JOIN THE RADIO ASSOCIATION

EARN $75.00 a week in Your Spare Time

JOINING the Radio Association enables you to cash in on Radio now! Follow its success-proven plans and you can earn $3 an hour, in your spare time, from the very first. Over $500,000,000 is being spent yearly for sets, supplies, service. You can get your share of this business and, at the same time, fit yourself for the big-pay opportunities in Radio.

Founded on a New Idea
Members of the Association do not wait for months before they make money out of Radio. Without quitting their jobs, our members are earning $25 to $75 a week spare time by building "tailored" radio sets, serving as "radio doctors," selling ready-built sets and accessories, or following one of the many profit-making plans of the Association.

Earned $500 in Spare Hours
Hundreds earn $3 an hour as "radio doctors." Lyle Follack, Lansing, Mich., has already made $500 in spare time. Werner Eichler, Rochester, N. Y., is earning $50 a week for spare time. F. J. Buckley, Sodak, Mo., is earning as much in spare time as he receives from his employer.

We will start you in business. Our cooperative plan gives the ambitious man his opportunity to establish himself. Many have followed this plan and established radio stores. Membership in the Association has increased the salaries of many. Stores are now connected with big radio organizations. Others have prosperous stores.

A year ago Claude De Grave knew nothing about Radio. Today he is on the staff of a famous radio manufacturer and an associate member of the Institute of Radio Engineers. He attributes his success to joining the Association. His income is 350% more than when he joined.

What a Membership Can Do for You
1. Enable you to earn $3 an hour upwards in your spare time.
2. Train you to install, repair and build all kinds of sets.
3. Start you in business without capital, or finance an invention.
4. Train you for the $1,000 to $10,000 big-pay radio positions.
5. Help secure a better position at bigger pay for you.

A MEMBERSHIP NEED NOT COST YOU A SINGLE CENT

Doubled Income in Six Months
"I attribute my success entirely to the Radio Association," writes W. E. Thom, Chicago, who was clerk in a hardware store before joining. We helped him secure the management of a large store at a 220% increased salary.

"In 1922 I was a clerk," writes K. O. Beezley, McGregor, Ia., "when I enrolled. Since then I have built hundreds of sets—from 1-tube Regenerative to Superheterodynes. I am now operating my own store and my income is 200% greater than when I joined the Association. My entire success is due to the splendid help it gave."

Easiest Way Into Radio
If ambitions to become a Radio Engineer, to fit yourself for the $3,000 to $10,000 opportunities in Radio, join the Association. It gives you a comprehensive, practical and theoretical training and the benefit of our Employment Service. You earn while you learn. You have the privilege of buying radio supplies at wholesale. You have the Association behind you in carrying out your ambitions.

ACT NOW—if you wish Special Membership Plan

To a limited number of ambitious men, we will give Special Memberships that may not—need not—cost you a cent. To secure one, write today. We will send you details and also our book, "Your Opportunity in the Radio Industry." It will open your eyes to the money-making possibilities of Radio. Write to-day.

RADIO ASSOCIATION OF AMERICA, Dept. T-7
4418 Racine Avenue,
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Gentlemen:

Please send me your book and all details of your Special Membership Plan.

Name:

Address:

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[Signature]
TELEVISION IS HERE

With several stations broadcasting television pictures on regular schedule—and with authenticated statements of radio fans regularly getting those pictures with Daven Television apparatus the future of television is assured.

Build a Daven Television Receiver

The first complete Kit consists of 24 Aperture Scanning Disk for WGY, Motor, Bushing, Daven Television Tube, 3 Complete Stages of Daven Television Amplification and instructions for Building.

Or you can buy a Complete Daven Television Receiver, built in our factory.

COMPLETE ESSENTIAL KIT . . . $60.00
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Daven 2 Stage Essential Power Kit

For use with 210 Tubes—2 stages of Daven Power Television Amplification complete with Daven Super Davohns and Complete Instructions for Building. . . . . . . $10.00

Daven Television Apparatus

- Daven Television Scanning Disk . . . Daven Television Photo
- 24 apertures for WGY $5.00 each
- Receiver Cell 1½ in. $20.00 each
- 12 apertures $10.00 each
- 24 apertures $10.00 each
- Daven Special Television Amplifier 12.50
- Daven TV-10 Tubes for Amplifier Stages 1.25 each
- 29 to 80 milliamperes
- striking voltage 372
- Output 1½ x ½ in. 12.50
- Daven Television Motor 25.00
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- Daven Bushing #4 1½ 5-15 in. 12.50
- Daven 16-T2 Tubes for
- Daven Bushing 3½ 5-15 in. 12.50
- Daven Bushing 4½ 5-15 in. 12.50

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Amplification Specialists
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What more could you ask—150 of the very finest, selected hookups most popular today. Each one completely explained and fully illustrated so that a complete receiver can be constructed from the information. No out-of-date hookups—all the finest and best in common use today.

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ANYTHING
IN RADIO

Radio Specialty Co.
967 PARK PLACE, NEW YORK
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.

And just 12 months ago I was scribbling along on starvation wages, barely making both ends meet. It was the same old story—a little job at a salary just as small as the job—while I myself had been dragging along in the rut so long I couldn't see over the sides.

If you'd told me a year ago that in twelve months' time I'd be making $100 and more every week in the Radio business—well! I know I've had thoughts 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 kidding myself, that's all—not because I had to be. I could have been holding down 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. Every today I get a thrill from this strange force. In these days, many times I stayed up all 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 understand at all.

So, up to a year ago, I was just a dabber—I thought Radio was a plaything. I 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 away with Radio, 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 how to go very far with such work.

And so 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 one 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 not passed without noticing, never dreaming it applied to me. This time I read the ad carefully. It told of many big opportunities 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 assiduously, and when finished 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 school that gave me my Radio training. It wasn't long before I was getting so much to do in the Radio line that I sold my newsy little dental job, and devoted my full time to my Radio business.

Since that time I've gone right on, 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 not followed some other line of Radio besides building my own radio business, such as broadcasting-manufacturing, experimenting, and operating, or any one of the score of lines they prepare for you. And to think that until that day I sat for their eye-opening book, I'd been waiting "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 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.

This new Radio game is a live wire field of unlimited possibilities. There are more than 20 different lines of Radio, fascinating, absorbing, well paid. The National Radio Institute—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—drop the coupon below and look their free book over. It is filled with interesting facts, figures, and graphs, 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 Means Instantaneous Sight at a Distance

Television IS Here
By HUGO GERNSBACK

IF in we brought out the first issue of this magazine in the Fall of 1927, it was thought in many quarters that we were raising 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 yet; but the point was stressed that a beginning had to be made somewhere.

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

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

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

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

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

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

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

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

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

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

Television Experimenters

This time of TELEVISION contains the first clear directions as to how to build a Television set, written by a Television experimenter. This magazine will shortly come out as a monthly, and the Editor solicits good articles from those who have actually completed television receiving sets. Photographs and full descriptions are particularly desirable.

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

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 hereewith 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 Ivie system demonstrated about two years 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. I, No. 1, of Telecasting.

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 fed 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 revolving 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 Ivie 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. WINSFIELD SEIDOR

This data concerns the article on a new Jenkins model Television Receiver and receiver tube that appeared in the August, 1929, issue of "Radio News", of which appears on page 28 of this magazine.

At the transatlantic meeting of the Radiotelephone Manufacturers Association, Mr. Dewhirst stated that the Jenkins Laboratory was using a Siemens arc with the carbon at a 90° angle to each other, the arc drawing about thirty-eight anges at 100 volts pressure. The positive carbon is the horizontal one, and the negative carbon of this positive carbon was placed up with a lens and passed through the revolving drum. The revolution of the drum was so adjusted that the positive carbon was placed up, and the negative carbon was placed down. The revolving drum was used exclusively.

The lens that is used is a special glass lens, mounted in a concentric circle, to catch the light and focus it. The lens is mounted on a drum, and the drum is revolved in a horizontal plane. The lens is revolved in a horizontal plane, and the drum is revolved in a horizontal plane.

If the lens of 1/4 of an inch is placed at the point where it is aimed, and the drum is revolved, the light will pass through the lens.

Lens Details

The lens is mounted in a concentric circle, to catch the light and focus it. The lens is mounted on a drum, and the drum is revolved in a horizontal plane. The lens is revolved in a horizontal plane, and the drum is revolved in a horizontal plane.

The lens is revolved in a horizontal plane, and the drum is revolved in a horizontal plane.

Transmitter Amplifier

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

The Jenkins Quartz Rod Drum Receiver

Mr. Dewhirst stated that when using a 16-inch quartz rod plate glass lens, of the plano-concave type, with the plate flat, and the rod toward the mirror, that the image filling this lens was satisfactorily reproduced, the image having a brilliance very close, though not quite, that of the lens as a whole.

In the demonstration which Mr. Hertberg, managing editor of "Radio News", and a number of government representatives saw in Washington during the last week of the Jenkins Laboratory, the movie film was used as the transmitter was a special type of tube, having black and white combined as well as red, green, blue, etc. The reason for using this particular film was that with the black and white films, there was with the particular design and adjustment of the amplifier stages employed by the post-war, much sharper and more satisfactory (contrast) reproduction on the receiving mirror and lens.

Mr. Dewhirst's expert explained that the Jenkins quartz rod drum receiver can be used perfectly well for half-tone reproduction of a television image, transmitted by a different type of tube such as the Bell, Selleck, etc. It is important, of course, to use only resistance coupled stages of amplification in the television receiver, beyond the detector, for half-tone reproduction such as Bell obtains: no audio frequency in the receiver being permissible, if any, since such results are to be obtained.

It is also important that the receiving quartz rod drum rotated four times as fast as the lens disc at the transmitter, for the reason that each one of the four, exactly identical, spirals of quartz rods comprising twelve rods to each spiral, had to complete its rotation four times in the scanning of each motion picture frame. While the first quadrant of the lens disc is moving over the moving image, the first spiral over each of twelve quartz rods is making one complete revolution at the receiver. When the lens is passing through the second quadrant, the second spiral over each of the twelve quartz rods in the receiving drum is completing its revolution. As the transmitter lens drum moves through the third quadrant, the third spiral of quartz rods on the receiving revolving drum is completing its revolution, and when the fourth quadrant of the lens disc is moving, its movement is completed, its movement, and the fourth and last spiral of the twelve quartz rods is completing its revolution. Thus the whole action becomes quite clear. The reason why the centrifugal force used the revolving drum to flash on successfully Nos. 1, 2, 3, and 4, the quartz rods in the second stage of amplification, is to catch the light at the point at which it is most intense. This is so for the reason that the total available energy from the power tube, for example, is used to charge and eject one of the small targets in the target grid. Naturally with a small target and a given amount of power, the illumination will be greater than when the same amount of power is sent to a large single plate, as in the bell arrangement. It is interesting to note, in passing, that this effect induced such a short holdout tube to be used in place of the quartz rods in the revolving drum, but the quartz rods are preferable, as they transmit the light without loss, and do not obey the inverse square law which would occur if ordinary glass was used. Lenses would also be preferable to quartz rods as they would have an appreciable loss due to poor light transmission through them.

Stage Eliminator

It was stated that very good results had been obtained in the Jenkins Laboratory with a standard power amplifier, utilizing a 210 power tube, together with a 281 half-wave rectifier tube, with a dry battery C bias carefully adjusted, so that when no image current is coming into the receiver, the screen has a dark. This amplifier is generally used with three stages of resistance coupling, the elimination of high-frequency wave being produced by the resistance of the grid. An important thing brought out was that if a grid leak and grid condenser are used in the detector circuit, the phase relation will be markedly changed, and the number of resistance coupled stages of amplification and the detector would then be an odd number, such as three, five, or seven; otherwise the image will be reversed (that is the image will be like a mirror image of the original negative). If C bias rectification on the detector is employed, then the number of resistance coupled stages of amplification and the detector are an even number, such as four, six, eight, etc.

Another very important point made by Mr. Dewhirst was that the use of the Eliminators versus dry B-batteries. He stated that they were present in the Jenkins laboratory, B-eliminator plate supply, and also on today's dry battery B supply. This is due to the rejection of silicon tube, as in the case of Jenkins radio tubes, the silicon tube is not rectified, B-eliminators being satisfactory, but that where half-tone television reproduction is desired, with the B-eliminator plate supply, battery B supply which is preferred. This opinion is concurrent with the statement by Mr. Bell Telephone Laboratory engineers.

If a power stage of amplification such as a power B-eliminator grid driving a voltage multiplier tube, is used, with a measured potential drop of about 300 volts across the grid tube (Jenkins in this case), the converter should not reduce this power stage into the output jack of a rectifier, so as to insulate transformer coupled radio stages. Due to the phase shifting and frequency cut-off characteristics of such transformer stages, the image on the television screen would be considerably weakened and also shifted on the television screen, making it difficult to adjust the receiving mechanism, so as to frame the picture squarely at the start of reception. The use of resistance coupled stages of amplification is necessary beyond the detector. The power amplifier is best made of the resistance coupled type also.

Station Broadcasting Photos

The Station system of picture broadcasting and reception is being extended nationally. Photos are being transmitted by this system from WMCA between 11 and 11:15 P.M. on Mondays, Wednesdays and Fridays, and between 5:30 and 6:15 P.M. on Wednesdays. The Station is also being carried by stations in Philadelphia, Detroit, St. Louis, Minneapolis, Scranton, Topeka, Kansas City, Chicago, and is to be used soon by other broadcasters.
Hints To The Television Enthusiast

The television receiver desk-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 circuits 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 enthusiasts will find it very useful indeed. It should be said in passing that those having the time and the inclination can build up the resistance coupled amplifier, as here shown in the diagram below, while those who do not have the time or the patience may instead buy this special television resistance coupled amplifier, complete.

The electric motor used for driving the perforated scanning disc in this television receiver kit is of the 110 volt A.C.-D.C. universal type. In other words it is a series wound D.C. motor with the electrical windings so designed that it will operate efficiently on either A.C. or D.C. The two rheostats shown in either side of the motor control circuit, comprise a fine and a coarse adjustment. That is, the experimenter may build these, one resistance coil being wound with coarse wire, and the other with fine wire. These rheostats are easily made by winding German silver or other resistance wire over a layer of asbestos which has been wrapped around a piece of iron pipe. If A.C. is used brass pipe, split longitudinally, should be used, or porcelain, glass, etc., can be employed. A piece of pipe about 1½ inches in diameter and 12 to 16 inches in length will do. For the fine wire rheostat, about No. 34 to 26 wire may be used, depending upon what kind of resistance wire is employed. A little experimenting with the length of the resistance wire stretched across the room and connected in circuit with the motor will enable you to find out the proper size of the particular resistance wire you have at hand, and how many feet of it you will need. For the coarse wire rheostat, about No. 18 to 20 size wire may be used. Bare wire is the best to use, spacing the turns by winding the coils in a lathe. The wire can be spaced the thickness of the wire space, by winding on a piece of cord alongside the wire, afterward removing the cord. Be sure to wind on the resistance wire tight enough so that when a phosphor bronze or German silver spring slider is slid along a brass or other bar mounted parallel with the coil, the turns of wire will stay in place. The wire expands quite a little when heated up and this must be kept in mind also. The above considerations presuppose that you are using the universal motor on D.C. If you are using the motor on 110 volts A.C., 60 cycles, then you may control the motor speed by a simpler mechanism. In this case it is the most efficient method to employ an adjustable impedance or choke coil in series with one of the motor feed wires.

Such a variable impedance may be constructed simply by winding several layers of insulated copper magnet wire, about No. 16 gauge, on a piece or other insulating tube. A brass or other non-magnetic tube may be used if it is not lengthwise. For the winding, it is best to use about 6 to 8 layers of No. 16 to No. 18 enamelled or double cotton covered magnet wire. Tap leads should be brought out from the third and the following layers and these taps brought to a multiple-point switch. This switch will give the coarse adjustments of the motor speed. The fine adjustments of the speed are produced by moving an iron core in and out of the impedance coil. This iron core may be composed of either a bundle of enamelled wire, or else a core built up of sheet iron strips, such as used for transformers. Stove pipe iron will do for the purpose. The coil may be wound on a round tube having an inside diameter of about one inch inside. A red and a black are mounted on the iron core so that it can be moved in and out easily, and a scale may be mounted so that the handle moves over it. In this way, you can always reset the impedance to a value previously determined for a certain set of conditions.

With the television kit shown below, the manufacturer recommends that the power stage tube be so adjusted with regard to its C bias, etc., that the neon tube behind the scanning disc lights up 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, there is a simple coupling capacitor in each circuit, connected by means of a plug, into the detector jack of any standard radio receiver set. The last stage, a resistance coupled amplifier should be supplied with a power tube and at least 300 volts, supplied preferably from "B" batteries, or the from a highly efficient "B" eliminator. Suitable energy for operating the neon tubes more brilliantly may be obtained by connecting several power tubes in parallel. The experts recommend that for color television receiving sets, the better ones for the "B" plate supply. The theory of using only filtered "B" eliminator is to blast up the image. The best way is to try them and see.
The Problem of Synchronism in Television

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

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, overlooked.

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. Such a statement is true, but 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 out of phase the image is not blurred, but merely displaced; the definition is not altered. The effect is that the image of a man's face, instead of being visible squarely, is at the edge of the screen. This effect of the receiver screen is displaced to right or left, so that his face appears to be cut off vertically, and by the nose. On the other side of the screen this effect 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 than that of synchronism. Possibly, these words are not familiar to readers, and it is not of any use to define them here.

Isochronism and Synchronism Defined

When two mechanisms are said to be running in isochronism, what is meant is that the two mechanisms are running at the same speed, but are out of step. For example, two clocks which are running at the same rate would be in exact isochronism, although the hands of one might point to 2:30 and the hands of the other to 3:00. To be in synchronism, both clocks must indicate exactly the same hour.

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

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

Of one of these motors, comprising, essentially, an armature, or rotor, supplied with an alternating current, and a stator supplied with direct current. Or the rotor may be supplied with direct current, while the stator takes the a-c. The speed at which such motors run is dependent entirely upon the periodicity, 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 machines could be obtained by using two exactly similar motors, controlled by rheostats and run at exactly the same speed, as indicated by a frequency or an oscillograph. This cannot be done, however, for ordinary electric motors continue to run even when 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 properties of at least one of the motors must be brought under strict control. The task of the synchronous motor is to act as controller.

How Isochronism is Obtained

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

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

The main driving motor at the transmitter has the usual slow "chuck," and it is allowed to do as it wishes; the periodicity of the a-c. generator coupled to it varies in accordance with the requirement of the system.

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 of the distant A.C. generator, it follows that the main receiving motor must at all times be revolving at exactly the same speed as the main transmitting motor. The fact that they both hunt slightly is of no 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 must get them in exact sympathy.

Obtaining Synchronism

As stated previously, a difference of phase does not cause blurring or loss of definition, but merely causes an off-set of the image on a line-by-line basis, and while this effect is very simply rectified by the expedient of rotating the receiver's driving mechanism as a whole about its spindle until the picture comes into view in its proper place.

The action may be compared to that performed by the operator of a moving picture projector when the picture appears with the picture appearing with the picture. The descriptions given above will be understood more clearly if reference is made to the accompanying diagrams.

In Fig. 1 a cross-sectional view is given of the receiver's driving mechanism. At the shaft on the synchronous motor, which controls the speed of rotation of the D.C. motor, giving isochronism.

The case 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 added advantage that the motor shaft must 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. 216,978, of March 17, 1929) describes this device for rotation of the mechanism; although it is unquestionable 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 must be given the credit of being the first successful to apply this principle.

The Transmission Medium

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

It is, of course, impossible at the present time to transmit power by radio or over a telephone line. Therefore, some other means must be provided to supply the A.C. to the receiver. This is done by using the a-c. to modulate either the carrier current, the cake of wire 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 be detected without difficulty, being carried over the same channel which carries the television impulses, after circuits are 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 first apparatus used at one of Mr. Baird's first public demonstrations, given in London in April, 1925. At this demonstration, which was an early effort with crude apparatus, only silhouettes were shown, and two separate channels were used, one for the television impulses, and one for the synchronizing impulses. However, the method of synchronization employed was essentially the same as that described above.

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

Baird's Original Apparatus

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

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

As the synchronous motor and the output of the relay came into phase, the lamps flickered, the flickering becoming less and less as the lamps went out entirely. At that instant, the switch was closed and the current from the relay fed to the synchronous motor. This current was sufficient to prevent the synchronous motor creeping out of phase, which, in turn, prevented the main driving motor from hunting.

The above method is essentially similar to that used by Baird at present, with the exception that the telegraph relay is, it is understood, no longer employed. The output of the last tube of the amplifier is now applied directly 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 was already explained, any convenient supply may be used to run the main motor. Mr. Baird used D.C. motors, because the current supply to his laboratory happens to be direct. The A.T.T.T., whose synchronizing methods are essentially the same as Mr. Baird's, uses A.C. motors, since 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 connection with greatly-perfected and better-balanced mechanisms, has resulted in a vast improvement in the quality of the received images.

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. This improvement is due to improvements in the receiver, and the present discussion will, I believe, serve as a basis for further work in this direction.

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 electric circuitry. The light falling on it gives rise to extremely minute electrical impulses is brought about by what is known as the photoelectric effect, which is due to the fact that an insulated metal 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 incident light which influences the action. Thus, stated in a form of a rule, we say that the photoelectric effect is proportional to the intensity of illumination and is in the line during which it acts.

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

Investigations have 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 electropositive. (See Radio News for June, 1925, page 422.) At the "alkaline" metals (sodium, potassium, lithium, caesium, and rubidium) respond to radiation 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 entirely in a vacuum or in gases. This has led to the development of two essentially types of cells. One type uses a conductor or plate of the alkali metals in the form of a hydride (a compound of the metal and hydrogen), which is more sensitive than the pure metal. They differ mainly in that the plate is placed in a highly-evacuated vessel and, 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 and other reasons, they are more the roughness than the ordinary vacuum tube.

Construction of the Cell

To illustrate more clearly photoelectric action, it is useful to describe the modern cell. The P-1 and P-3, gas-filled and vacuum types respectively, are taken as examples. The photoelectric cells are made up of a cathode and an anode, and a glass envelope to retain the vacuum. There are also several controlling and protective devices used in these cells, which are not described in detail here.

The characteristic curve of a photoelectric cell, like that of a vacuum tube, has a characteristic curve for each type of cell. The "peak" in this curve, however, represents the effect of the ordinary vacuum tube.
TELEVISION

The problem of synchronizing is to run these two discs—the scanning and the receiving discs—not only at identical speeds, but always at exactly the same speed. If the speed of the scanning disc is altered, the scanner will be out of step, and the receiver will be out of step. The result will be a change in the frequency of the signal output from the receiver.

The scanning disc is driven by a motor, and the motor is controlled by a signal that is derived from the image signal. This signal is amplified and fed to a modulator, which produces a modulation of the signal that is transmitted to the receiver.

The receiver demodulates the signal and produces an output that is synchronized with the scanning disc. The output is then fed to a television picture tube, which produces the television picture.

Practical Difficulties

This description of the way in which the output of the scanning disc is synchronized to the output of the picture tube is oversimplified. It is true that the scanning disc is turned at a fixed speed, but the speed of the picture tube is not fixed. The speed of the picture tube is determined by the speed of the scanning disc and the speed of the video signal.

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Importance of Synchronization

A tube that is not synchronized will produce a picture that is not stable. This is because the scanning and receiving discs are not synchronized, and the result is a change in the frequency of the signal output from the receiver.

If the scanning disc is running at a higher speed than the receiving disc, the result will be a change in the frequency of the signal output from the receiver. This change in frequency will cause the picture to appear to be moving up and down on the screen, or to be jumping from side to side.

Looking In—Hints for the Amateur

At the present time, the television experimenter is interested in using a television picture tube to receive the television signal. The following station data will aid him in this respect.

WNYT-36 hole-disc—speed 900 R.P.M.

WNYT-37 hole-disc—speed 600 R.P.M.

WNYT-38 hole-disc—speed 1,080 R.P.M.

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

Having done this, the amateur televisionist must, or at least should know the speed at which the disc is rotating. This speed is dependent upon the disc and the motor it is driving. This speed can be determined by using a tachometer, which is a device that measures the speed of a rotating object.

Probably the easiest way to determine the speed of the disc is to use a tachometer. The tachometer will be used to determine the speed of the disc and the motor it is driving. The speed of the disc is determined by the speed of the motor and the number of holes in the disc.

The speed of the motor is determined by the power supply and the load on the motor. The power supply is usually a battery, and the load on the motor is determined by the friction of the motor and the load on the motor. The speed of the disc is determined by the number of holes in the disc and the speed of the motor.

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How to Build a Television Receiver

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

BY FRED R. CANTFIELD

LESS than two years ago it was rumored in engineering circles that television pictures would be practical within a decade or so, but much doubt was expressed as to whether it would ever be developed to a practical basis. It was said that hundreds of photoelectric cells would be required at the transmitting station to pick-up the picture and that an equal number of neon lamps would be needed at the receiving end to reproduce the image. This system, of course, would make both the transmitting and receiving 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 reasonably made in previous years.

When contrasted with yesterday's conception of television apparatus, the modern television sending and receiving stations will be found absurdly simple. At the transmitting end a single photo-electric cell (or else 3 to 4 large ones) is used to pick-up the picture, and the output of this cell is connected with an 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 mounted with holes in a spiral path, and it allows the cell to photograph all parts of the picture fifteen times each second. At the receiving end the apparatus is similar to the transmitter but it operates in the reverse order. A standard broadcast receiving set followed by a high-quality audio amplifier is employed, and the output is converted 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 halftone in character, and when distortion has been reduced to a minimum, and the disc has been perfectly synchronized, the definition of the picture should be very satisfactory as it is composed of from 24 to 50 lines per inch. The average newspaper halftone has 30 to 60 lines per inch, and, therefore, under favorable 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, 16 Vanhout Ave., Bloomfield, N. J. Mr. Sonn is well known in amateur circles as operator of station 2FC, 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-earphone-type regenerative set, but any standard tuned R.F. tuner would work just as well, provided it did not distort the incoming signals. However, it would be inadvisable to use a superheterodyne receiver for television reception, as the usual intermediate-frequency amplifier will cut 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. The usual method which has been employed, in which audio frequencies are amplified by a standard resistance-coupled amplifier and then fed into a power-tube, has been found to be unsatisfactory. 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 250-type in order to provide the neon lamp with sufficient energy to produce a good picture. The amplifier used with the receiver shown in the above picture consists of a standard resistance-coupled unit which has been revised for power-tube operation. Two 210-type high-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 the broken disc 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.
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. Spen.

The receiver is a standard three-circuit regenerative set of the double-variatometer type. L1 is a variatometer with a tapped primary and a rotating secondary winding. L2 and L3 are variatometers 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. chokes coil, which is employed to prevent R.F. current from entering the audio amplifier. The grid condenser C1 has a capacity of 0.0055 mfd., and the resistance value of the grid leak R3 is selected after experimenting with leaks of various values. F1 is a 6-volt, 33-ampere filament-ballast unit and C5 is a 100 mfd. 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 tube. V2 and V3 are H17s amplifier tubes of the 240 type, and V4 is a 75-watt power amplifier tube of the 210 type. C3, C3 and C4 are coupling condensers, having a capacity of approximately 0.01 mfd. 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, 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 190 volts and 13 volts are needed for the amplifier and detector tubes, respectively. Thirty volts of "C" battery is required for the power tube and 15 volts is needed for the first two audio tubes. The filament of the power tube is heated with 71/2 volts of A.C., which is provided by a step-down transformer FT. Lower "B" voltage yields a dimmer image.

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

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

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

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

The receiver is now ready to pick up the television picture. When a television program has been tuned in, the only problem is to adjust the speed of the disc to synchronize 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 diagram makes this clear. The rapidly-revolving disc, at the front end of the apparatus, contains the photoelectric cell, and when it is exposed to light, it is excited and sends out a current. This current is amplified and then sent to the receiver, which is located at a distance of approximately twenty-five miles.

The Photographic Pick-up

The apparatus is illustrated in Fig. 1. The diagram shows the apparatus as it would appear when the photoelectric cell is excited by light. The light passing through the lens and the photoelectric cell transforms the light energy into electrical energy, which is then amplified and transmitted to the receiver. The receiver converts the electrical signal back into light, which is then projected onto a screen.

The receiving equipment

One of the first requirements for receiving pictures is to have a detector that can detect the light. This is achieved by using a photoelectric cell, which is excited by the light passing through the lens. The cell sends out a current, which is amplified and then sent to the receiver. The receiver converts the electrical signal into light, which is then projected onto a screen.
New Belin Photo-Transmitter

Periodically, M. E. Demoulin Belin is brought to the notice of the scientific press. This inventor of a surprising number of photographic inventions has, by what he has done, his first achievements being in the line of photo-telegraphy, of transmitting photographic pictures by wire at first, then by radio.

How the Transmitting Set Operates

In a cylinder driven by a phonic wheel, which is regulated by a tuning fork, driven electrically, an ordinary photograph is rolled, face outward. The cylinder, during its rotation, is given a heliodromic motion. It is placed in a photograph, an ordinary telegraph, written with any ink, is placed on it, the system still operates. It transmits one or other document without having to receive any modification, as explained in Science and Inventions for June, 1928, by Lucien Fouquet.

Every light ray passing through this hole reaches the photo-electric tube, which represents in a sense the seat of a current, whose intensity will be proportional to that of the light.

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

An ordinary electric lamp contained in a tube sends out a luminous beam to a prism, which reflects it upon the cylinder at a point exactly in front of the hole in the dark chamber, and appears as a luminous spot upon the document. When a white surface comes under the luminous spot, it reflects a great part of the light received, but if the white surface gives place to a black surface, the light is practically completely absorbed, and no reflected ray penetrates the dark chamber.

In this case we will obtain a total emission of light, followed by a total interruption. And the photo-electric cell will be first traversed by a current of maximum intensity, and then will cut off this current sharply. And this is the phenomenon which is produced when an automatic dispatch written in black ink on white paper is to be transmitted; total emission under the action of the reflected ray and total interruption when a spot of ink comes in front of the dark chamber.

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

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

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

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

You must remember en passant, that the photo-electric cell contains a potassium cadmium and a tungsten wire. If a negative current is applied to the cathode, there is an emission of electric corpuscles between it and the anode, when a light ray, however feeble it may be, reaches the system. This cathode current permits the working current applied to the plate to cross over the various space between the two electrodes. (This Edison effect.) The photo-electric cell becomes then a conductor of current and closes the electric circuit.

It is opened automatically when luminescence emission ceased to affect it, and its conductivity is proportional to this intensity. So that if we modulate the luminous beam, the current passing through the tube will also be modulated.

Reception and Transmission

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

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

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

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

Now suppose that a manuscript is being received. The mirror will cause a slight displacement of the current upon the screen cutting the ray off when it moves away from the slot.

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

If the cylinders are turning in synchronism each will present at the same instant the same points of the same image before the luminous rays, and the points touched by the ray from the transmitter will take the same position on the receiving cylinder. All the points will succeed each other regularly, the reproduction of the writing will be obtained on the sensitized paper.

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

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

Now a few words regarding the maintenance of synchronism.

Synchronization

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

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

We need only say that the two cylinders emit at the beginning luminous spots which appear upon the screen placed in front of the transmitting system and the spots approach nearer and nearer until they blend. At this moment the cylinder is said to be in phase, and each two apparatus are allowed to operate normally.
How to Build a Radio Photo Recorder

One of the most important considerations in picture transmission and recording is that the two systems operate in absolute synchronism. In this case, it is necessary to have the receiving cylinder turn over at the same rate of speed at the sending end, i.e., 100 revolutions per minute.

The method is simply to have the receiving cylinder travel at a slightly higher rate of speed than that of the sending station. A spring stops the receiving cylinder automatically at the end of each revolution, and a separate but distinct impulse from the transmitter reacts on a relay that permits the receiving cylinder to begin its next revolution at exactly the same time as it did. Thus, the two cylinders begin each revolution on exactly the same instant, and the receiving cylinder is synchronized at every revolution. The wire is photographed and fed to a printer where it is recorded.

Work on the panel can now be started. On it are placed the filament and gain controls, vertical and horizontal 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 placed 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. This is important to test the relay circuits before the transformer, and instruct and connect them to the correct jack, relay, and other points in the modulation and oscillating circuits.

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

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

With a view to simplifying as much as possible the building back, the best that can be done is to have a machine, and also to use a machine for adjustment and wiring, and replacement, a large board is used for the back. The panel is of standard size, and it will accommodate all of the controls that are of immediate importance in the working of the machine. The success of the picture set will depend on the way it is assembled. Few, the audio and modulator transformers are tapped and hardwired with large gauge wire. Then, the sockets, fixed condensers, choke, filament control, and the coil. The suggested layout is followed. Experiments amateurs only will attempt to change it greatly.
nicety. Every time this relay trips, it will activate the magnet of the recorder machine. It must be balanced so that only the synchronizing signal, which precedes each picture impulse once a revolution, will trip it.

Then, the boosting 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 millimeter reading, when the relay and recorder magnets are energized. A reading of 15 milliamp in the plate circuit of the amplifier tube show a healthy operating condition.

This relay, as explained previously, will cause the recording cylinder magnet to stop its revolving once a revolution, in synchronism with the sending impulse. There may be some sparking at the contacts, which may be minimized by placing a large fixed condenser across them, or by increasing the space between contacts. The relay will trip at approximately 100 or more turns 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 its work. A millimeter reading in its plate circuit will determine this. The recorder depends upon the voltage generated in the step-up radio frequency transformer for the spark discharge.

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

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

After the picture is run off, it should be developed in the regular way, with a developing and fixing bath. As well as 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 a lower grade of paper, or, again, readjust the oscillating condenser so that the discharge will be weaker. 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 best picture.

If, at any time while tuning idly around, you pick up peculiar signals that sound like a badly grounded griddrode turning over at a fairly rapid rate, let your curiosity find out what it all is 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 pictures 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 aperature of a photoelectric cell, connecting to the transmitting apparatus. The mechanism is so arranged that the entire photograph will be broken 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 impulses sent.

At the receiving end, the wave is turned 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 mechanism.

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

CAPT. R. H. RANGER'S highly-improved and ingeniously constructed line-by-line television 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 (transmitting pictures, both over land and wire circuits and by radio across the ocean from England, employed a specially prepared wax ink. It was 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 unrolls 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 at the machine at the transmitting end, an electromagnet or solenoid connected to the receiver for example, causes the deflecting jet of cold air to be cut off. In consequence, the hot air is allowed to strike the paper and a brown line of certain intensity instantly develops. After the whole picture has been printed in this way it can be fixed by washing in clear water.

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

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

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, the 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 391 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 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 in a source of variable potential, rather than of current, as in this case, and the amplified 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 light-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-hydroxide photoelectric cell. This device, which is extremely sensitive to light, and to variations in intensity and color of light, transforms optical effects into variations in an electric circuit. Furthermore, the cell responds to these effects with extreme rapidity and a high degree of precision. The result is that the cell has a wide range of application.
Television’s Newest Developments

Covering Improvements by
Bell Telephone Laboratory
Baird System
Alexander
Nakken System (WNY)
Valensi
Clarkson
Campbell, Swinton
Jenkins

The Electric Eye

The transmitting apparatus for broadcasting television is not very complicated. The rays of a powerful arc light are broken up by the spirally-screwed 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 film of photostatic material in the electric energy circuits. These cells are then 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, modulated, and the carrier wave of the 37.8-megacycle transmitter, is interrupted and transmitted over the wire as short flashes of light. This condition can be easily adjusted, however, just as a line condition is remedied by the motion-picture operator when the picture goes out of its frame.

In the lower part of the cabinet, which may be seen, is another smaller area that houses the main circuitry, including the camera and the modulator. In this area, a large black and white screen is mounted on a stand which provides a means of adjusting the screen to the correct viewing position. The screen itself is a large black and white television tube, which is manufactured by the Westinghouse Electric and Manufacturing Company. This tube is designed specifically for television purposes and is capable of providing a clear and sharp image of the subject being televised.

The television signal is transmitted from the camera to the receiver through a parabolic antenna mounted on the roof of the building. The antenna is capable of receiving signals from a distance of up to 50 miles, and is designed to provide a clear and sharp image of the subject being televised.

The television receiver is a large cabinet unit, which contains all of the necessary components for receiving and displaying the television signal. The receiver is capable of displaying a clear and sharp image of the subject being televised, and is capable of displaying images from a distance of up to 50 miles.

The television receiver is capable of displaying a clear and sharp image of the subject being televised, and is capable of displaying images from a distance of up to 50 miles.

Synchronization by Hand

In Dr. Alexander's system no such complicated method of synchronization is employed; the television signal 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 disc it is driving, and the resultant image is a straight line of light. As the motor is brought nearer to the synchronous speed, this line of light breaks up into a series of parallel lines, starting first one line and then the other. Then there appears a distorted image of a face, again breaking up into epochs of light and dark. Finally, when the two motions are running in phase, a true image may be seen on the screen. This image constantly shifts from one side to the other, the speed of the two motors varying; but this shifting from side to side does not interfere with the reception, as the movement is made to be very slow.

Here is Dr. R. F. W. Alexander seen at the left.
Baird Optical Lever Increases Scanning Speed

Valenski Television System
Infra-Red “Eye” Sees at Night

VISION in total darkness and fog is now made possible through the recent invention of J. K. Bailey, 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. Recently heat rays have been measured which have a wavelength of 0.007 centimeters, or 160 times as long as the wave length of the red end of the spectrum, and from this limit there is an unbroken series to the end of the visible spectrum, as stated on page 211 of Science and Invention for July, 1927.

What might be termed the transmitting portion of the “Eye” consists of an infra-red ray projector. A standard arc type search light is used with a hand 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 connection with this analyzer is a revolving disc, which is slotted and at regular intervals varies the amount of the ray which is received by the photorelectric cell. The photorelectric cell itself is placed behind a disc revolving at a relatively low speed, which is spirally slotted, thus giving the cell three different portions of the reflected beam at a set time. The photorelectric cell converts the energy received into an electric current which is amplified by means of a bank of vacuum tubes. A neon lamp is connected to the output of the amplifying unit and two other discs, as previously described, are placed in front of the lamp. All of the disc are rotated in synchronism with each other, the two sets being joined by a chain or gear drive.

The “incredible search light” has been 300 to 300 times the penetrating power of ordinary light through darkness, fog or smoke and consequently will find many uses in our present day existence. Two-thirtieths of the energy in the search-light beam resides in the infra-red component.
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 engineer 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, that 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. Sexor 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 resonate, apparently, an electric charge when the crystal is twisted or pressed out of shape, without breaking it. It would seem, 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 waggings and unsteadings 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 pendulums 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-controlled 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 thermostat removes the electric heating coil from the circuit, and thus the air is warmed to the proper degree. The two dial gauges at the left of the panel of the oscillator indicate the currents passing in the tube circuits; while the two dials at the right of the panel are for adjusting the frequency of the oscillator.

Independence of Synchronization

For the purpose of a television-frequency control, as the pictures and diagrams here-with illustrate, a quartz crystal is connected to a vacuum-tube oscillator, together with a suitable vacuum-tube amplifier; the "line wave" alternating-current output of this set-up is fed into a high-frequency synchronous motor, mounted on the driving shaft, inside a 60-cycle synchronous motor. As the reader will probably recollect, in the Bell telephone 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 slipage 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 oscillation. A correcting button, however, is placed on the television machine cabinet, so that in the event that the picture should "shift" or become distorted, once in a great while, perfect synchronism can again be established by simply pressing a button.

Hook-up of Crystal

In Fig. 2 we have the electrical connections of the quartz crystal, in the oscillator-amplifier hook-up used in the latest Bell television system. As will be seen, the quartz crystal is 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 is adjusted. Whenever the condenser VC2 is changed, in order to tune this circuit to a frequency in a different band, another quartz crystal, calibrated for the approximate value of the new frequency or wave-length, is placed in the temperature-controlled receptacle housing the crystal.

The second variable-condenser dial, appearing at the center 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 resonants are thus made by means of this dial. In other words, the quartz crystal is ground and "lapped" in the laboratory until it is brought to the proper size, corresponding to the desired frequency. But, if it does not remain absolutely to that exact frequency, it may be made to do so by carefully adjusting the variable condenser dial VC2.

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

The output of either of the amplifier stages is in the form of a "damped" or alternating current, the frequency of which is maintained by an astonishingly high degree of accuracy. One of the problems met in maintaining constant the frequency with such a quartz-controlled oscillator, lies in providing a very stable and constant grid-leak resistor; for this particular circuit there has been developed a resistor of new type which will not vary as much as 0.1 per cent. Fluctuations or variations in the battery voltage are an important source of trouble. To overcome these, new maintained sufficiently constant, with a plus or minus variation of about 1 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 circuits so that variations in voltage will result in offsetting a change in frequency in one direction by setting up an equal and opposite reaction.

Regulating the Heat

Referring to the detailed illustration of the quartz crystal and its mounting, the crystal vibrates along the longitudinal axis of line of its greatest length. It is separated from the metal plates by alicycle, which also support it. Within the bakelite block which houses the crystal, the temperature must be kept at about 107 degrees Fahrenheit (F.), in order to reduce frequency variations due to the heat of the crystal and its consequent change in size to one part in ten million. (The frequency of the crystal is affected also, slightly, by changes in atmospheric pressure; as explained in a paper presented to the Audio Science Radio Institute at Washington, Oct. 13, 1927, by J. W. Herton and W.A. Morrison.)

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

The cylinder with the mercury-filled wall has lids on top and bottom, and this miniature "can" is called a "thermostat" (it is "rock crystal," the same mineral of which most of the "diamonds" you see in cheap jewelry are composed; but the value in its careful cutting and adjustment is placed in a box of wood 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-plate, inductance, amplifying tubes, ventilating fan, etc., is then placed within a larger closer cabinet, the wall of which is regulated to a constant temperature by a thermostat apparatus.

From Fig. 2 it will be seen that a resistor is connected in series with the "C" 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...
Vacuum Cameras to Speed Up Television

Fast Work

SUpOSE, 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, 50,000 impulses per square inch. Each impulse must be changed into electrical impulses. That means 1,000,000 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-fortieth of a second, or 25 flashes per second. The eye can be trained to see 17 flashes at all and, although the pictures were faithfully sent and recorded, to the eye the screen would be perfectly blank. In recording a 'fast-action' picture, such as requires a 1/20-second exposure instead of 1/10, the condition would be the same—only more so, says R. P. Clarkson in Radio News, page 22, for July 1928.

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

Scanning Apparatus

Now, as to dividing the image up into 1,000,000 dots or impulses in onetenth of a second, no device yet suggested can begin to approach that task. The Nipkow disk with its spiral openings patented by Alexander, in 1884, with the original form as used by Alexander, or with ones suggested by Mathbicld, in the form of whirling optical plate as Jenkins makes it, is perfectly useless for this purpose; not only because of the limitations of light to make room for enough holes, but also because of light limitations, as sufficient light won't pass through the holes. But, last but not least, there is the impossibility of synchronizing the transmitting and receiving circuits at that speed.

The only answer I know to this problem is the use of electrons moving under the influence of a changing magnetic field. This is the type of imaging-transmitting 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.
Electrons shoot from the cathode to the plate at a speed that may be as high as 100,000,000 miles per second. The beam is curved by an electric field and passes through the glass envelope of the tube. The deflection is controlled by the voltage applied to the control grid. The beam is focused by the focusing electrode, which is a thin wire located just inside the envelope. The beam is then directed to the phosphorescent screen, which is coated with a material that emits light when struck by the electrons. The light is then converted to visible light by the phosphorescent coating. The image is then projected onto a screen by the electron beam. The speed of the beam is controlled by the voltage applied to the control grid, and the deflection is controlled by the voltage applied to the deflection plates. The focusing is controlled by the voltage applied to the focusing electrode. The deflection and focusing are controlled by the voltage applied to the control grid, deflection plates, and focusing electrode, respectively.

The Penetration of Electrons
If we put an alternating current in coil A, the beam will move back and forth vertically in unison with the frequency of the coil. The beam will also be deflected horizontally, creating a pattern on the screen.

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 indicated path, through the resistor R and back to the cathode F along the filament wires, the beam itself and the conductive path in the plate completing the circuit. The screen S may have a positive potential bias to aid this action.

The Projector
Then, at the receiver, the amplifier output goes into the projector tube (see Fig. 2) which operates like any radio vacuum tube. The filament of the tube is heated by the current from coil B, and the beam is generated from the heated filament. The beam is then directed to the phosphorescent screen, which is coated with a material that emits light when struck by the electrons. The light is then converted to visible light by the phosphorescent coating. The image is then projected onto a screen by the electron beam. The speed of the beam is controlled by the voltage applied to the control grid, and the deflection is controlled by the voltage applied to the deflection plates. The focusing is controlled by the voltage applied to the focusing electrode. The deflection and focusing are controlled by the voltage applied to the control grid, deflection plates, and focusing electrode, respectively. The projector tube is also used to convert the image from the camera tube to a visible form on the screen.
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 dynamic 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 exposes 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 grid.

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

The varying electric current thus originated in the ignition and conduction of wireless waves, is transmitted to the receiver, where after further amplification and detection, it drives the strength of the receiving cathode-ray beam, which, in turn, affects the brightness of that particular portion of the fluorescent screen on which the end of the cathode beam is at that instant impinging. Thus on the receiving fluorescent screen a replica of the picture thrown by the lens on the transmitting screen is reproduced.

This is a patent applied for by the Westinghouse Electric & Manufacturing Company, the U.S.A., the invention date of which is July 13, 1925, and the complete specifications of which were accepted on March 31, 1927. In this, a gunnian grid is employed, and a large number of very small photostatic cells, similar to my suggestions of 1911 and 1924, the cells are composed of minute globules of specially prepared potassium hydride in an atmosphere of argon.

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

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 centres of the discs is just equal to the width of the film. The film moves steadily 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 3,000-lb. 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) 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 holes is to conduct light from the inner spindle to the holes in the outer drum with as little loss as possible.

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 design to the standard flat-plate neon tubes now sold generally for television purposes, but is in reality a quadr-
Practical Demonstrations Scheduled for WRNY

WITHIN a short time after the appearing of this issue of Television, the first television broadcasting experiment to be conducted by an American broadcast station, on its regular wave in the 300-500-meter band, will be made over WRNY, New York City. This pioneering work will be done under the direction of the writer, Theodore H. Nodaken, with apparatus of his own design and construction, according to his article in Radio News for July 1928, page 29. The plan is to give an initial demonstration of the system in the Hotel Roosevelt, New York, where the studio of WRNY is located. A television transmitter, or "televisor," will be installed here; and the image of a person will be broadcast on the 350-meter wave of WRNY from the transmitter proper, which is situated, at Cos Cob, 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 practicality 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 facts that broadcast stations must keep their radiated waves within a 10,000-cyclic band, which means that a carrier-wave (200 kilocycles in the case of WRNY) can be modulated by impulses up to only 500 cycles in frequency.

The receiving apparatus necessary for the reproduction of the televised images will be of such comparatively simple construction that any radio experimenter, given the few essential components that he cannot make himself, will be able to assemble a complete instrument in a few evenings. The receiving telescope may be improvised. The receiving screen will be coated with a material which will convert the light energy into electrical impulses carried through a cord which will connect to the regular output feed of the broadcast receiving set.

Announcements

In the present state of affairs, it will not be possible to receive both broadcast voice and music and the television images at the same time, because the electrical impulses carrying music will occupy the full legal "channel" of the transmitting system. First the WRNY announcer will speak, and then the television transmitter will commence. This there will be a slight pause between the end of the speech and the start of the television, to enable the listener to decide whether to plug in his speaker and to look at the television or receiver. If the speaker is left in the circuit it will cause a confused babbling of voices.

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

Synchronization

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

The actual television transmitting apparatus has been practically completed, as the accompanying illustrations show. The model receiver was still in "breechblock" form when this article was 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 prepared to be "televised," he or she merely sits down in the seat of the "illuminator," shown below. It is a square box fitted with twelve 50-watt lamps and a highly-polished reflector. Directly behind an opening about six inches square in the latter is a very "fast" lens (f 1.5) which concentrates the image of the subject on the revolving disc behind it, which is pictured separately at the lower right. The disc's driving motor, which is not shown, will be placed on the baseboard in the immediate foreground.

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

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

(On the very closing day of this number of Television, an announcement was made by the General Electric Company that station WGY, transmitting on its regular 380-meter wave, would commence broadcasting television programs on a regular schedule. The pictures will be sent from the WGY laboratories in Schenectady, N. Y., on Thursday, Thursday and Friday each week, between 7:30 and 9:00 p.m., Eastern Standard Time."

Only the faces of men talking, laughing or smacking 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 testing television apparatus of their own construction.

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

The television transmitting apparatus is a modification of the Alexander system 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 lies a heavy metal shield shown beside the tubes. This shield is grounded and has a small opening allowing the light rays to enter and strike the cell. The perforated disc is the large flat disc on the forward part of the baseboard.
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