NATIONAL RADIO INSTITUTE

Complete Course in PRACTICAL RADIO

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Radio-Trician
(Trade Mark Registered U. S. Patent Office.)

LESSON TEXT No. 39

TRANSMISSION AND RECEPTION OF PICTURES BY RADIO

Originators of Radio Home Study Courses
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Radio-Trician's

(Trade Mark Registered U. S. Patent Office.)

Complete Course in Practical Radio

NATIONAL RADIO INSTITUTE WASHINGTON, D. C.

Transmission and Reception of Pictures by Radio

HISTORICAL

Like all forms of communication, the transmission of exact reproductions has risen to commercial application, only after a long period of development and research.

In 1848, Alexander Bain received the first United States patent for a system of picture transmission. This system was crude and unworkable, but it contained the fundamentals of our present-day methods.

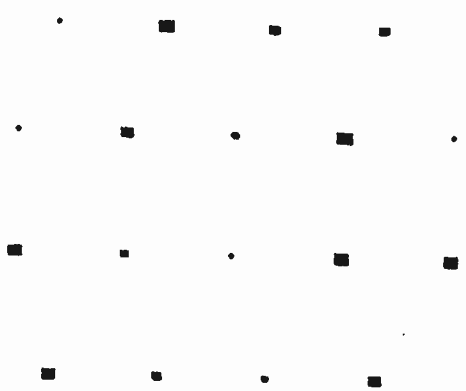

Fig. 1.—Korn Picture Receiving Typewriter Characters. A Nineteenth Character is that of Clear White.

It was not until May, 1891, that N. S. Amstutz, of Valparaiso, Indiana, sent a picture over telegraph wires twenty-five miles in length, accomplishing the first successful transmission.

Professor Korn, of Berlin, Germany, made further improvements and in 1906 transmitted pictures over several hundred miles of telephone wires. In 1908 he succeeded in accomplishing the transmission of pictures by radio.

The Great War, in 1914, forced the abandonment of plans for trans-Atlantic picture transmission, and it was not until 1923 that the development of long distance radio picture transmission was undertaken by various laboratories in the United States again.

The world is eagerly awaiting the inauguration of commercial radio pictures and radio-vision and the fact that the work is going on in earnest cannot be doubted, when it is realized that more than two million dollars per year are being spent in the United States alone in research work along these lines.

Practically all of our communication companies have developed systems for the transmission of photographs, and there are also several foreign systems.

To date some two hundred and forty patents covering the art have been issued, and as many more applications have been filed.

TYPES OF SYSTEMS

Today there are picture transmission systems working over telegraph, telephone and cable lines as well as over radio circuits. They may be classified under three headings, namely, *coded, dot-dash* and *modulated systems.*

CODED SYSTEMS. THE KORN SYSTEM

In coded systems no direct communication is employed. The picture to be transmitted is first coded by converting it into the form of a message composed of code letters. At the receiving end, the code message, which may be received over any existing telegraph or telephone circuit, is decoded by means of a chart or special decoding machine. Figure (1) shows the characters made by a special picture receiving typewriter for this system of transmission and from this an idea may be obtained as to how the different tonal values, of which the picture is composed, are put down on the recording paper at the receiver end of the circuit.

In June, 1922, the first picture was transmitted across the Atlantic Ocean by radio, (Figure 2). The transmitter was located at Rome, Italy, and the receiver at Bar Harbor, Maine.

This first trans-Atlantic radio picture transmission was accomplished by Professor Korn, by means of the coded sys-

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World.

YORK, SUNDAY, JUNE 11, 1922.

Entered as Second-Class Matter Post Office, New York, N. Y.

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WARD'S
R-IN-LAW
BLACKMAIL

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Mrs. Curtis, Who Is
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·ES SHE WILL
ON-IN-LAW'S LIFE.

Free on Bail—
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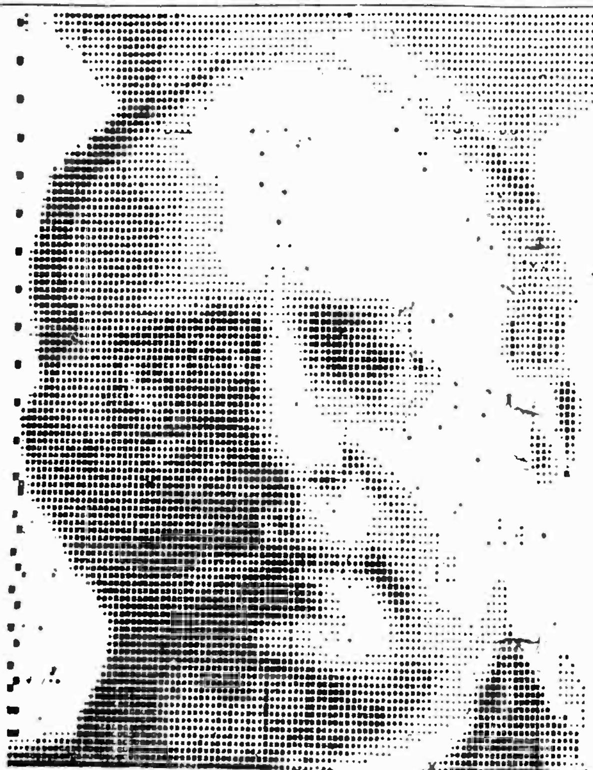

PHOTOGRAPH SENT by WIRELESS from ROME to BAR HARBOR, MAINE, REDUCED ONE-THIRD. AT LOWER RIGHT, PICTURE REDUCED to STANDARD ONE-COLUMN SIZE

PHOTO SEEN IN U. S. 40 MINUTES AFTER SCIENTIST IN ITALY RADIOS IT ACROSS

The World Offers Proof That Arthur Korn of Germany Has a Practical Apparatus for Sending Negatives to Any Wireless Telegraph Station.

NAVY STATION IN MAINE PRINTS PICTURE FROM ROME.

ufacturer who is married to an ... usually jealous wife. One evening you see this prospective customer dining in a restaurant with a chorus girl. What would you do?"

If you can answer that and 149 other queries to the satisfaction of

was one hour old. How long would it take to get four in the fourth generation?—i. e., four great grandchildren of the parent. (The parent counts as the first generation and the first offspring comes at the end of the first hour. All the animals live ...

Four of Family Killed as Train Strikes Motor Car

Fig. 2.—First Picture to be Sent by Radio Across the Atlantic.

tem. The picture was converted into a regular code message and transmitted, as such, across the Atlantic.

At the receiving end the code message was translated into the original picture by means of the special typewriter having the nineteen characters shown in Figure 1.

Figure 3 shows a sample of the tape that comes out of the printer in the course of transmitting a picture by this system. This tape, which carries the picture in letter form, may be given to any telegraph operator who will handle it in the usual manner employed in the transmission of ordinary traffic.

kk kkxxa qummz xxxx xxrrr rrrxx xxqx xxmmmm

bqqvo ojddd dddd dhjjj jjjj goova mxxrr rrk

Fig. 3—Korn Picture Code Tape as Delivered by a Picture Transmitter. This Tape is Then Transmitted by Manual Operation Where Automatic Radiotelegraph Facilities Do Not Exist.

Where the picture is to be transmitted on an extremely fast radiotelegraph circuit, the picture impulse can be sent

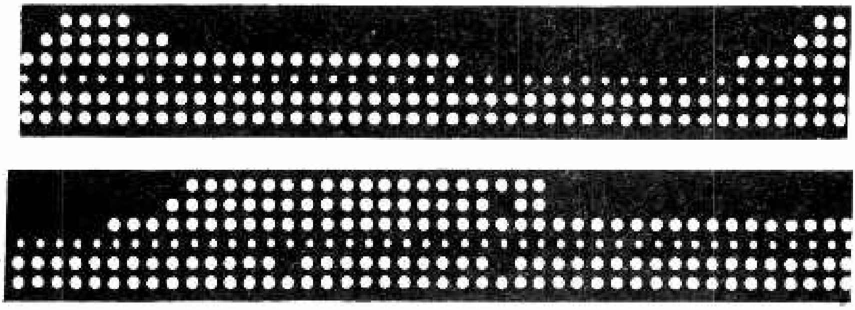

Fig. 4.—Samples of the Baudot Tape Used to Transmit Pictures by the Bartlane System.

directly into the keying circuit of the radio transmitter and when an automatic receiver is used, the transmission of the picture can be accomplished automatically, from start to finish. Where high-grade radiotelegraph circuits are not available, recourse to manual operation must be made.

When the code message is delivered to the operator of the picture receiver, he simply strikes the keys of a hand operated typewriter, whose characters are the eighteen values of picture gradation represented by the squares and dots of varying size, shown in Figure 1. The nineteenth character is "white."

In manual operation, to insure continuity in recording, it is customary to send the number of the line, immediately preceding the line itself.

Looking at the Korn picture shown in Figure 2, notice the similarity to the tonal construction of a newspaper half-tone. This characteristic in Korn pictures, permits their reproduction in newspapers, without putting them through any special process.

CODED SYSTEM. THE BARTLANE SYSTEM

We will now consider the Bartlane method of picture trans-

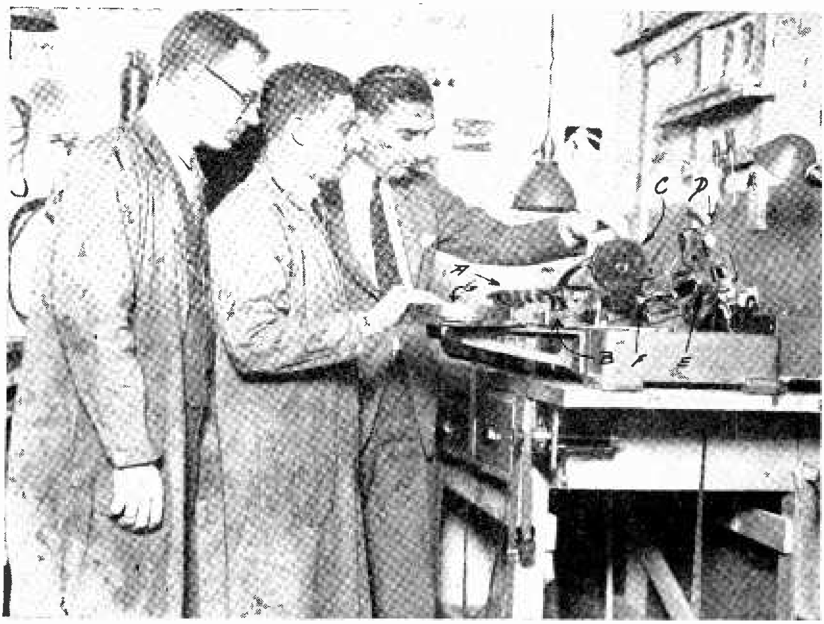

Fig. 5.—The Bartlane Transmitter.

mission which is at present being worked over trans-Atlantic cables, but which can be adapted to radiotelegraphic use.

The name Bartlane is coined from the names of its two inventors, Mr. Bartholomew and Captain MacFarlane, both of the Daily Mirror of London, England.

This system was invented in 1920 and the first trans-Atlantic cable picture was transmitted in 1921, between London and Halifax, N. S. It is like the Korn system, in that it employs the telegraphic typewriter to convert the picture values into those that will fit our standard forms of communication.

The Bartlane system utilizes the telegraphic typewriter to an even greater extent than the Korn system and one of the basic elements is the Baudot Tape.

Figure 4 shows samples of the Baudot Tape as used in the transmission of pictures by the Bartlane system. This type of tape is the one most used by English and American automatic telegraph printer systems. It consists of a central guide hole, three holes on one side of the guide hole and two holes on the other side.

The combination of certain holes, transmits certain impulses, which actuate the typewriter keys at the receiving station. Synchronism is positive and is effected by the central or guide hole.

In transmitting a picture by the Bartlane system, an ordinary photograph of the subject for transmission is made first. With the negative film thus obtained as a basis, five tint plates are made, by allowing five different periods of exposure.

Plate No. 1, for instance, might be exposed for two seconds; plate No. 2, for four seconds, etc. These plates are made of zinc and when they are developed, they will have a certain amount of insulating surface over part of the plate, which is, in effect, the half-tone characteristic. These plates will show an increasing amount of insulating area as the time of exposure, in the process of making the plate, is increased.

These five tint plates are attached to a rotating cylinder which is motor driven and synchronized with the tape punching equipment. Each of the tint plates has an electrical contact finger which operates its particular punch magnet, when a part of the tint plate having no insulating surface, touches the contact finger. In each unit length of tape, there is a space in which each of the five punches, operated by the contact fingers functioning on the five tint plates, may make a hole.

From the foregoing explanation you can get an idea how the tonal values that make up the picture for transmission, are changed into electric values by the contacts on the tint plates, and are then registered on the transmitting tape.

When there is a clear spot on all five tint plates, the contacts, "making" the circuit through the five punch magnets, will be closed and five holes will be punched in the transmitting tape.

As the cylinder is rotated spirally, all sections of the picture will eventually be passed over, and its respective shade punched in the tape. By use of this tape, signals will then be transmitted over the regular wire or radio printer circuit and on the receiving end will actuate what is termed a "reperforator." Figure 5 shows the arrangement of the Bartlane picture transmitter.

The "reperforator" is a machine which receives the incoming electrical impulses and translates them back into a tape that should be the exact duplicate of the transmitting tape.

In the receiver, a beam of light is focussed upon the tape as it is passed through. The amount of light that is permitted

Fig. 6.—Picture Transmitted and Reproduced by the Bartlane System.

to pass through this tape, is, of course, determined by the number of holes in the path of the beam of light.

This light after passing through the tape is focussed on a photographic film which is inside a light tight box. This film is wrapped around a cylinder which is the same size as the transmitter cylinder and its speed is regulated by means of the central synchronizing holes in the received tape.

A summary of the action involved shows that the picture for transmission is obtained in the form of a negative photographic film; five tint plates are made from this film and the picture is recorded on a transmitting tape, the five holes in the tape representing five different tonal values. Signals are transmitted to the receiver by means of the tape, these signals being translated back into the form of a tape again. Each of the five unit holes in the tape registers a definite tonal value on a recording film by means of a beam of light which is focussed on the tape as it passes through the receiving apparatus.

The outstanding features of the Bartlane system, are, *first*, automatic transmitting and receiving; *second*, the use of standard automatic telegraph tape; *third*, automatic synchronizing by means of the guide holes, and last, the transmission may be speeded up by breaking the tape at different points and transmitting the various sections thus obtained, over several channels, rejoining them before they pass through the picture receiver.

MODULATED SYSTEMS

Modulated systems are arranged to transmit pictures using signals of modulated character. Three methods will be explained, representative of the three different ways of producing modulated photographs. These three systems are the Belin Telestereograph, the Jenkins' method and the Phono-Photo, the latter being an invention of E. H. Hansen.

MODULATED SYSTEMS. THE BELIN METHOD

The Belin method, invented in 1908, was primarily designed for use on land lines. It was not used over radio circuits until 1922.

In the Belin system what is termed a "relief" cylinder, is used to carry the picture for transmission, rather than the varying light method produced by shining a light through the transmitting film, as in the cases of the transmission systems previously described.

The relief cylinder is made by taking an ordinary negative film, and printing through it, with a strong light, on a carbon-gelatine-bichromated paper. Upon development, the gelatine is swollen, due to the fact that the printing has baked the clear parts, hard, permitting the places where no light struck, to become soluble in water.

This print is transferred to a brass transmitting cylinder, and permitted to dry. When dry, it will be found that the lighter shades have practically no relief, and are down to the brass itself, while the darker tones attain a height proportional to their photographic value. The overall relief is some five thousandths of an inch.

Pressed against the cylinder, is a stylus, similar to a phonograph needle. This stylus rises and falls as it passes over the rotating cylinder, and this motion is transferred to the diaphragm of a microphone. The microphone is of the carbon granule type with a very thin diaphragm. Very little resistance, therefore is offered to the needle, thus preventing the scratching of the relief cylinder. As the diaphragm of the microphone moves up and down, the internal resistance of the microphone changes in accordance with these vibrations and a current, modulated in character, is produced in the microphone output circuit.

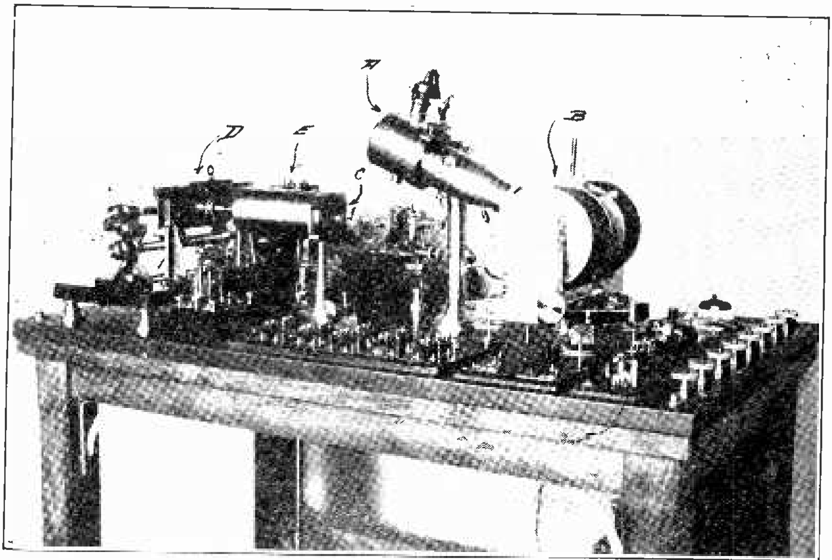

Fig. 7.—Belin Transmitter and Receiver.

The modulation frequency, which we may call "picture frequency," is very low, being from one to one hundred cycles. This frequency would be very inefficient if introduced directly into the modulating circuit of a radiotelephone transmitter so it is first used to modulate the output of a six hundred cycle tuning fork, which in turn, modulates the radio-frequency carrier wave.

These radio signals are received by an ordinary radio receiver, care being taken to provide for an efficient audio-frequency amplifier for the six hundred cycle modulation frequency.

In the output circuit of the audio-frequency amplifier, there is a step-down transformer to step down the voltage and step up the current for maximum effect upon the armature of the receiving oscillograph.

MODULATED SYSTEMS. THE JENKINS' METHOD

In the latter part of 1922, the first radio picture was transmitted by the Jenkins' system. This picture was transmitted

Fig. 8.—Reproduction from Transmitted Picture by the Belin System.

from the inventor's laboratory in Washington, D. C., to his home, located in the same city.

The outstanding feature of the Jenkins' system is the use of a prismatic ring for analyzing the surface of the picture to be transmitted. A beam of light, when passed through a rotating ring of this type, is caused to oscillate, having its hinged section, or line of action, fulcrumed, in the plane of rotation of the prism ring.

The oscillation is always in the plane of the diameter of the disc, from the point where the light passes through the prismatic ring section.

By the use of two of these rings, a beam of light can be thrown up and down, and from one side to the other. If both transmitter and receiver rings are rotating synchronously, the receiver beam will always be in the same part of the picture as the transmitter.

By means of a projection lantern and a transparent negative, the transmitter analyzes, or slices, the picture, and passes the beam of light from the source, on through to a photoelectric cell. This cell is arranged so that it converts the light variations impressed on it into electric energy, which in turn

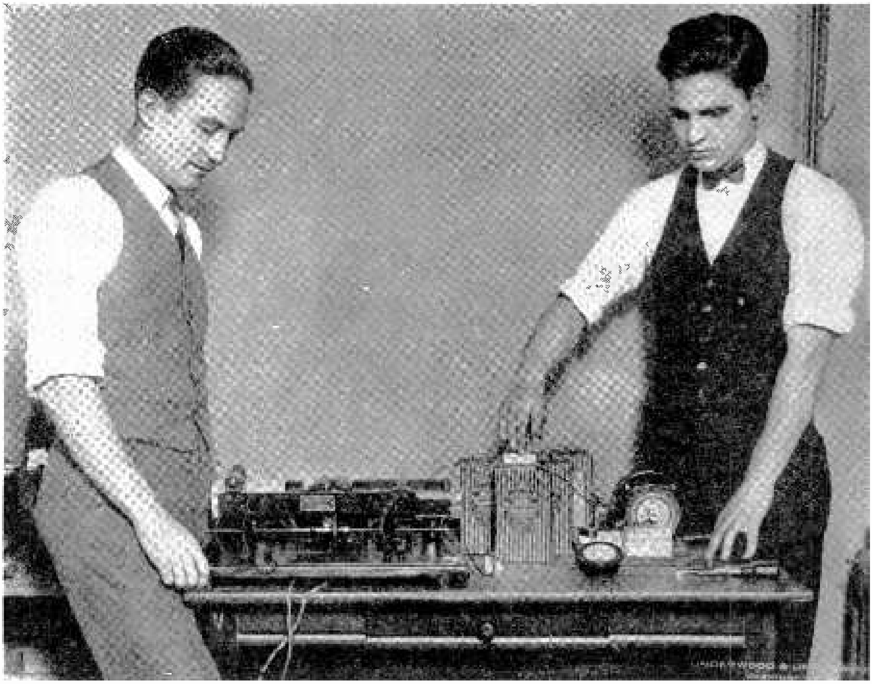

Fig. 9.—Jenkins' Small Machine for Sending Photos by Radio.

modulates the carrier-wave of the transmitter just as the voice frequency modulates the carrier-wave in radiotelephony.

The signals picked up at the receiver are applied to a pneumatic oscillograph, which reflects a beam of light through a set of prismatic rings. The rings allocate the light to its proper position on the flat recording plate.

The pneumatic oscillograph is a very clever invention of Jenkins' and is simply a radio headphone, with a mirror mounted in a small cap opening. The air pressure caused by the displacement of the diaphragm, causes the mirror to move and the beam of light is correspondingly shifted.

Synchronizing in the Jenkins' system is accomplished by synchronous motors driving the prismatic rings. In circuits where the transmitter and receiver cannot be supplied with the same alternating current for driving these synchronous motors, small dynamotors are used, their speed being maintained constant by electrically driven tuning forks.

The contacts of these forks are placed across the A. C. end of the dynamotor. Since both the fork and the A. C. generator have the same frequency, any attempt of the D. C. motor to speed out of phase, is checked by the torque of the coupling shaft of the A. C. machine.

A "Radio pen" which writes and draws pictures, tracing exactly the same lines as those laid down by a distant hand, is another device invented by C. Francis Jenkins, Washington, D. C.

MODULATED SYSTEMS. THE PHONO-PHOTO METHOD

This system, invented by E. H. Hansen, was first used in the transmission of pictures by radio, from the inventor's laboratory in New Jersey, to the New York Offices of the New York World.

In the modulated type of radio picture transmission systems, the results obtained are dependent upon keeping the received signal level, at a nearly constant value. The picture gradation depends upon the degree of modulation of the received signals.

In the Phono-Photo method, the modulation is accomplished by actually varying the transmitting wave-length. The receiving station is equipped with a radio receiver and separate heterodyne, set at a middle or mean value, and the transmitter varies the frequency from one side to the other of this middle frequency point. Thus, the received signal is of varying frequency characteristic rather than of varying intensity.

The transmitter consists of a cylinder, upon which is placed a black and white print instead of the negative film, ordinarily used in picture transmission systems.

A beam of light is focussed to a point on the print, which reflects an amount of light dependent upon the tonal value of the picture at that point. This reflected light is passed on to a light-proof box, within which is the photo-electric cell.

As the transmitting cylinder rotates, the spot of light passes over different sections of the print attached to the transmitting cylinder. Different values of light are reflected to the photo-cell and it changes these varying light values into varying values of electrical energy.

These varying electric currents in the photo-cell output circuit are amplified and used to control a solenoid operated condenser which is connected in the tuning circuit of the radio transmitter. This automatically variable condenser is applied in the master-oscillator tuning circuit of the type of radio trans-

Fig. 10.—Sample Picture Obtained by Jenkins' Method.

mitter employing a master-oscillator to control the frequency of the currents in the output circuit of the power amplifier tubes.

One of the advantages of this method is that it permits the full oscillator efficiency of the transmitter to always be employed instead of modulating the output as in the previous methods described.

The radio receiver is tuned to one frequency and the incoming signals of varying radio-frequency, subsequently set up signals of varying audio-frequency, in accordance with the varying light reflected from the transmitting print.

These received signals are applied to the coils of an oscillograph which actuates a mirror. The mirror reflects light on a sensitized recording film. The amplitude of the mirror varies in accordance with the frequency variations in the incoming signals and it is easy to see how the intensity of the signal output from the radio receiver would vary as the incoming frequency was the same or different from that to which the radio-frequency circuits of the receiver were tuned.

It will be noted, that although this system is classed as a modulated system, it is a frequency operated system, and is about thirty per cent more efficient, with a transmitter of a given capacity than the other modulated methods described.

Synchronism is obtained in this system by means of local chronometer circuits which actuate magnetic clutches. By means of commutators, the clutches traveling slightly faster than one revolution per second, are disengaged, and upon receiving the second impulse from the chronometers, are reengaged. Phasing arrangements are provided, in order that daily corrections may be made, at either the transmitting or the receiving station.

Figure 12 is a sample of a picture that was sent by radio by the Phono-Photo method.

DOT-DASH METHODS. THE TELEPIX SYSTEM

The dot-dash method is the most reliable for operation over great distances. One of the systems of this method was inaugurated, in the United States, in 1923. It is called the Telepix system and is the invention of Ferree and Wisner, of Chicago, Illinois.

The transmitter consists of a motor driven cylinder which carries the picture to be transmitted, in the form of an insulating photograph, upon a copper plate. This plate is made by first obtaining a photograph negative and then obtaining a positive from it. A screen, having horizontal ruled lines upon it, is placed in front of the negative during the process of making the positive.

This positive, which looks like a picture composed of ruled lines, is then placed in a printing frame with a copper plate which has been sensitized with a coating of bichromated fish glue.

After being exposed for a suitable length of time, the plate is developed and when this operation is complete, the picture is represented on the copper plate, by horizontal insulating lines of varying width.

The copper plate thus obtained, is then wrapped around the transmitting cylinder and a contact arm swung into place. The cylinder is rotated and as the contact moves over the insulation and the copper, dashes of varying length are transmitted for each of the horizontal lines passed over. A lateral

Fig. 11.—C. Francis Jenkins and His Device, "The Radio Pen."

movement is imparted to the cylinder by means of a screw feed. This gives approximately thirty-two lines per inch. The dashes sent out from the picture transmitter operate the control relays at the radio transmitting station and radio-frequency energy is sent out, in the form of dashes of varying length.

8x At the receiving station, there is a relay which controls a current supply to the recording cylinder. The recording cylinder is similar in size and shape, to the transmitting cylinder, and carries a saturated paper sheet. The two leads carrying the current supply to the recording cylinder from the receiver relay are connected to the metallic cylinder, under the saturated paper, and to the contact arm which rests on the surface of the paper.

Whenever current passes from the contact arm, through the paper, to the metallic cylinder, electrolytic action takes place and the recording paper is discolored at this point, due to chemical action taking place in the solution with which the recording paper is saturated.

Synchronism is accomplished by means of impulses sent over the signalling circuit. These impulses operate friction clutches at the receiver in a similar manner to that described in the Belin process.

Figure 13 is a picture of the Telepix transmitter and receiver.

THE PHOTO-RADIO SYSTEM OF THE RADIO CORPORATION OF AMERICA

The system developed by the Radio Corporation of America for the transmission of pictures by radio, is called, "Photo-Radio." It is the invention of Captain Richard H. Ranger, one of the company's designing engineers.

Captain Ranger started on the problem of transmitting pictures by radio, late in the year 1922. Two years later, in November, 1924, the results of his work were manifested in the successful transmission of pictures by radio, from London to New York.

At the present time, the R. C. A. has a practical method of transmitting pictures by radio. Since it is one of the foremost radio picture transmission systems, and in view of the fact that this part of the course has to do, primarily, with "Radio Pictures," we shall allocate more space to "Photo-Radio" than to any of the other various picture transmission systems.

Figure 15 is a drawing of the fundamental elements in the "Photo-Radio" transmitter. First, we have a concentrated source of light (A), the light rays from which pass through the condensing lines (B). This keeps the rays from spreading out and passes then on to the deflecting lens (D) which is inside the glass cylinder (C).

At (D), the light rays are bent through an angle of ninety degrees and directed at the focusing lens (E). According to the diagram, the light rays from the source (A) pass through the open end of the glass cylinder at (x) and out through the glass wall of the cylinder at (y).

The lens (E) focuses the rays of light on a minute aperture (G), within the dark box (F). This small aperture is about one sixty-fourth inch square. The light passing through here strikes the deflecting mirror (H), which bends the rays through an angle of ninety degrees and passes them

Fig. 12.—Sample of Picture Transmitted by Phono-Photo Method.

out of the dark box at (I), and on to the photo-cell box, within which there is a sensitive photo-electric cell.

THEORY OF OPERATION

Let us assume that there is an important athletic event taking place in London, England, and it is desired that a picture of the victor, in the act of winning, be available in New York, as soon as possible, after the completion of the event.

A picture of the event is taken with an ordinary newspaper man's camera. The film thus obtained is developed and attached to the glass cylinder (C). Either a negative or a positive film can be used, although a positive is preferred. For this particular type of equipment, the five by seven inch size gives the best results.

When the film is in place, the light (A) is turned on as is the main driving motor. The rays from the source of light are concentrated in a minute spot of very high brilliancy, at the point (y), where they pass through the glass walls of the cylinder and the film which is attached thereon.

If the dark box remained in one position, the mirror (D) would remain stationary and the spot of light concentrated on the film would also stay in the same place. The dark box does not remain in one position—it moves back and forth on the tracks (K), at a leisurely rate of speed, in a horizontal direction.

The mirror (D) always has the same relative position with respect to the focusing lens (E) so it follows, that as the dark box moves back and forth, the concentrated spot of light, whose position is controlled by the mirror (D), moves back and forth across the film which is attached to the surface of the glass cylinder.

Starting at the beginning of a cycle of events, we will consider the dark box at the extreme left of its movement in that direction. It now starts to move towards the right and as it does so the little spot of light moves horizontally across the surface of the film on the cylinder until it reaches the extreme right of the film.

At this point, the direction of motion of the dark box and of the spot of light is reversed and the cylinder, with film attached, is moved 1/120 inch in the direction of rotation. Now the spot of light moves back across the surface of the film, on a line 1/120 inch below its path from left to right.

At the end of the stroke from right to left, the direction of travel of the spot of light is reversed, the cylinder steps ahead 1/120 inch and a new portion of the film is covered by the light spot.

In this manner, the entire film is covered by the spot of light.

If there were no film attached to the surface of the glass cylinder, the beam of light passing through the cylinder and reaching the focusing lens, would always have the same brilliancy. However, the film attached to the surface of the cylinder, is dense in some places and thin in others, thus the beam of light passing through it varies in intensity.

The translation of the picture into light values is the first step in the transmission of pictures by radio. The thinner the film, the greater the amount of light that gets through; the denser the film the less the amount of light that gets through. Hence we have the different degrees of film density translated at this point, into terms of light values of different degrees of intensity, each light value reperesenting a definite film density.

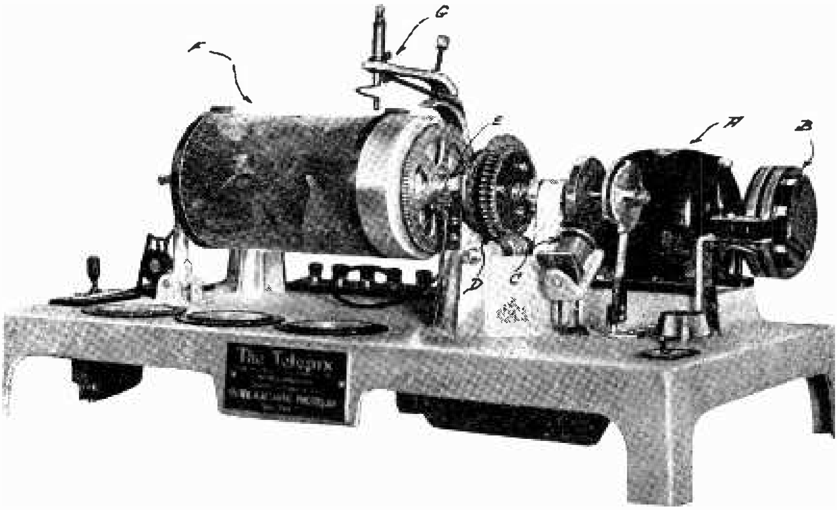

Fig. 13.—Telepix Transmitter and Receiver.

These varying light values are focused on the aperture (G), deflected by the lens (H) and enter the photo-cell box where they strike the sensitive surface of the photo-cell within.

We have translated the original film into light values but we can't send these light values very far and must eventually get them in terms of electricity if we wish to control the output of a radio transmitter.

The photo-cell is the device which is used to change the light values into electric values. The potassium type of cell is used, the selenium cell being too sluggish for picture transmission work. Fundamentally, it is a two electrode tube whose impedance can be made to vary in accordance with the amount of light shining on its sensitive surface.

In operation, it is kept inside of a dark box, isolated from all light, except that which comes to it through the film. With no light shining on it, the impedance of this tube is infinitely high and no current flows between the two electrodes, even though there is a high potential applied to the anode of the cell.

When light reaches the sensitive area within the cell, the impedance decreases to a certain value and there is a flow of current in the photo-cell output circuit due to the high potential applied to its anode.

The more light reaching the photo-cell, the greater the current flow in the photo-cell output circuit. However, even the maximum flow of current in the photo-cell output circuit is very small. In actual operation, if the photo-cell output current reaches 1. micro-ampere when the maximum amount of light strikes its sensitive area, this is quite sufficient for satisfactory results.

This, then, is the second step in the transmission of pictures by radio, the changing of the varying light values into varying electric values.

These minute currents are amplified by means of vacuum tubes and made to modulate the output of a 40 cycle oscillator. This oscillator, unmodulated, operates its output relay at the rate of 40 dots per second. A graphical record of the relay operation shows that its marking and spacing contacts are closed within an equal interval of time.

The Amplified currents from the photo-cell circuit modulate the output of this relay. The whiter or thinner the positive film on the transmitting cylinder, the greater the amount of light that gets through to the photo-cell, the greater the amount of current in the photo-cell output circuit, and the greater the spacing and the less the marking in the relay output.

This means that when there is a lot of light coming through the film, the output relay is making very light dots few and far between. When the maximum amount of light (the thinnest spot in the film), gets through to the photo-cell, the output relay doesn't go over to marking at all but remains on spacing.

When the beam of light from the source is passing through denser portions of the film, less light reaches the photo-cell, there is less current in the photo-cell output circuit and the oscillator output relay makes longer dashes with less spacing between them.

When the minimum amount of light is arriving at the photo-cell (due to the beam passing through the darkest portion of the film), the oscillator output relay remains on marking all the time.

This, then is the third step in the transmission of pictures by radio; the changing of the varying currents in the photo-cell output circuit into dots and dashes of varying length and frequency.

Fig. 14.—Sample of the Transmitting Plate for the Telepix System.

The photo-transmitter output relay puts polarized direct current on the control line to the transmitting station. (By polarized current we mean that the tongue of the relay is connected to the grounded neutral of a commercial 220 volt D. C. supply; the marking contact of the relay being connected to the positive 220 and the spacing contact to the negative 220 volt terminal. When the tongue of the relay is on marking, current flows down to the transmitting station in one direction and when the tongue of the relay is on spacing the control current flows in the opposite direction.)

These bidirectional direct current pulses control the output relays of the radio transmitter, and dots and dashes are sent out into the ether in the form of radio waves.

For transatlantic and transcontinental work, 200 K. W. radio transmitters are used. These stations are normally used in the transmission of long distance radiotelegraph traffic. When it is desired to send out a picture, the control is simply switched from the telegraph operator to the photo-transmitter. The high power radio station of the Radio Corporation of America, at Rocky Point, Long Island is used for this purpose. It puts around 500 amperes of radio-frequency current in the antenna.

These picture signals in the form of radio-frequency dots and dashes are picked up at a radio receiving station which has apparatus tuned to the wave-length on which the picture signals are transmitted. A station equipped to receive these signals has been built by the Radio Corporation of America, at Riverhead, Long Island. Here the radio signals are picked up on the receiving antenna, amplified, heterodyned, detected, amplified and sent in to the offices of the R. C. A., New York City, in the form of audio-frequency dots and dashes. These dots and dashes sound about the same as the dots and dashes that are made by opening and closing a 1,000 cycle buzzer circuit.)

These audio-frequency dots and dashes are amplified at the New York end of the line, rectified, and applied to a push-pull relay as unidirectional direct current pulses. This relay changes the picture signals to bidirectional direct current pulses and as such, they are applied to the coils surrounding the armature which is attached to the recorder pen. The recorder pen moves up and down in synchronism with the dots and dashes, leaving a visible record of the incoming signals on the receiving paper.

A pen carriage moves back and forth, horizontally, in synchronism with the dark box carriage at the transmitter. At the end of the travel of the pen carriage in one direction, the paper roll advances 1/120 inch. The picture is unfolded at the receiver, taking about 6 minutes to each linear inch of picture.

The spot of light moves across the thin portions of the

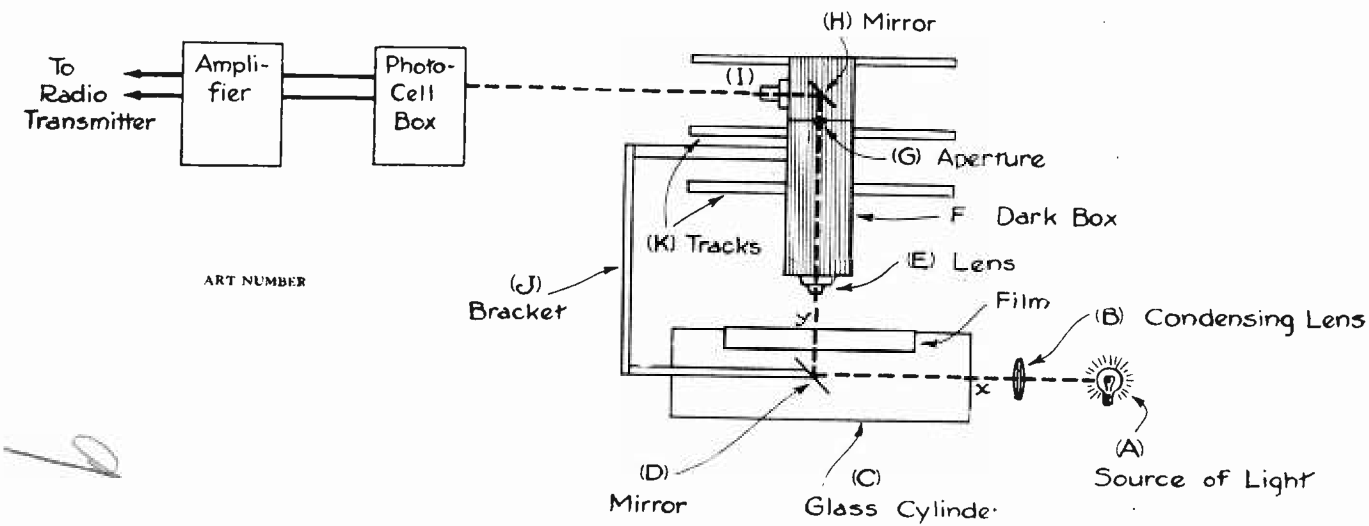

Fig. 15.—General Arrangement of the Fundamental Elements in the Photo-Radio Transmitter.

ART NUMBER

transmitting film and the incoming pulses at the receiver cause the recorder pen to make light dots as the carriage moves across the width of the recorder paper. As the denser parts of the transmitting film are covered by the light spot, the recorder pen makes long dashes as it travels across the paper.

Fig. 16.—Reproduction of Picture of Ex-President Coolidge, Transmitted from London, England, to New York City.

Normally, the recorded pen is not in contact with the paper; it is the signal currents passing through the armature coil that cause the pen to be pulled down against the paper.

One novel feature of the recording of the picture is that

(Continued on Page 27)

÷PHOTORADIOGRAM TRANSMITTING SYSTEM÷

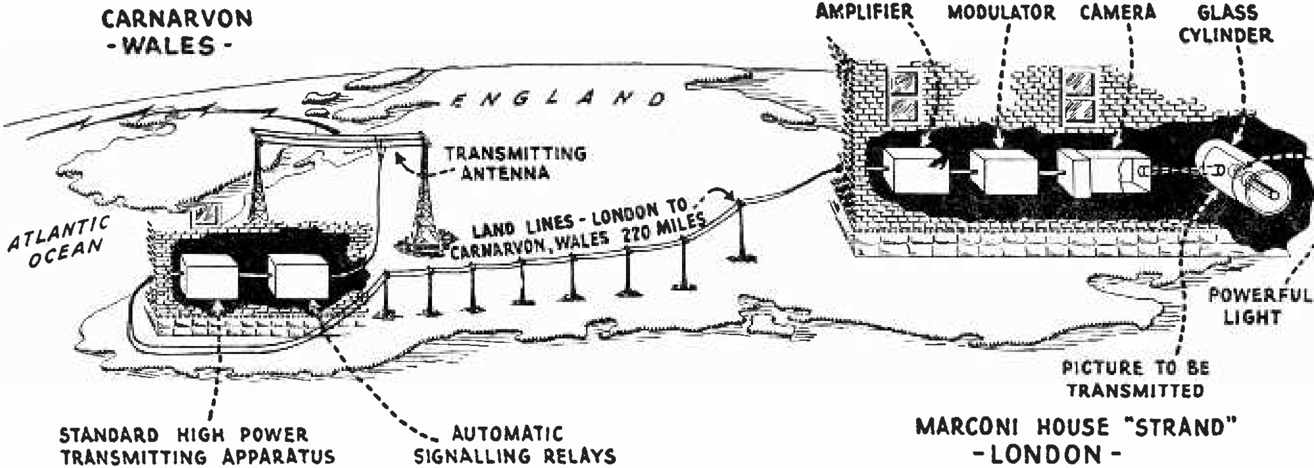

Fig. 17

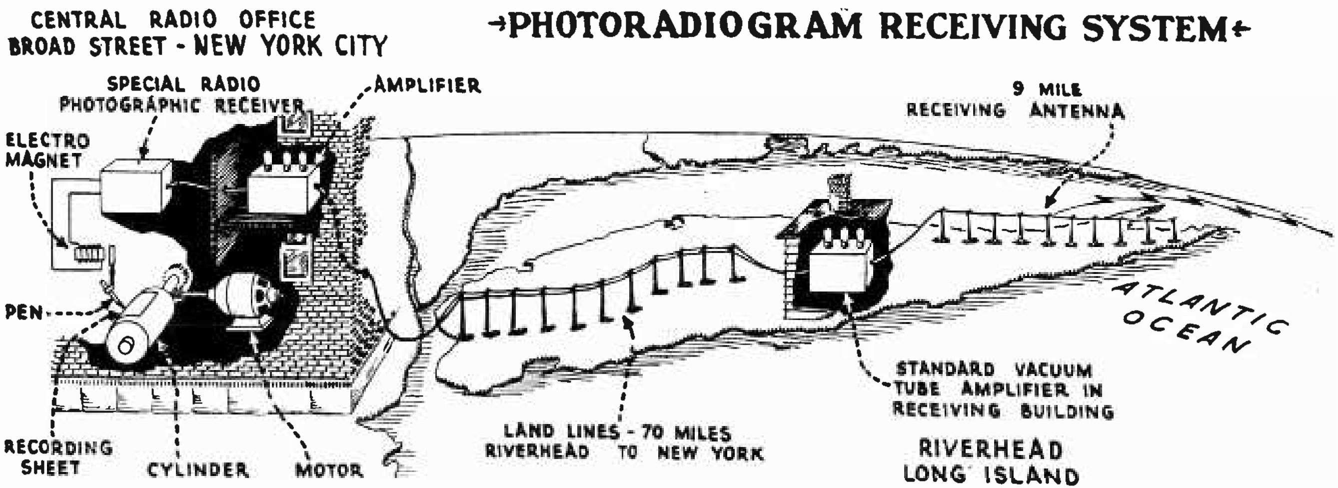
CENTRAL RADIO OFFICE
BROAD STREET - NEW YORK CITY
→PHOTORADIOGRAM RECEIVING SYSTEM←
SPECIAL RADIO PHOTOGRAPHIC RECEIVER
AMPLIFIER
ELECTRO MAGNET
PEN
RECORDING SHEET
CYLINDER
MOTOR
LAND LINES - 70 MILES RIVERHEAD TO NEW YORK
9 MILE RECEIVING ANTENNA
STANDARD VACUUM TUBE AMPLIFIER IN RECEIVING BUILDING
RIVERHEAD LONG ISLAND
ATLANTIC OCEAN

Fig. 18.

(Continued from Page 24)

the record is made in wax, not ink. The pen is fed with colored wax from a little wax-well, which looks much the same as an ink well. A small heater coil is incorporated within the well to keep the wax in the liquid state.

It was found with the ink method, previously employed, that, due to the carbon in the ink, if the receiver was left shut down for any considerable period of time (a few hours), the pen would be clogged up when the receiver was again started up. Even during operation, the pen was quite apt to clog or run dry, thus spoiling the picture.

The wax method of recording removed a source of trouble due to clogging pens. A receiver could remain idle for a week, then when it was started up again and the wax heater coil turned on, the wax would thaw out and flow freely. As soon as the wax is deposited on the recorder paper it returns to the solid state and there is no danger of its running.

SYNCHRONISM

Obviously, one of the basic elements of success in the transmission of pictures by radio is the absolute synchronism between transmitter and receiver. The spot of light that moves across the transmitting film must reach the end of its travel in one direction at exactly the same instant that the recorder pen at the receiver reaches the end of its travel in the same direction.

Synchronism is effected by having driving motors, for the moving elements of the transmitter and the receiver, that run at exactly the same speed. This speed in each case is maintained constant by means of a tuning fork. Hence, constant speed tuning fork controlled motors are used at both the transmitter and receiver. Auxiliary apparatus is connected in such a manner as to afford an automatic check on the constancy of the speed of the driving motor. Any discrepancies are taken care of by a small correction motor which functions on the main motor drive shaft.

RADIO PICTURES FROM LONDON TO NEW YORK

The first public demonstration of the working of this system of picture transmission was held on Sunday, November 30, 1924, at the offices of the engineering department of the Radio Corporation of America, New York City, where pictures transmitted from the offices of the British Marconi Company in London, by radio, were received.

Figure 16 is a copy of the first picture to come by radio from London. Figures 17 and 18 show, schematically, the circuits involved in the London to New York picture transmissions.

The photo-transmitter was located at the London offices of the British Marconi Company. The pictures to be transmitted were translated from the original films into light values, then into electric values and as such were put on the 220 mile land line to the radio transmitting station at Carnarvon, Wales. Here, the picture signals in the form of direct current pulses were made to actuate the output relays of the radio transmitter. The signals were sent out into the ether as radio-frequency energy, on a wave-length of 14,000 meters.

The signals from England were picked up at Riverhead, Long Island and relayed to New York over a 70 mile land line. At New York, they were applied to the photo-receiver equipment, which translated them into pictures.

SUMMARY

Before closing the discussion on this system, let us summarize the action that takes place in the transmission of a picture from one point to another by radio.

The subject is first photographed, the film thus obtained is attached to the transmitter cylinder, the film is translated into terms of light values, the light values are changed into electric values and modulate the output of an oscillator or dot-maker. These bi directional direct current dots and dashes operate the output relays of a radio transmitter, hence they are changed into radio-frequency dots and dashes (C. W.)

These radio-frequency dots and dashes are picked up on a receiving antenna and are amplified, heterodyned, detected, amplified, rectified, changed from unidirectional direct current pulses to bidirectional direct current pulses and as such are applied to the recorder pen on the "Photo-Radio" receiver.

TEST QUESTIONS

Number Your Answer Sheet 39 and add Your **Student Number**

Never hold up one set of lesson answers until you have another set ready to send in. Send each lesson in by itself before you start on the next lesson.

In that way we will be able to work together much more closely, you'll get more out of your course, and better lesson service.

1. Give the three classifications for transmitting pictures by radio.
2. Name the outstanding features of the Bartlane system.
3. Describe in a brief manner the underlying principles of one modulated method of sending pictures.
4. Explain how the picture frequency in the Belin system modulates the carrier wave.
5. Describe the action of the Photo-Electric cell in the Jenkins' system.
6. What is the usual method of synchronizing the receiving apparatus in the Jenkins' system?
7. Explain the essential feature of modulation in the Phono-Photo method by E. H. Hansen.
8. How is the picture recorded in dot-dash method by the Telepix system?
9. Show by a drawing the fundamental elements of the Photo-Radio transmitter.
10. What type of current is used to operate the control line to the transmitting station?

RADIO BY MAIL

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