very clearly, and lots of things I didn't see through at all.

So, up to a year ago, I was just a dabbler. Of course I had read about the new art of Radio, but never realized what an enormous, fast-growing industry Radio had come to be—employing thousands, and thousands of trained men. I usually stayed home in the evenings after work, because I didn't make enough money to go out very much. And generally during the evening I'd tinker a little with Radio—maybe a set of my own or some friend's. I even made a little spare change this way, which helped a lot, but I didn't know enough to go very far with such work.

And as for the idea that a splendid Radio job might be mine, if I made a little effort to prepare for it—such an idea never entered my mind. When a friend suggested it to me a year ago, I laughed at him. "You're kidding me," I said.

"I'm not," he replied. "Take a look at this ad."

He pointed to a page ad in a magazine, an advertisement I'd seen many times but just passed up without thinking, never dreaming it applied to me. This time I read the evening I'd tinker a little with Radio—what a big opportunity for trained men to succeed in the great new Radio field. With the advertisement was a coupon offering a big free book full of information. I sent the coupon in, and in a few days received a handsome 64-page book, printed in two colors, telling all about the opportunities in the Radio field, and how a man can prepare quickly and easily at home to take advantage of these opportunities. Well, it was a revelation to me. I read the book carefully, and when I finished it I made my decision.

What's happened in the twelve months since that day, as I've already told you, seems almost like a dream to me now. For ten of those twelve months, I've had a Radio business of my own. At first, of course, I started it as a little proposition on the side, under the guidance of the National Radio Institute, the outfit that gave me my Radio training. It wasn't long before I was getting so much to do in the Radio line that I quit my steady little clerical job, and devoted my full time to my Radio business.

Since that time I've gone right on up, always under the watchful guidance of my friends at the National Radio Institute. They would have given me just as much help, too, if I had wanted to follow some other line of Radio besides building my own retail business—such as broadcasting, manufacturing, experimenting, sea operating, or any one of the scores of lines they prepare for you. And to think that until that day I sent for their eye-opening book, I'd been wailing "I never had a chance!"

Now I'm making, as I told you before, over $100 a week. And I know the future holds even more, for Radio is one of the most progressive, fastest-growing businesses in the world today. And it's work that I like—work a man can get interested in.

Here's a real tip. You may not be as bad off as I was. But think it over—are you satisfied? Are you making enough money, at work that you like? Would you sign a contract to stay where you are now for the next ten years—making the same money? If not, you'd better be doing something about it instead of drifting.

The Radio game is a live-wire field of golden rewards. The work, in any of the 20 different lines of Radio, is fascinating, absorbing, well paid. The National Radio Institute—the oldest and largest Radio home-study school in the world—will train you inexpensively in your own home to know Radio from A to Z and to increase your earnings in the Radio field.

Take another tip—No matter what your plans are, no matter how much or how little you know about Radio—clip the coupon below and look their free book over. It is filled with interesting facts, figures, and photos, and the information it will give you is worth a few minutes of anybody's time. You will place yourself under no obligation— the book is free, and is gladly sent to anyone who wants to know about Radio. Just address J. E. Smith, President National Radio Institute, Dept. 9-K-4, Washington, D.C.
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 experimenters 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.
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 television described in Vol. 1, 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.
Special Details on Jenkins Radio Movies

ADDITIONAL DATA ON JENKINS TELEVISION RECEIVER AND MOVIE REPRODUCTION SYSTEM GIVEN BY HIS RADIO ENGINEER, MR. THORNTON 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. Dewhirt stated that the Jenkins Laboratory was using a specially made carbon in such a position that the arc was drawing about thirty-eight amperes at 110 volts pressure. The positive carbon was the horizontal one, and the glowing crator 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.

As if the scanning pencil of light in each case passed through 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. Dewhirt 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. Dewhirt stated that the disc, with all the mechanical work of accurately aligning and mounting the lenses cost about $9,000. These lenses were first chosen to be perfectly 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. Dewhirt why an ordinary metal disc with small holes was not used in place of the round lenses, and he stated that if a powerful and accurately controlled beam was focused on the moving film by the use of the lenses. Apparently a disc with small holes could be used in its place, at least for experimental work by the amateur.

Transmitter Amplifier

Mr. Dewhirt stated that a three-stage resistance coupled amplifier, carefully designed, was used to first amplify the photoelectric cell current, and that this was then fed 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. The 281 is designated inside of the laboratory, all in one room, the output from the ninth stage can be connected either directly, or preferably, through power stage of power amplification, to the neon tube placed inside of the Jenkins revolving quartz rod drum.

The Jenkins Quartz Rod Drum Receiver

Mr. Dewhirt stated that when using a 10-inch diameter plate glass lens, of the plano-convex type, in the plano flat side toward the mirror, that if image filling this lens was satisfactorily reproduced, the image having a brilliance even better, he thought, than that from a cell televisor receiver. The 10-inch lens mentioned has a focal length of 21 inches (that is, to the 3 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 the same as the 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 mirror and lens the best result of the projector stages employed at present, a much sharper and more satisfactory (contrary to image) reproduction is produced on the receiving mirror and lens.

Mr. Jenkins' expert explained that the Jenkins quartz rod drum receiver can be used for the reproduction of television images, such as those from a television transmitter, such as the Bell type, and an attempt made to reproduce it on the quartz rod drum mirror 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.

Another very important point asked Mr. Dewhirt was that concerning the use of B-eliminators versus filtered B-eliminators. He stated that if they were at present using in the Jenkins laboratories, B-eliminators plate supply, and also at times dry battery supply. Mr. Dewhirt 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 used, the current was to be filtered with that given the writer by the Bell Telephone Laboratory engineers.

A power stage of amplification, such as a 200 volt B-supply, was used to charge and their amplifier B-supply, it was stated, should be charged and their amplifier B-supply, it was stated, should be charged and their amplifier B-supply, it was stated, should be charged and their amplifier B-supply, it was stated, should be charged in such a manner 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.

In the demonstration, a very small target and a given amount of power, the illumination will be greater than when the same amount of power is used in connection with the Bell arrangement, as in the Bell arrangement. It is interesting to note, in passing, as this expert pointed out also, that when the Hertzberg system is 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 standard power amplifier, utilizing a 210 power tube, together with a dry-cathode, rectifier tube, with a dry battery C bias care-fully adjusted, so that when no image current is coming into the receiver tube, the drum 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 the expert, so that each member 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 their amplifier resistance coupled stages of amplification used after the detector should then be an odd number. Otherwise the reverse, 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 frequency is employed the second member of the resistance coupled stages to be used after the detector is an even number, such as four, eight, etc.

Another very important point asked Mr. Dewhirt was that concerning the use of B-eliminators versus filtered B-eliminators. He stated that if they were at present using in the Jenkins laboratories, B-eliminators plate supply, and also at times dry battery supply. Mr. Dewhirt 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 used, the current was to be filtered 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 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 trans-former 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. That is why it is important to connect the picture squarely at the start of reception from each station. Resistance coupled amplifier stages are necessary between the detector and their amplifier B-supply, it is best made of the resistance coupled type also.

Stations Broadcasting Photos

The Rayofield system of picture broadcasting and receiving is being extended nationally. Photos are being transmitted by this system at 11:30 A.M., 11:30 P.M., 1:30 A.M., on Mondays, Wednesdays and Fridays, and between 9:30 and 10:15 P.M., on Wednesdays. The system is also being transmitted 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 television 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 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 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 coarse wire, and the other with fine wire. Such a variable impedance may be constructed simply by winding several layers of insulating copper magnet wire, about No. 16 gauge, on a fibre or other insulating tube. A brass or other non-magnetic tube may be employed. A piece of pipe about 1½ inches in diameter and 12 to 16 inches in length will serve. For the fine wire rheostat, about No. 24 to 26 wire may be used, depending upon what kind of resistance wire is employed. A style 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 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 tightly 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.

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 used. 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 blur up the image. The best way is try them and see.

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 blur 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, but 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.

Fortunately, however, an analysis of the facts shows that if the transmitting and receiving mechanisms are one 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 both 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 not in 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 time.

When the first efforts were made to achieve television, attempts were made to obtain isochronism by means of telegraphy; i.e., by means of pendulums and tuning forks. Such methods, however, do not lend themselves to television, for they are too inefficient or inaccurate.

By using synchronous motors, however, perfect isochronism can readily be obtained, and the speed of all 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 demonstration of television were achieved by John L. Baird, the British inventor.

One of these motors comprises, essentially, an armature coupled with an alternating current, and a stator supplied with direct current. Or the motor 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 a timekeeper.

**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 the limit, within very reasonable limits, the better are the results.

This A.C. output is then conveyed (as will be discussed later, 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 on any convenient supply.

The main driving motor at the transmitter has the usual tendency to "hunt," and it is allowed to go 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 is 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 image mechanism a whole amount 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." Too, the descriptions given above will be understood more clearly if reference is made to the accompanying diagrams.

Fig. 1 is a cross-sectional view of the receiver's driving mechanism. At the extreme right-hand end of the shaft is the image-exploring disc. Further to the left, within the "carcasse" (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 carcasse 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, but it is possible 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 radio, results which are 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. As the synchronizing note 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 synchronizing note was increased in frequency 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 speed 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 led 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-diminished 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 is applied.

This proportionality between the intensity of the illumination and the electronic emission is strictly true; and whatever apparent exceptions may 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 phenomenon 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, cesium 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 taken to prevent oxidation of the plate and, for this and other reasons, they are more than roughly exhausted than the ordinary vacuum tube.
through the glass. The only other element is the anode, or filament, which has 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 is more sensitive to light, consequently makes a greater current. In the diagrams the 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, it will be observed that a very low current flows after excessive potential and while glowing, of course, are not sensitive to light variations. Efficient operation is had with a control through the cell rises and falls with the varying intensities of the light directed on the plate.

Conversion of light into electric current is generally made into an amplifier.

Importance of Synchronism

The problem of synchronisation is to run these two discs—the scanning and the receiving—half a cycle or not only different speeds, but always in exact step; i.e., if the tenth aperture of the transmitting disc comes to pass through and fall on the subject’s face, the eye at the receiver will be looking at the high-frequency lamp also through the tenth aperture, and so on. Ordinary photographic film is not “seeing” the eye of the subject, while the eye of the receiver is looking at the position of the light on the film; but it is obvious by the above that, states Mr. T. Thorne Baker in the English publication, Amateur Wireless, for June, 1928, the mean adopted by Baird and other workers has been to employ synchronous motors, or motors the speed of which can be controlled by the 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), each vibration making another contact, K2, thus completing a circuit including a battery, E, and the winding of W, one of the magnets of a multiple-pole electro-motor.

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 used 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. One 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, 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-synchronous fashion. Mr. Baird has told me that the effect is that of the whole image swaying slightly, although definition is not impaired.

It is perfectly real synchronisation that has solved the problem of telegraphing simple pictures. It shows how 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 photo-telegraphy.

But faulty synchronisation prevented the success of the Korn teleautograph system, which it did all other attempts at telegraphy for the following twenty years. And synchronisation still remains the biggest problem in television.

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 receiving apparatus which will give a response to the extremely minute impulses involved and to the rapid fluctuations necessary to transmit printed or vocal communications.

It is fortunate for the progress of visual communication that the photoelectric cell, although it has some disadvantages, is in 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 loss of accuracy.

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.
WRN—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 who desires to become a good master of his art must be more interested in how to manage his apparatus than in what is going to happen in the studio. So far, the studio work has been done in several places and 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 from the newly acquired disc.

Having done this, the amateur televisionist must, or at least should know the speed at which the station’s 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 to a very simple placing a rheostat or a variable impedance (choke coil) connected in series with the motor. This will give any speed desired, the lower the difference in speed of 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.

A few words concerning the adjustment of the neon tube will probably be of interest. It should be said that no neon tube or 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 begins to glow with a definite light. With an incoming television signal, the plate current increases and the neon tube glows. With the second method, the neon tube is allowed to glow when no signal is coming in, an incoming image signal causes a decrease in the plate current of these tubes, with the neon tube. Dry "B" batteries are recommended for amateur television reception, the potential varying from 130 volts up to 350 volts. The higher the voltage, the brighter the image created by the neon tube and the whirring 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

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 be needed at the receiving end to transmit a single photo-electric cell to photograph all parts of the picture, and that an equal number of neon lamps would be required 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 absolutely 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 operates in 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.

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 Television

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-varieton-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 advisable to use a superheterodyne receiver for television reception, as the usual intermediate-frequency amplifier will cut side-bands 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. An 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 of the grid leak R7 is selected after experimenting with leaks of various values. C1 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 1½-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 13¼ volts is needed for the first two audio tubes. The filament of the power tube is heated with 73½ 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 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.

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. The receiver is now ready to pick up the receiving disc. However, if larger discs are to be used, the size of the cabinet must be increased proportionally.

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 in the signal of a broadcasting station and note the results. If the station has a strong signal, the music and voice 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 photo-electric 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 photo-electric cell. (See Fig. 1.) The diagram makes this clear.

The rapidly-revolving disc, at the front end of the cylinder, has around its circumference a series of indentations or notches. These notches interrupt the light rays at a certain frequency and the photo-electric 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 photo-electric 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 photo-electric 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 loudspeaker the apparatus shown in the 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 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.
New Belin Photo-Transmitter

PERIODICALLY, M. Edouard Belin brings to the notice of the scientific press this inventor of a surprising apparatus which has been realized—perfect synchronism of the two cylinders. In the transmission of a photographic image, the same phenomena occur but the mirror will be actuated by variable oscillations. The opaque screen will 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.

New 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 attainable, it is absolutely necessary that 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 Lavoisier. 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 shunt off alternately the currents. As the legs of two tuning forks giving the same note produce the same effect, it will be seen that two motors transmitting these vibrations will turn at the same speed, though they may be 500 or more in number.

Here is the condition realized—perfect synchronism of the two cylinders.

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...
How to Build a Radio Photo Recorder

One of the most important considerations in picture transmission and reception is that the two systems are 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. 

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 re-acts 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 the same plane, and the receiving cylinder is synchronized with 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 photograph 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.
2. Potentiometer, 200 ohms, high current capacity, R2.
3. Film resistor, 10 ohms, high current, with filament switch, R4, S.
4. Fixed condensers, 0.0005 mfd., C1, C2.
5. Variable condenser, 0.0005 mfd., C3.
6. R.F. choke, 85 millihenries, I.
7. Switch, filament circuit type, S1.
9. 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, gain, and other 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.

Putting together the mechanism that will put the receiving set into the input transformer are now the connections from the receiving set to be connected to the picture machine. Then, secondary connections are made, for the plate 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 colored, in the telephone manner, and carefully tied together. Necessary jacks, all connections should be soldered, and individually tested. All parts should be inspected before wiring 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 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 almost that 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 discharges 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 synchronizing process.

The entire recording mechanism looks very

Diagram of the recorder. A device of this type is available completely assembled, or it can be built by the experienced machinist.
nicety. Every time this relay trips, it will close the circuit of the recorder magnets. 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 itself, as a result of 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 perform by 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 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. Ario 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.

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CPT. 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.

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.

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

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 photovoltaic 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 photovoltaic 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 photovoltaic cells in the thick, square darkened iron plate), 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 shaling, 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 lamp 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. He said that this lamp would 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 that those working in television have had to face.

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 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 1/1000-inch) trace successive lines on the picture, literally “painting” it in one revolution. The line 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.

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 the face, again breaking up into splashes 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 is 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 a push-button, and thereby increasing the speed. This is far from being a difficult feat, as it requires the skill of the operator. Sometimes, when the two motors get slightly out of synchronism, the lower half of the image may be nearer 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 little condition is remedied, a new condition begins. For example, the 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.
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 265,646.)

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 the 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
Infra-Red "Eye" Sees at Night

VISION in total darkness and fog is now 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 infra-red rays, those invisible heat rays which are found beyond 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 speed so great that with a micro-ammperes at about 12 volts, it was possible to light and extinguish a brilliant luminous point of a fluorescent screen. The concentration of the electrons in these 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 four 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 are 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.

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 mains; H. 8-volt circuit; L. line; J. perforated plate; K. Braun tube; L. signal; M. photovoltaic tube; N. light generator; O. beam of parallel light rays; P. arc light; Q. object to be transmitted.
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 infra-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 infra-red 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 pen-dants 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 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 converter, let the pictures and diagrams here-with 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 synchronization 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 synchronization 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
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 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 wavelength, 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 indicated 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 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 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 "jewels" along the longitudinal axis of one of its greatest length. It’s 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 of a degree (F.),). 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 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 line, 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 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 balsawood 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, filament, 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...
changed into electrical impulses. That means ordinary printed magazine quality, there must be provision made for, say, 14,000 variations for one fourteen-millionth part of a second. 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 vary 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 correct continuously, this is evidently not the ideal solution of the synchronization problem in television.

Vacuum Cameras to Speed Up Television

S U P P O R E, 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 implies 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-shaft, not a neon lamp or anything of the sort, but the impact of a stream of electrons on a screen which not only divides the light, but actually changes it as well. 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.

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 limitation 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.

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.

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...
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 a 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 an I 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 lights up the thin conductively 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 "luminizes" or lights up at that spot 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 image. 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. It is, of course, the same as 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 luminous 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 graduations 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 picture 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 apparatus 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.
New Jenkins Radio Movies

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 the same pitch, so placed that the film is pulled past any fixed point next to the film, at the rate of 900 revolutions 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. 5.5. 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.

The images on the film are projected on 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-
ruple tube. It is about four inches long and one inch in diameter, the little plates or "targets" being about 3/4-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 contact, while the other makes a wiping contact over the four sections of a split ring. The four sections each have a "target" 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 revolving switch. The revolving element is a foot in front of the mirror, standing up 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.

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 television.

Practical Demonstrations Scheduled for WRNY

WITHIN a short time after the appearance of this issue of Tele- vision, 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 "television," will be installed here; and the image of a person will be broadcast on the 320-meter wave of WRNY from the transmitter proper, which is situated at Coytesville, N. J. A receiving set with a television 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, could assemble a complete instrument in a few evenings. The receiving television will form an independent unit, and will be equipped with rca tubes which will connect to the regular output posts of the broadcast receiver.

**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 television, to enable the listener to disconnect his loud speaker and to hook on the television or recharger. If the speaker is left in the circuit it will emit a curious howling of total random 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 motors, as in all systems of television and radio transmitters, there is little possibility of enlarging the images with pleasing results.

**Synchronism**

Both transmitting and receiving televisions will employ revolving discs. The all-import-
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. 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 photoelectric 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 round object behind the reflector is a lens.)

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 the 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 pass through it. The photoelectric cell is the large bulb mounted on the forward part of the baseboard.
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