Radiomovies
Radiovision
Television

Dedication

¶ *The thing is done, the long pull is ended—we are broadcasting radiomovies entertainment to thousands: and the credit, in no small measure, is due to the clever and charming young folks who have worked with me—Sybil L. Almand, Florence M. Anthony, Vera T. Hunter, John N. Ogle, Stuart Jenks, Paul Thomsen, and Elwood Russey.*

Mr. C. Francis Jenkins

Born in the country, north of Dayton, Ohio, in 1868, of Quaker parents. Spent boyhood on farm near Richmond, Indiana. Attended country school; a nearby high school; and Earlham College. "Explored" wheatfields and timber regions of Northwest, and cattle ranges and mining camps of Southwest United States. Came to Washington, D. C., in 1890, and served as Secretary to Sumner I. Kimball, U. S. Life Saving Service. Resigned in 1895 to take up inventing as a profession. Built the prototype of the motion picture projector now in every picture theater the world over; developed the spiral-wound paraffined all-paper container; and produced the first photographs by radio, and mechanism for viewing distant scenes by radio, and radiomovies for entertainment in the home. Has over four hundred patents, foreign and domestic; and maintains a private laboratory in Washington. He is a member of the Franklin Institute, the American Association for the Advancement of Science, National Aeronautical Association, and founder of the Society of Motion Picture Engineers. Has several times been honored by scientific and other bodies for original research and attainment.

Preface

I presume that no other invention has ever had so much advance publicity as television, radiovision, and radiomovies, before the same was made available to the public. In this respect it is certainly unique, for printer's ink by the ton has been spread over type faces with this very result.

And perhaps this is well, for it most assuredly has stimulated a competitive activity in development, greatly to the benefit of the public, and probably not possible of attainment by any other means.

When, in June of 1925, I gave the first public demonstration of radiovision and radiomovies, the attainment was broadcast by the Associated Press and given world-wide front-page publicity.

But still no spontaneous response by the public was evident until in April, 1927, the A. T. & T. Co. transmitted visual images of living persons from Washington to New York, over their regular wire channels of communication.

This transmission of visual images over wire was described in prepared press matter as "television," just as a wire instrument for audible communication is called a telephone; and a wire message by dot-and-dash translation a telegram.

And so in this book the word "television" will be used in just this way: i.e., the transmission of living images by wires; while the process of transmitting images by radio from living subjects will be called radiovision; and broadcast records on film of these persons and scenes will be styled radiomovies. These definitions make for intelligible discussion of the several subjects.

As wires were not readily available to me, my activities have been almost wholly limited to the methods and mechanisms employed (since the writing of the 1925 book) in the transmission and reception of radiomovies and radiovision.

This volume is primarily intended to treat of that formative period between the first constructive demonstration of electrical transmission of vision, whether wire-carried (television) or radio-carried (radiovision), and its general public acceptance as a source of informative entertainment in the home.

With this object in view it would seem quite appropriate that the principles involved be explained and illuminated by analogy, and the apparatus be described and illustrated in detail, from the simplest form to the more complex.

And while the best television, radiovision and radiomovie pictures are still crude, at the time of the writing of the copy for this book, there is a fascination in mysteriously picking electrical signals out of the invisible space about us and building up a moving picture therefrom; a thrill which equals, if indeed it does not exceed, the first audio music of the crystal and headphone set of the early days of broadcasting.

As is generally acknowledged, the wonderful development of shortwave, high-frequency radio communication is due to the American amateur, so I invited him to participate with me in the development of visual radio. With this object in view we began broadcasting radiomovies July 2, 1928, on a regular schedule. This gave the amateur action-pictures to "fish" for; and during August following a hundred or more had finished their receivers and were dependably getting our broadcast pictures, and reporting thereon, to our great help.

At this writing thousands of amateurs fascinatingly watch the pantomime picture in their receiver sets as dainty little Jans Marie performs tricks with her bouncing ball, Miss Constance hangs up her doll wash in a drying wind, and diminutive Jacqueline does athletic dances with her clever partner Master Fremont.

Silhouettes only were initially broadcast by us from W3XK, in order that the picture frequencies band might be kept within the legal limit, i.e., 10 kilocycles. And, also, these silhouettes were very much easier for the amateur to get, while he was building up a technique.

Some time after these broadcasts were begun, our need for a wider band, which would permit the broadcasting of halftone movies, was presented to the Federal Radio Commission, and a band 100 kilocycles wide was assigned us (4,900 to 5,000 K.C.)

These halftone broadcasts are received on your radiovisors as readily as the silhouette radiomovies, and bring us a milestone nearer the promised goal, now not so far away, when we shall see world events as we sit at our fireside.

I should like to take this occasion to express my appreciation of the liberal and helpful attitude not only of the Radio Commissioners, personally, but of the officers of the Radio Division of the Department of Commerce before Congressional authorization of the Radio Commission. I have had every possible evidence of a friendly, helpful spirit. With such a stimulus we could not fail.

As to the future; it is confidently believed that by the time this book is off the press, a machine I now have in work, built on an entirely new principle, will be completed. With this transmitter, inaugural ceremonies and similar national events, baseball and other outdoor sports, theatrical performances, and even grand opera will ultimately be broadcast for home entertainment.

And so a new industry appears in swaddling clothes. In due course it will toddle forward on uncertain feet; will have its struggles with measles, toothache, and growing pains; eventually to arrive at man's estate, to add to the comfort and enjoyment of millions.

Index

RADIOMOVIES

HOW TO MAKE YOUR OWN RADIOVISOR

Radiomovies*

HOW TO MAKE YOUR OWN RADIOVISOR

The telescope enables us to see to great distances, but only along straight lines. As our only long, straight lines lead away off into space, telescopes are necessarily pointed skyward.

But with the radio we can see along curved lines; we can see around obstructions, and over mountain ranges—may one day even see halfway around the earth. What a stimulus to peace between nations!

Then folks in California and in Maine, and all the way between, will be able to see the inaugural ceremonies of their President in Washington, the Army and Navy football games on Franklin Field, and the struggle for supremacy in our national sport, baseball.

This pantomime story-teller will come to our firesides as a fascinating teacher and entertainer, without language, literacy, or age limitation; a visitor to the old homestead with photoplays, the opera, and a direct vision of world activities.

The first public demonstration which proved conclusively that this could be done was made three years ago, on June 13, 1925, when readily recognizable moving objects in the Naval radio shack, NOF, at Anacostia, were seen in my laboratory in Washington, by Secretary Wilbur and admirals of the Navy; by Acting Secretary Judge Davis and Mr. W. D. Terrell, of the Department of Commerce; and by Director Dr. Geo. M. Burgess, and Secretary Henry D. Hubbard, of the Bureau of Standards, and many others.

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* Reprint from Science Service syndicate copy.

Radio vision is not visionary, or even a very difficult thing to do; speech and music are carried by radio, and sight can be so carried just as easily. For radio is not a noise; it is a carrier, comparable to copper wires extending in every conceivable direction from the broadcast station.

Doubtless the story of motion picture entertainment in the theater will be repeated in radiomovies in the home.

On July 2, 1928, at 8 o'clock, Eastern Standard Time, Station W3XK, the Jenkins Laboratories, Washington, D. C., inaugurated the first regular schedule of broadcast radiomovies.

These broadcasts were continued for an hour each Monday, Wednesday, and Friday, on 46.72 meters (6,420 kilocycles) for distant reception, and 186 meters for local receivers.

Silhouettes only were transmitted initially, because picture stories in silhouette are easier for the beginner to pick up; and obviously the width of the picture-frequency band is very much less, and, therefore, the latitude is greater.

Simple subjects were first broadcast, then more elaborate subjects, and still later picture stories. As with other broadcasting, an announcement preceded each feature, and each picture story finished with the word "End." A switch then substituted the loud-speaker for the picture receiver again, ready for the next announcement.

But it was soon discovered, in repeated broadcasts of radiomovies, that radio stories in silhouette were just as entertaining as movie cartoons in the theater.

It has been predicted that such broadcasts, combining pantomime fascination of motion pictures with the intriguing mystery of radio, will build up a demand for mechanisms never before equalled in the history of human entertainment.

Nor has any invention ever had so much anticipating publicity—a publicity which antedated the actual completion of its successful attainment by fifty years.

And this in spite of the fact that it is based on one of the simplest of the mysteries of our childhood, when mother drew parallel lines across a piece of paper, under which she had put a penny, and made a pictures of the Indian appear. The explanation, of course, is that the humps on the penny varied the pressure of the pencil on the paper to build up a picture, though the lines were drawn straight.

This is exactly the process employed in the reception of radiovision or television images. However, instead of a pencil the lines are drawn with a point of light, sweeping across the picture screen in successive parallel journeys, at the same time the intensity of the point of light is varied by the incoming radio current to make the picture.

Each picture frame is thus covered every fifteenth of a second, and persistence of vision builds up the image directly on the eye, and we say we see the living person at the other end of the television wire or the radiovision channel.

Because of the anticipating publicity referred to, and now that it is actually done, there probably exists a latent interest in visual radio which will unexpectedly burst into a torrential demand for receivers.

Because such sets are not now available, it is expected that amateurs all over the country will be building their own motion picture receiving sets, just as they built their first crystal and headphone audio sets.

It is the object of the following description, then, to show just how simple this mysterious thing, radiovision and television, is; and how quite inexpensive receivers can be made by most any one clever in the use of common tools, in anticipation of the day when radiovisors will be as common in the home as audio-receivers are now.

Perhaps it should be explained here that, in the following pages, radiovision means radio transmission and reception of images from living objects and scenes, and radiomovies the transmission of such subjects from a record of them on motion picture film.

To the present time, the fundamentals of all systems are the same—only the mechanisms differ. And but two methods are employed, i.e., the disc scanner and the drum scanner.

Owing to the limitations of the disc scanner, it may not unfairly be compared to the first audio-radio receiver, the crystal and headphone set; and because of its greater possibilities, the drum scanner may just as fairly be considered comparable to the three-element tube. The disc receiver is the simpler mechanism and will be the one first described herein, the drum scanner requiring in its construction parts not so easily had.

But both devices scan the picture in the same way; namely, they build up a picture line by line, from left to right, with line distribution from top to bottom, in consecutive sequence just as you read the lines of type on this page.

Each radiovision picture frame is thus made up of forty-eight lines for quality of detail, and fifteen picture frames per second to get the smooth continuity due to the persistence of vision of the human eye.

The Standardization Committee of the Radio Manufacturers Association at its Chicago meeting October 13, 1928, to which Mr. Jenkins had been invited, adopted these three factors as standard.

Just because the picture-receiver described herein is so simple, don't think it won't work. It will, and will give very interesting motion pictures, for that is exactly what they are in the radio-receiver; small pictures, to be sure, but fascinating pictures, nevertheless, mysteriously picked out of invisible space.

In the disc-receiver there are but three parts, a neon lamp, a scanning disc, and a motor to rotate it. You will need to buy only the neon lamp, G-10 A.C., 110-volt lamp, which can be obtained at most electric shops for 55 cents. You can also buy the scanning disc, if you prefer. Made with accurate tools, it may be better than you will make without. The scanning disc shaft (Fig. 3) should be made by a model shop or machine shop, with the two brass bearing-bushings referred to later, though you can use a 5/16-inch square-head bolt 5 inches long with two nuts and three washers thereon between which the scanning disc is clamped.

You will also want four round-head wood screws No. 10, 1¼ inches long, together with a half pound of ten-penny nails.

The material needed will be a ¾-inch board 8 x 15 inches; another ¾ x 6 x 8 inches; two ¾-inch strips 3½ x 8; one ¾ x 17/16 x 6 inches; and a block ¾ x 1½ x 2 inches. The block has a ¼-inch hole bored through it endwise; the 6-inch piece has a 5/16-inch hole bored into the end 2 inches deep, and a ½-inch hole through it the thin way, an inch from the end, and intersecting the 5/16-inch hole. In the larger board cut a slot 1½ inches wide and 9 inches long,

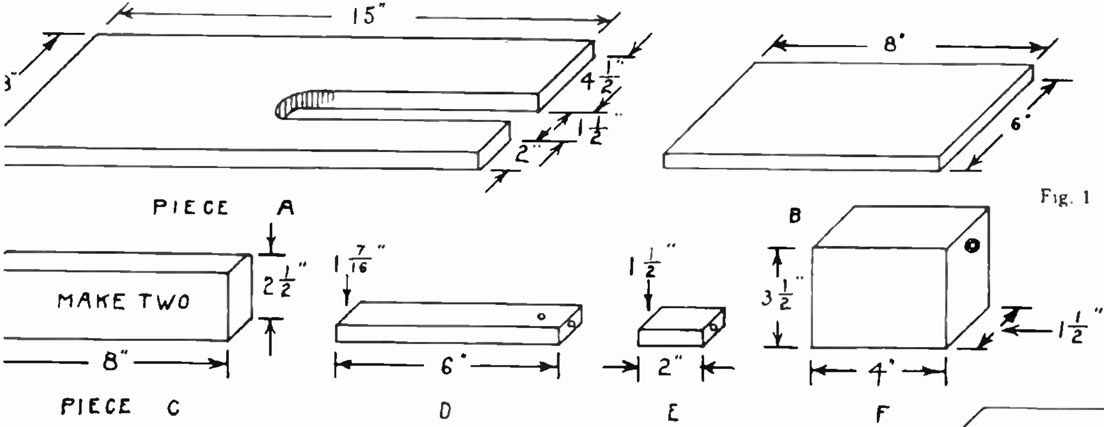

15"
3"
4 $\frac{1}{2}$"
1 $\frac{1}{2}$"
2"
PIECE A
8"
6"
B
MAKE TWO
2 $\frac{1}{2}$"
8"
PIECE C
1 $\frac{7}{16}$"
6"
D
1 $\frac{1}{2}$"
2"
E
3 $\frac{1}{2}$"
1 $\frac{1}{2}$"
4"
F

Fig. 1

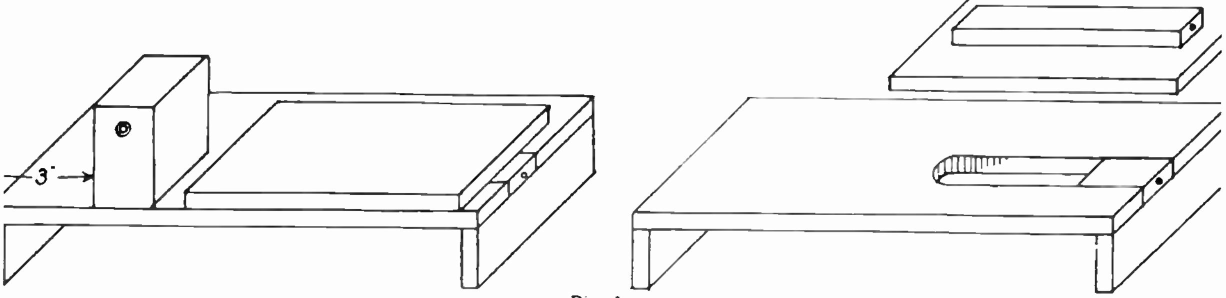

3"

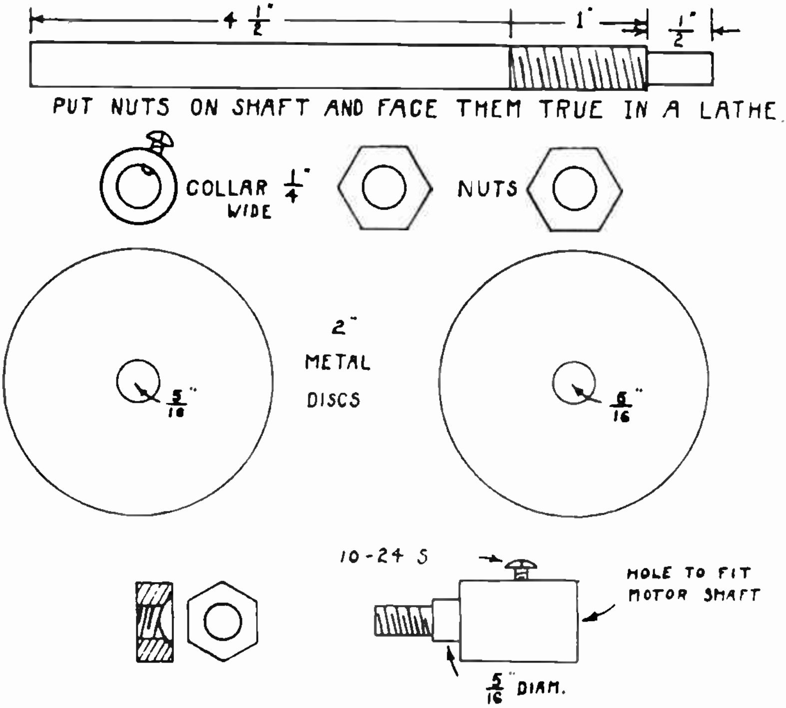
Fig. 2

2 inches from one edge. All these pieces are illustrated in Fig. 1, and may be made of most any kind of wood.

Get a maple (preferably) block 1½ inches thick, 3½ inches wide, and 4 inches long. Bore a hole through it endwise, ½ inch from the top edge. Into each end of this hole push tightly fitting brass bushings each an inch long, the bushings having 5/16-inch holes therethrough. Bore oil holes down into each bushing.

Under the ends of the large board, the baseboard, nail the 8-inch strips; and in the slot, flush with the end, glue or otherwise fasten the block. On the bottom of the smaller board, the motor board, screw the 6-inch piece, equi-spaced endwise, 2 inches from the far edge with the holes to the right. See Fig. 2. Then assemble the two by putting the strip on the motor board into the slot in the baseboard. Now fasten the scanning-disc shaft-bearing block with an end flush with the long edge of the baseboard and parallel to and 5 inches from the end of the board, with two screws up through the baseboard into the block. A hand drill will be a great aid.

For the scanning disc, cut a 12-inch diameter disc out of most any thin material, like sheet iron, "tin," brass, aluminum (blacked), millboard, cardboard, or even heavy black paper. The best results will be attained by first putting a 5/16-inch hole in the center of a roughly cut out disc, mount it on the shaft on which it is finally to be used, then turn it slowly while holding a knife-blade, or other sharp tool, against the disc 6 inches from the center of the shaft. With the point held steady on a block or the like, a scratch can be made on the disc which is a true circle, 12 inches in diameter. A sharp pencil will do to mark paper or cardboard, of course.



PUT NUTS ON SHAFT AND FACE THEM TRUE IN A LATHE.

FIG. 3

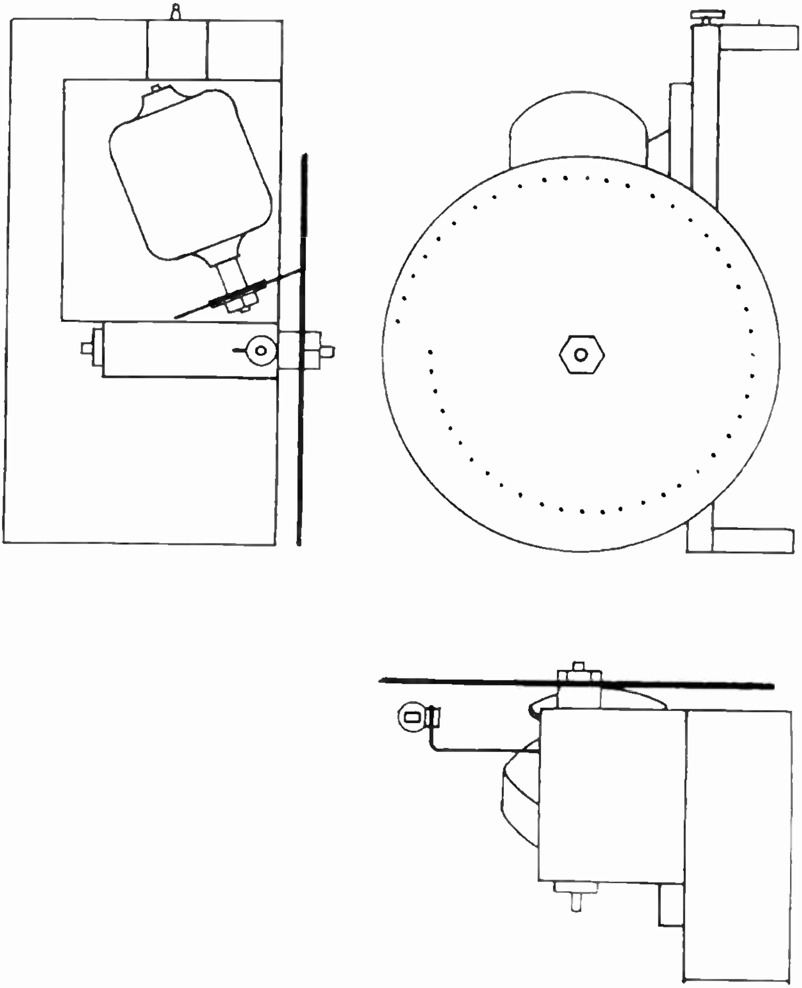


FIG. 4

With tinner's snips, if metal, or scissors, if cardboard or paper is used, a disc will be cut out along this circular scratch. But before doing this, divide the circle into 48 equal spaces. With a pair of dividers this can be sufficiently accurately done, though it is tedious, and takes time to do well. Take the disc off the shaft to lay out these 48 dots on the circular scratch. The 48 spaces will be a little less than ¾ inch separated. Next draw radial lines from the center of the disc to each of the 48 equi-spaced dots on the circle.

Now put the disc back on the shaft, held tightly thereon with the nuts, and tie on the outer end of the shaft a shoemaker's thread, a fish-line, or similar string not easily stretched. Wrap the string around the shaft a few times so it will "stay put." Into a loop at the other end of the thread put a pencil or scratcher held steady, perpendicular to and touching the disc near the bottom edge. By turning the disc a spiral line is drawn on the disc because the thread wraps up on the shaft, shortening it as the disc is rotated. The spiral should begin about ¼ inch from the edge and make a complete turn. The beginning and the end of the spiral will be a little less than ¾ inch apart.

Where this spiral line crosses the radial lines is where the 48 scanning holes are to be drilled, if the disc is metal, or punched, if the disc is paper.

The spirally located scanning holes should be about 1/32 inch in diameter. Theoretically this is too large, but it will give a brighter picture, and, like the method of laying off the scanning disc spiral, is not sufficiently wrong to be noticeable.

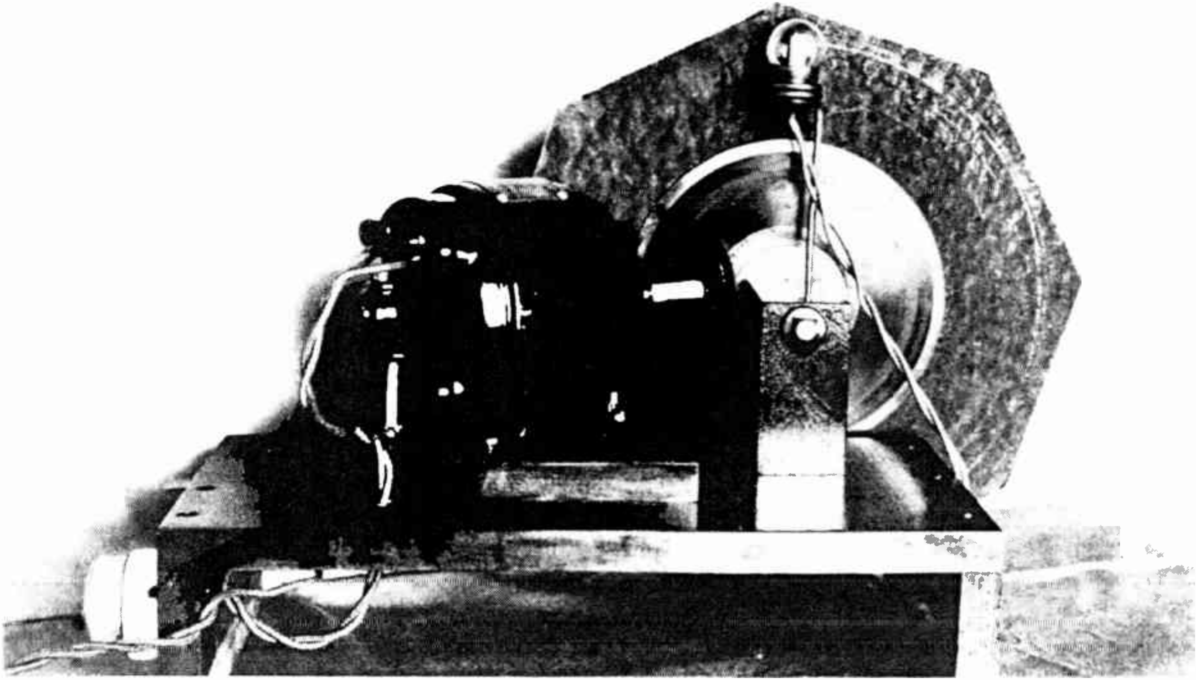
If a paper disc is used, punch the holes by breaking a needle in two and use as a punch, on the sawedoff end of a block of wood. The pieces punch out, leaving a clean hole, if the punching is done in the end of the block against the grain of the wood.

With the scanning disc back in place on the shaft, mount the neon lamp close behind the disc at the top. A very convenient lamp holder can be made of a piece of No. 10 wire wrapped about three times around the end of a broom handle with a separation that fits the threads in the screw base of the lamp. Push the straight portion of the wire into a hole in the shaft-bearing block, and bend the wire so that the spiral holder stands up like a candle holder.

The receiver is now ready for the motor. Most any small motor will do, A.C. or D.C. to suit the house current, and 1/20 h.p. is ample. On the shaft of the motor put the hub (Fig. 4) with nut and flanges between which a rubber driving flange is clamped. This driving flange is cut from a punctured or blown-out inner tube automobile tire. First cut a center hole 5/16-inch diameter. Cut the disc out roughly and put it on the motor hub. Start the motor and touch the disc with a pencil about 1½ inches from the motor shaft center. Now take the rubber disc off and, with sharp scissors, cut on the pencil line, which will give you a 3-inch rubber driving disc when clamped between the 2-inch flanges of the motor hub, and the nut tightened.

The motor hub is best made in a machine shop, and like it is shown in Fig. 4, although a driver can be made by fastening the rubber with shellac to a wooden disc slipped tightly on the motor shaft.

Now set the motor on the motor board, and fasten it in such a position that the rubber disc bears lightly against the back of the scanning disc about 2½ inches from the axis of the scanning disc, when the



Completed Radiomovies Receiver exactly as it was completed by an amateur from the parts herein described and illustrated.

motor board is midway of its possible movement. If a paper scanning disc is used, it may be necessary to put it between two toy talking machine records, for the driving disc to bear against.

Synchronism is attained by moving the motor board to or from the center of the scanning disc, by the screw S shown in Fig. 6. This is a long-shank round-head ¼-inch machine screw with nut, or a squareheaded bolt about 3½ or 4 inches long. Solder a wing into the slot of the screw to facilitate rotating it, or into a hacksaw curf in the bolthead. Put the nut in the ½-inch hole of the guide strip on the bottom of the motor board, and screw the bolt into it through the hole provided therefor. This will leave the wing-nut at the end of the baseboard readily accessible for moving the motor to and fro.

Don't use a rheostat in circuit with the driving motor; let the motor run at its natural period, the speed for which it was designed; synchronism is attained by changing the distance of the motor from the center of the scanning disc, *not by changing the motor speed.*

Connect the radio output to the lamp, preferably through a switch, with about 250 to 300 volts in circuit with the switch and lamp. A power pack can be used instead of "B" batteries.

The glowing electrode (cathode) of the lamp should face the disc, of course. If it does not, reverse the electric connections.

Now go ahead and tune in the station broadcasting pictures; then adjust the speed of the scanning disc to 900 R.P.M., which means only that the motor board is moved outward from the scanning disc center, by turning the screw, until the picture comes in, as one looks at the neon lamp through the tiny holes in the disc.

Begin with motor driving-disc about 2 inches from the scanning disc center, and draw it outward, with the screw, very slowly so as not to go past the point of synchronism. It is surprisingly easy to get and maintain synchronism by this mechanism.

At first, with an induction or D.C. motor, there will be only black and white dots and dashes in the picture area, but as the speed of the disc approaches synchronism with the speed of the transmitter at the broadcasting station, the picture will suddenly appear, as one looks at the lamp through the flying holes of the scanning disc; although the picture will probably be leaning to the right or the left, at the same time it is traveling transversely. But still further adjustment with the screw will bring it to a stop.

When the transmission of the picture ends, the radiovisor should be switched off and the loudspeaker switched on, so that the announcer may be heard again.

If the picture appears upside down, take off the disc and turn it around, the other side out. This will make the picture right side up. If it is wrong right and left like looking at one's self in a mirror, turn the disc the other side out again and reverse direction of motor rotation.

While the radiovisor will get pictures when attached to any good radio set, better results are obtained if a resistance-coupled amplifier is used. Perhaps you already have a resistance amplifier; many have.

However, two diagrams of very good receiving sets with resistance-coupled amplification are shown here, with the values of the various elements given for each.

1. For best picture reception, the receiver must be on the point of non-oscillation, or just below the point where oscillation begins. A receiver that will bring in good phone reception will produce good pictures; therefore, the receiver must be adjusted similarly.

2. The silhouette images received from W3XK should be in black. In other words, the lamp is continuously lighted until picture signals blink it out to make up the movie pictures in black silhouette on a pink ground.

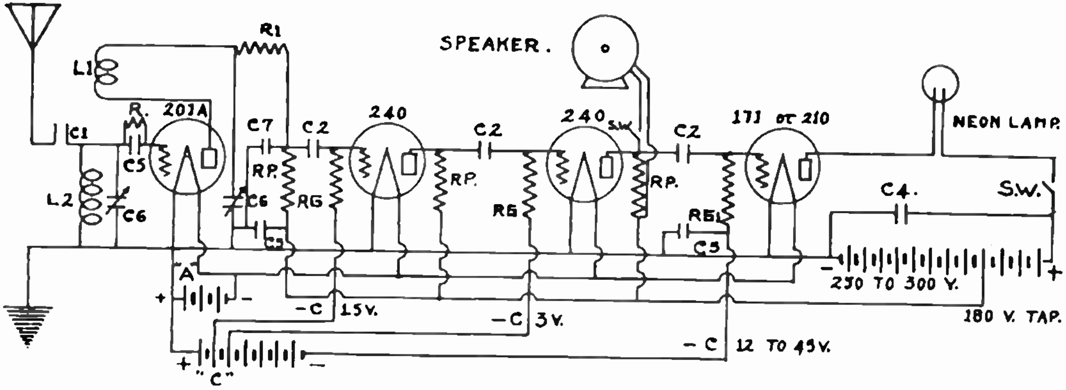
3. The amount of light given off is regulated by the "C" bias on the last tube of the amplifier, although the bias must be high enough to permit the incoming picture signals to overcome the plate current, blocking the light given off by the neon lamp. It has been found that a "C" bias voltage between 12 and 45 volts on the last tube will be sufficient on all types of neon glow lamps.

Assuming that one prefers to make one's own radio receiver, there will be needed a board 21 inches long and 12 wide, upon which to mount the parts; and also a piece of 1/8 inch bakelite on which to mount the tuning condensers, filament rheostat, switches, etc.

As it is very desirable to shield the set, the front panel should be lined with a copper sheet of the same size, but with drill holes larger than the holes in the bakelite. To insure adequate insulation a three-sided copper box 20 inches long, 10 inches wide, and 7 inches high at the back, should be pro-

Simple Standard Four Tube Radio Vision Receiver

46.7 METERS

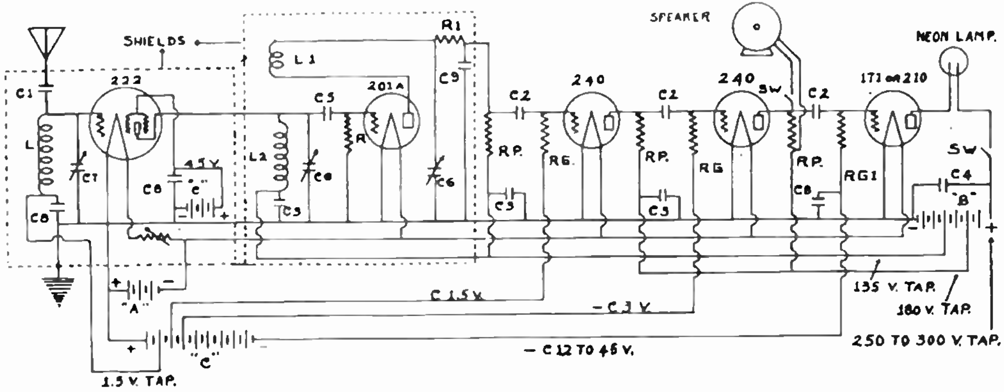


C1—2 pieces 1½" square copper plates spaced ¼"
C2—.01 M.F.D. Mica coupling condensers
C3—At least 1 M.F.D.
C4—At least 4 M.F.D.
C5—.00025 M.F.D.
C6—.00014 M.F.D. Variable condensers
C7—.001 M.F.D.
SW—Speaker and Neon Lamp cut-out switch
All resistors must be non-inductive

R—2 to 7 megohms
R1—.025 megohms
Rp—.25 megohms
Rg—1 megohms
Rg1—.5 megohms
L1—5 turns 3" dia. No. 18 D.C.C. Wire
L2—6 turns 3" dia. No. 18 D.C.C. Wire
L1 and L2—Spaced ¼"
Antenna—50 to 100 feet total length

Ideal Radio Vision Receiver Using Standard Parts

6420 K. C.



C1—2 pieces 1½" square copper plates spaced ¼"
C2—.01 M.F.D. Mica coupling condensers
C3—At least 1 M.F.D.
C4—At least 4 M.F.D.
C5—.00025 M.F.D.
C6—.00014 M.F.D. Variable Condensers
C7—.00014 M.F.D. Variable Condensers
C8—At least .01 M.F.D.
C9—.001 M.F.D. Mica Condenser
Antenna—50 to 100 feet total length
SW—Speaker and Neon Lamp cut-out switch

"All resistors must be non-inductive"
R—2 to 7 megohms
R1—.025 megohms
Rp—.25 megohms
Rg—1 megohms
Rg1—.5 megohms
L —6 turns 3" dia. No. 18 D.C.C.
L1—5 turns 3" dia. No. 18 D.C.C.
L2—6 turns 3" dia. No. 18 D.C.C.
L1—and L2—Spaced ¼"
UX-222—Requires only 3.3 volts on filament

vided to set down over the parts on the board; and which, meeting the copper lining of the bakelite front panel, completely shields the set, as it rests on the copper lining of the baseboard itself.

In addition to the radio material already listed, there will be needed for the standard four tube set 1 UX-201A Detector tube, 2 UX-240 Amplifier tubes, 1 UX-171 Output tube, 4 UX Sockets; 1 Cone speaker, 2 Cutout switches, 1 6-volt "A" Battery, 1 22½-volt tapped "C" Battery, 1 7½-volt tapped "C" Battery, 6 45-volt heavy duty "B" Batteries, 1 Neon glow lamp, 2 or 3 Antenna insulators, 25-foot ground connection wire. For the "Ideal Receiver" the following should be added: 1 UX-222 two-grid Tube, 1 UX Socket, 1 (extra) 45-volt "B" Battery, 1 20-ohm Resistance, and the shielded unit or box.

Please remember it is far more important to have a good radio set and adequate resistance-coupled amplification than any other one thing. Certainly without such a set one only wastes one's effort in trying for radiomovies.

OPERATION

Now one should learn the little tricks of operation, which the engineer would call building up a "technique," so that trouble may be recognized if it occurs, and one may know what to do to correct it.

First of all, of course, tune in the station broadcasting at that particular time, which may be known by the published schedule. It is easy to tune sharply, for one hears the announcer on the loudspeaker, and tunes for the strongest signal.

In tuning in stations which do not yet publish a regular radiovision broadcast schedule, one simply will have to "fish" for it, and tune sharply when found. It will not be long before one learns to recognize the peculiar sound of radiovision and radiomovies; and after that it is easier to find picture broadcasting stations.

Having tuned sharply and gotten the best signal strength possible, snap the switches to cut-out the loudspeaker, and cut-in the radiovisor, i.e., the picture receiver.

Now, the picture may be upside down; or it may be wrong right and left, like looking at a photograph in a mirror. However, except in reading titles it is not often important whether the picture is correct right and left or not; but it is very necessary to have the subjects head up, of course. But in any event, right and left correction is attained by reversing the motor, while if the picture is up-side-down the disc must be taken off and turned around and put on with the other side of the disc next to the lamp.

The only further condition about which one needs to bother is whether the picture is negative or positive. To change from one to the other, perhaps the best way is to add another stage of amplification, although it can be done by substituting a "C" battery bias for the grid-leak and condenser on the grid of the detector.

The first scheduled broadcasting from W3XK was silhouettes, i.e., black figures on a lighted background, because this is the easiest for the amateur radio fan to get at first. Later halftone values, i.e., the different shades between black and white which go to make up the face, clothes, and tone combination of objects, will be broadcast. But adjustment of your radio receiver and amplifier is all the change that will then be required. Your radiovisor will not

Frames taken from early (1928) Radiomovies broadcasts from W3XK. The Jenkins Laboratories, Washington, D. C.

Frames taken from early (1928) Radiomovies broadcasts from W3XK. The Jenkins Laboratories, Washington, D. C.

need any alterations; it will reproduce any tonal value put out by the broadcast station and picked up by the radio set.

The next important attainment is learning to know what the picture characteristics mean. For example, it may be discovered when one is near synchronization between receiver and transmitter by the appearance of streaky lines diagonally across the picture area. Still further improvement in synchronism is known by the fact that the picture takes form. But as the picture is traveling to the right or to the left, continue to adjust the motor-position screw, turning it one way or the other, noting whether the picture travel increases or decreases. Presently the picture stops; and there is the radiomovie in all its fascinating mystery.

But possibly the picture shows the upper half of the subject below and the lower half above in the picture frame, as sometimes one sees in motion picture theaters. Well, do just as the theater machine operator does, namely, "frame" the picture, start the travel again until the picture is "framed," that is, until it appears as a single picture, up and down. Of course, this may be done by turning the screw, but if instead friction is put on the disc, by touching it gently with a finger, until the picture is right, the picture is framed, but still stays approximately in synchronism, for the adjustment has not been disturbed. A slanting picture means lack of perfect synchronism, so adjust a little further.

Another thing which the beginner does not fully appreciate is that static and interference does not nearly always prevent the reception of a perfectly intelligible picture.

For example, in broadcasting weather maps, it was proved that ships at sea could receive good maps through static so severe that weather information by code could not be read at all. Similarly it will be found that static does not entirely spoil one's picture show.

So don't be discouraged by the racket put out by the loudspeaker; confidently throw the DPDT switch over onto the radiovisor, and the result will probably be a picture, though it may not be perfect. The novelty of the thing will make acceptable pictures, which later, as technical skill is acquired, will not be tolerated. Radiovision and radiomovies are now in a stage of development comparable to the crystal-headphone stage of audible radio; and this first radiovisor will not be acceptable after a few months, or perhaps after only a few weeks use.

Now just one caution about the motor driving disc: Do not use a leather-faced disc; it is too "savage." A rubber disc, recommended for this purpose, is necessary because of the delicate changes required in successful synchronism of the rotation of the picture scanning disc with the transmitter at the broadcast station.

Assume that fine pictures are being regularly received, although they are but one inch square, which only two or three people can view at the same time; it would be desirable if more persons could see these pictures. There are several ways this can be done, one of which immediately suggests itself, namely, make the disc larger; for example, a 36-inch disc should give a picture 2 inches square. But this means a new disc, which is difficult to get, and is of unwieldy size; a new mounting is needed, a heavier motor, and other difficulties are encountered. The best way then is to get a 10-inch diameter lens of 18 to 20-inch focus, put it in a suitable holder, and mount it on a chair back, or other support, in front of the picture, about 11 to 12 inches therefrom. The result is a picture as large as the 36-inch disc will give, and very much more satisfactory, for a whirling disc 3 feet in diameter is a formidable proposition in the home.

Another plan for getting large pictures with a small scanning disc is by optical projection. It presupposes the possession of a large-plate neon lamp. A lens is located between the lamp and the scanning disc to reduce the lighted field projected on the disc to the size only just covered by the separation of the perforations in the disc. The lens and lamp should be moved forward and back until this size spot on the disc is obtained. A reading glass will answer the purpose, though one (or both) of a pair of 4½ diameter 6-inch-focus condenser lenses will be better. They can be obtained at most any shop which sells magic lanterns or motion-picture projectors, and cost about $1.25 each.

This arrangement gives a somewhat brighter picture, but only one person can conveniently see the picture. To accommodate a group of five or six persons, mount the large 10-inch (18 to 20-inch focus) lens, as before, in front of the disc, in line with the light, and about 12 inches from the disc.

Of methods of synchronizing other than that described herein, the one most generally employed is that in which the scanning disc is mounted directly on the motor shaft and a rheostat is inserted in one lead of the main line circuit, or else in series with the field or the armature windings.

With the resistance located in the field the resistance makes the motor run faster; with the resistance in the armature the motor runs slower. A push button switch of the call-bell, pear-shaped type is often arranged to short-circuit a few turns of the live part of the resistance.

Assuming the resistance is in the armature, it is adjusted until the speed is just a very little too slow. Then, when the picture wanders, the push-button switch is pressed, and the picture comes back into "frame." A rather long flexible cord with the push switch in the end of it makes for convenience in boosting the motor speed.

Sooner or later automatic means for synchronizing will be adopted, and one of the simplest of these is the use of a light sensitive cell which is effected by a part of the light of the picture area falling on it, or by a special light spot provided for the purpose. This light cell is in series with the primary of a relay, the secondary of which takes the place of the push-button, for example, though other means may be controlled by the cell.

There are other schemes of synchronizing, of course, one of which consists in picking up at the receiver a special synchronizing signal sent out from the broadcasting station. This signal, when picked up too late by the receiver, actuates a relay to short-circuit the part of the resistance relied upon to boost the motor speed a little.

But of all synchronizing schemes, the simplest, of course, is to employ a synchronous motor to drive the picture transmitter at the broadcast station; and then to use synchronous motors on all receiving machines. Once the picture is tuned in and framed, there's nothing to do but sit at ease and watch the movie story told by the radio-carried signals.

As most residences are in the A. C. district of cities, the simplicity of the synchronous motor lends itself admirably to city distribution of radiomovie and radiovision entertainment.

Forty-eight lines per picture frame has been arrived at by several workers in this new industry for apparently adequate reasons; for example, this figure, and its multiples and divisors, are numbers upon which standard-cut gears are based. And 48-lines gives good definition in the picture. When further development permits greater refinement, doubling this base figure attains it and still stays within standard gear ratios.

Again, forty-eight is divisible evenly by more numbers than any other, i.e., 2, 3, 4, 6, 8, 12, 16, and 24, which by the way is doubtless the reason gear-cutters adopted it, as well as workers in radiomovies, radiovision and television.

Because forty-eight lines per picture frame is as logical in this new industry as four wheels were in automobiles, I predict its acceptance as standard, sooner or later, unofficially or by agreement.*

I trust you have found profit and enjoyment in the construction and operation of this simple receiver. It is thus a new art is born, and you have had a pioneer's part therein, and a pioneer's joy in exploration.

Other methods and mechanisms will be disclosed, hereinafter, some of which, it is confidently predicted, contain the fundamentals of the ultimately adopted mechanism.

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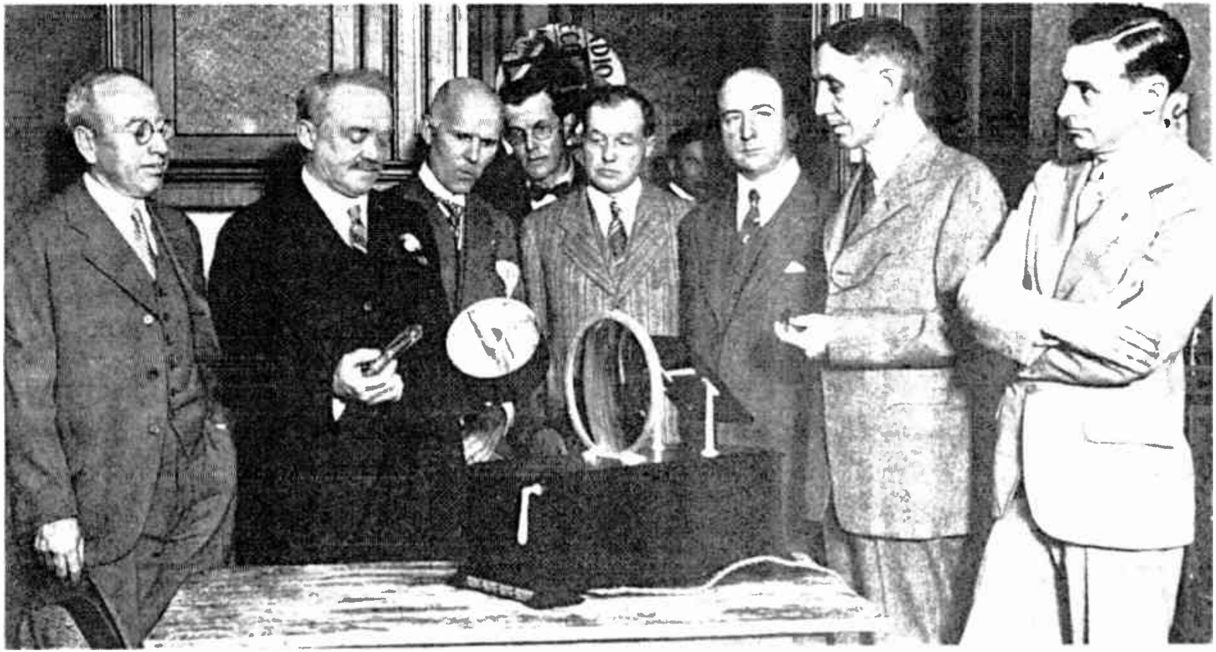
*Note:—The Radio Manufacturers Association at the Chicago meeting of its Standardization Committee, October 9, 1928, unanimously adopted for recommendation as standard practice: (1) 15 picture frames per second; (2) 48 lines per picture frame; and (3) scanning from left to right and top to bottom in consecutive sequence.

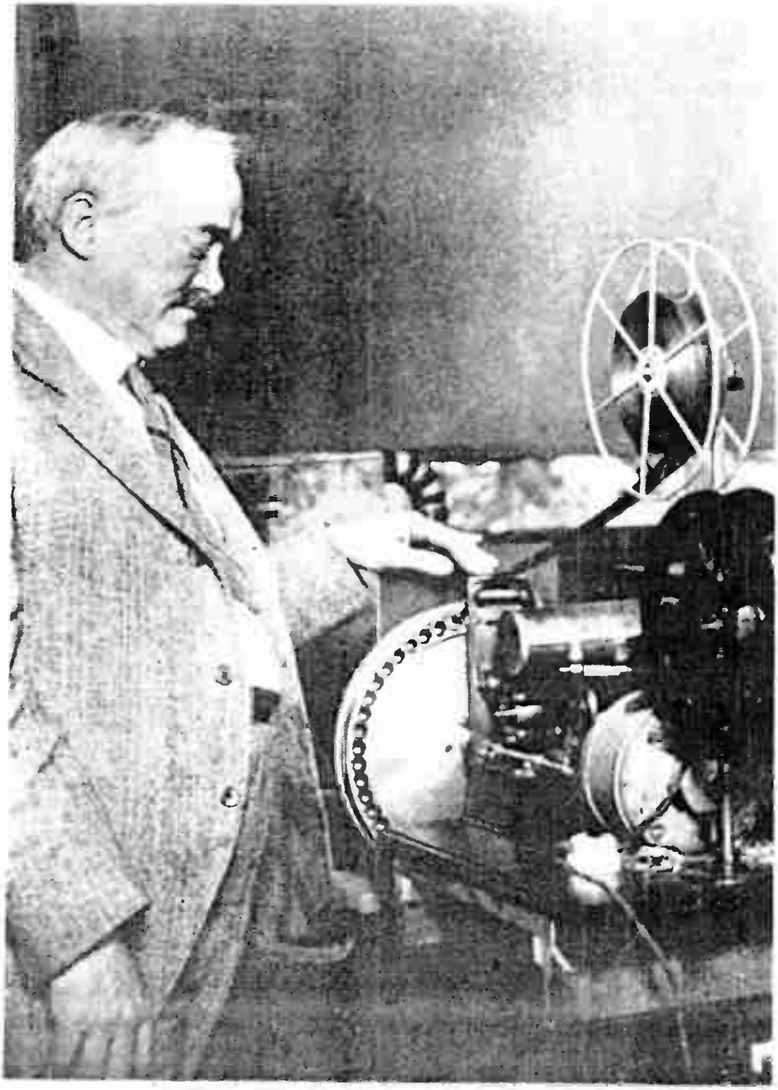
Honor Roll

The following is our honor roll of pioneers receiving Radio-movies, broadcast from the Jenkins Laboratories, 3XK, Washington, D. C., and who are making history with us in the development of a new art:

F. A. Hill, Chicago, Ill.
G. E. Sterling, Baltimore, Md.
Charles Hartman, Philadelphia, Pa.
William N. Parker, Chicago, Ill.
Arthur V. Aykroyd, Bethlehem, Pa.
Reuben M. Outten, Felton, Del.
Howard Adams, Jr., Baltimore, Md.
James Millen, Malden, Mass.
P. S. Hendricks, Wiamo, Mass.
Raymond Morgan, Philadelphia, Pa.
Paul Zerrahn, Belmont, Mass.
Boyd Phelps, Jamaica, L. I., N. Y.
Clifford Fraser, Bridgeport, Conn.
Harry M. Yingst, Harrisburg, Pa.
R. F. Schierland, Cincinnati, Ohio
P. W. Heasley, Akron, Ohio
R. H. Kolks, Cincinnati, Ohio
W. J. Flett, Atlantic City, N. J.
Norman L. Chase, Daytona Beach, Florida
Leo Hruska, Cedar Rapids, Iowa
Alfred Klapperich, Wilmette, Ill.
E. R. Thomas, New York, N. Y.
H. R. Searing, New York, N. Y.
T. D. Reimers, New York, N. Y.
Joseph H. Appel, Jr., Scarsdale, N. Y.
Joseph A. Stauhs, Newark, N. J.
Stuart W. Seeley, Jackson, Mich.
William A. Zarth, Washington, D. C.
R. H. Bahney, Massillon, Ohio
H. P. Hardesty, Detroit, Mich.



Distinguished visitors on the occasion of the inauguration by the Jenkins Laboratories of the first regular scheduled broadcasts of Radiomovies July 2, 1928. Left to right: Capt. S. C. Hooper, Navy; C. Francis Jenkins; Gen. George O. Squire; Capt. Guy Hill, Signal Corps, Army; Commissioner Harold A. LaFont, Commissioner Judge Ira E. Robinson; Commissioner Sam Pickard; and Carl Butman, Secretary Radio Commission (in rear).



The Jenkins Lens-disc Radiomovies transmitter of 1928. Lenses arranged in a circle; film moves continuously.

Sunday Star

HINGTON, D. C., SUNDAY MORNING, JUNE 14, 1925

"Radio Vision" Shown First Time In History by Capital Inventor

C. Francis Jenkins' New Wireless Apparatus Depicts Moving Objects Miles Away—U. S. Officials See Test.

"Radio vision," long the fantastic dream of science, became an accomplished fact yesterday afternoon with Secretary of the Navy Wilbur and other high Government officials witnessing the feat.

With the aid of a remarkable apparatus invented by the Washington scientist, C. Francis Jenkins, the Secretary of the Navy, Dr. George M. Burgess, director of the Bureau of Standards; Admiral D. W. Taylor, [illegible] Foley of the Naval Research Laboratory and others actually "saw" by radio an object set in motion several miles distant in front of a "radio eye" installed at the Naval Radio Station, NOF, at Bellevue, D. C.

It was heralded as the first time in history that man has literally seen far-away objects in motion through the uncanny agency of wireless.

As Secretary Wilbur watched the image of a revolving propeller, selected as the "subject" to be broadcast, as it cavorted on a small screen in the Jenkins laboratory, at 1519 Connecticut avenue, he remarked:

"I suppose we'll be sitting at our desks during the next war and watching the battle in progress."

"That's perfectly possible, Mr. Secretary," the inventor replied seriously.

The demonstration was of a strictly private nature and, in the words of Mr. Jenkins, did not pretend to be a "show."

"It is merely a scientific test that proves we have attained our goal," Mr. Jenkins told his visitors. "By making numerous improvements in our sending and receiving machines we expect to be able shortly to stage a 'radio vision show,' with the talent performing at the broadcasting station and the audience watching the performance at the receiving studio miles distant."

What the officials saw yesterday afternoon was the image of a small cross revolving in a beam of light flashed across a light-sensitive cell at Station NOF. No other objects were used in the test. The image, while not clear-cut, was easily distinguishable.

Director Burgess of the Bureau of Standards, in congratulating the inventor, said, "You've certainly got it, all right, if my eyes aren't deceiving

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Washington

NGTON: SUNDAY, JUNE 14, 1925

First Motion Pictures Transmitted By Radio Are Shown in Capital

Government Officials and Scientists, Summoned Quickly by Telephone, View Successful Experiment in Laboratory of C. Francis Jenkins—Small Apparatus Functions Perfectly.

A group of distinguished government officials and scientists, called unexpectedly from their offices and laboratories, sat yesterday morning in the laboratory of C. Francis Jenkins, at 1619 Connecticut avenue northwest, and saw for the first time in history motion pictures of a moving object miles away, received over the radio and thrown upon a miniature screen.

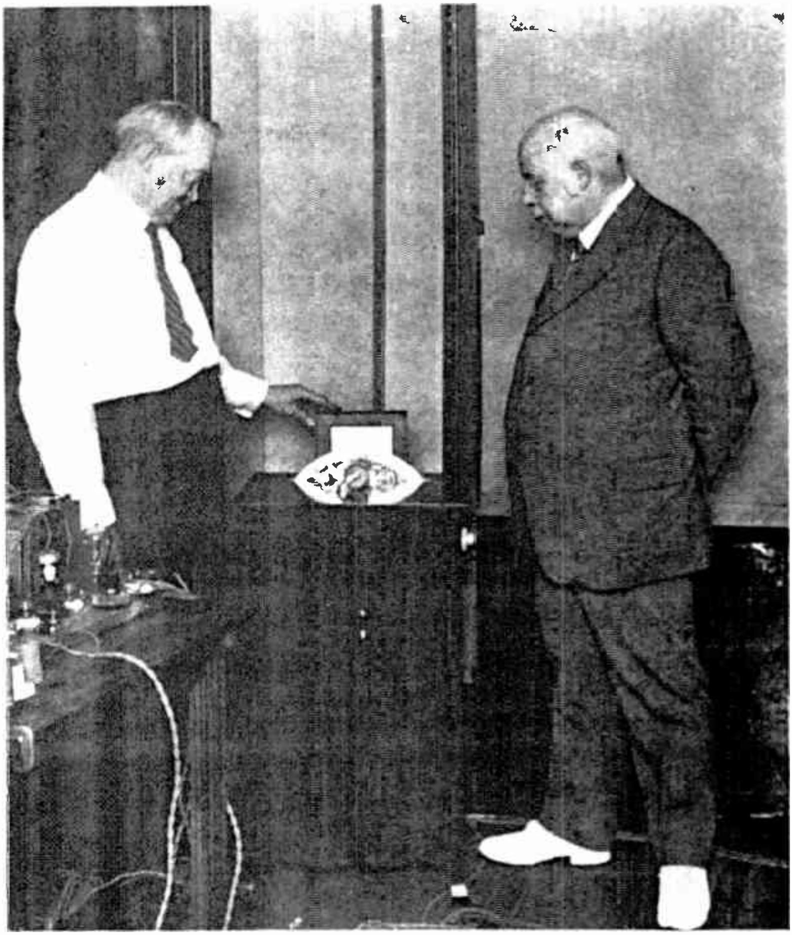
Among the visitors who had been called hurriedly on the telephone by Mr Jenkins when he found the machine functioning perfectly, and who visited the laboratory at various hours in the morning, were Secretary of the Navy Wilbur, Dr G K Burgess, director of the bureau of standards; Stephan B. Davis, Acting Secretary of Commerce, W. D. Terrill, of the radio department of the Department of Commerce, and two San Francisco scientists, who heard of the experiments and accompanied the officials to the laboratory.

Although the image broadcast was devoid of dramatic interest of itself, being merely a small model windmill with the blades in motion, NOF, the old naval radio station which was turned over to Mr Jenkins for experimental purposes when the department erected a larger one. It was from NOF that Mr. Jenkins broadcast still photographs to Philadelphia, Boston and other cities in [illegible]

To illustrate [illegible] a small model Dutch windmill was erected and the blades propelled slowly by wind from an electric fan. The image of this was thrown through a lens onto a ground glass. From this ground glass the image was picked up by Mr. Jenkins apparatus in much the same fashion that it is for a still photograph. That is, a small sensitive pencil travels across it making approximately fifteen lines to the inch converting the light intensity into electrical intensity or electrical modulations.

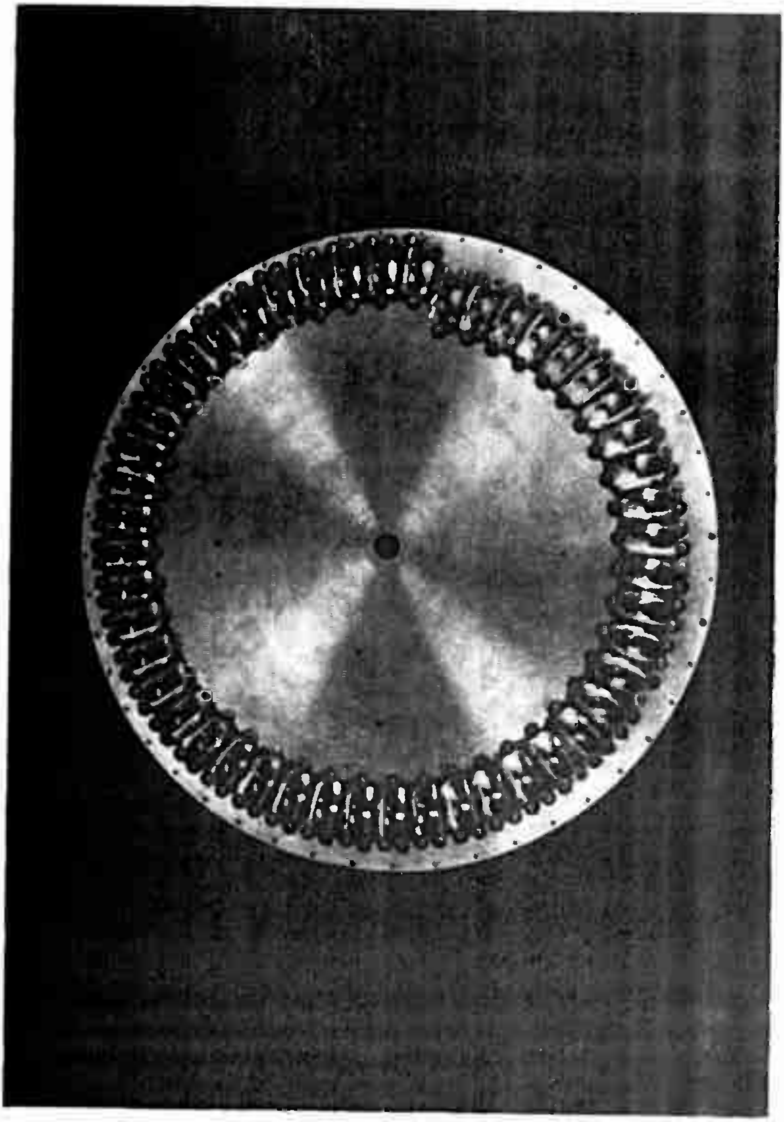
These modulations were broadcast over a wave-length of 546 meters and picked up in Mr. Jenkins' Connecticut avenue laboratory. Here the modulations were converted back into light values and a pencil of light made to travel in the same fashion as the sending

"The time is not very far off now when inaugural ceremonies, ball games, pageants, and other notable events may be seen reproduced in action on a small screen in the home, carried there by radio."



Dr. Geo. M. Burgess, director U. S. Bureau of Standards, inspecting apparatus Mr. Jenkins used to receive "Vision-by-Radio" on the occasion of the first transmission of vision and movies by radio from Navy Station, NOF to the Jenkins Laboratories, Washington, June 13, 1925.

THE LENS-DISC SCANNER



Jenkins lens-scanning disc, used in both Radiovision transmitter and projection receiver.

The Lens-Disc Scanner

Radiomovie pictures may be made larger, so that more persons can see the moving picture, by projecting the pictures onto a screen with a spiral lens-disc.

This disc is patented, U. S. 1,679,086, but you can make one of them for your own personal use, so go ahead.

Thus, take a spiral-apertured disc again—this time an 18-inch diameter disc is suggested. Close to the edge drill 48 holes 1/8-inch diameter and very accurately spaced around, preferably on a dividing engine head.

Now make the scanning apertures oblong, say 1½ inches radially, and ½ inch wide (circumferentially). The offset of the ends of the spiral should be about 7/8 inch.

At the top of each aperture drill two 1/8-inch holes, 5/8 inch apart, and one hole at the bottom, all three equidistant from the lens aperture, and far enough apart to take in the lens between. See illustration.

Now go to a friendly optician and buy one hundred lenses ("50 pair") unedged, just as he receives them from the two great factories that supply most of the opticians in the United States. Ask for 8½ diopter lenses. They are 42 millimeters in diameter. Get him to cut opposite sides off each, leaving the lens one inch wide.

Now mount the disc frame on a firm support, but so that the disc may rotate, for example, on the end of a table, with the disc overhanging, and almost touching the table. Drill through one of the spacing holes at the edge of the disc and into the edge of the table top. Into this fit a pin which will hold the disc while the lenses are being put on.

To put the lenses on there will be needed a gross of 4-40 screws, 3/8-inch long, and nuts and copper washers; and also about as many paper washers.

Now mount on the table an automobile headlight lamp, about 6 inches from the disc, and in line with the center of the lens-aperture on the horizontal diameter of the disc. Put one of the lenses in place on the aperture at the outer end of the spiral, and fasten with the three screws and with a copper washer and paper washer—not tightly, however. Put a screen of white paper on the wall, or other firm support, in the other focus of the lens, moving the several elements until the image of the lighted lamp filament is sharp.

Put another lens on the aperture at the inner end of the spiral, and focus it on the screen.

Mark on the screen the location of the image of the lamp filament through the outer and the inner lenses, and divide this distance into 48 such spots.

Obviously, the location of the lenses over all the apertures should make the image through each lens fall on its appropriate image spot. An apertured mask on the lamp will facilitate observation of the filament images.

It is desirable to check up the position of each lens, by going again around the disc holding the disc in position with the spacing pin while examining the register of the image on its particular spot location on the screen.

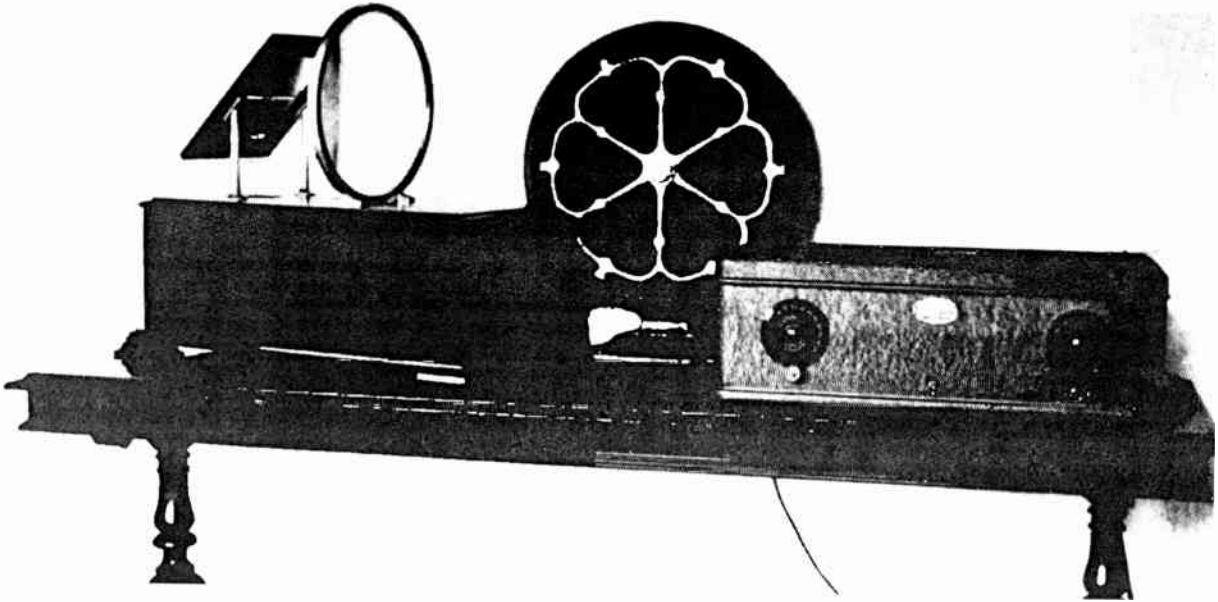
This checking having been completed, apply shellac with a match stick, to the top and bottom edge of each lens, so that it will creep in between the lens and the disc surface. Now leave overnight for the shellac to harden.

Next, move the lamp up closer to the disc, about half the first distance; loosen the screws holding the lens; at the outer end of the spiral insert a lens on the opposite side of the disc and tighten again. Now similarly locate a lens opposite the lens at the inner end of the spiral. Focus the images of each sharply, and divide the distance, if necessary, into equi-spaced spots as before for each of the other 46 lenses, and proceed to mount and secure all the lenses with the screws. And after these double lenses have been checked up for accuracy of location over each aperture, shellac these lenses also at the edge; and then shellac the nuts in place by touching the screw end with the match stick dipped in shellac. Don't whirl the disc for a whole day and night thereafter; let the shellac set first.

Mount the disc as the apertured-scanning disc was mounted, and rotate it in the same fashion. Then support a high-intensity high-frequency lamp a short distance back of the disc and in line with the median position of the spiral. In front of the disc set a screen to receive the projected image of the lamp. The lamp and the screen are in the conjugate foci of the lenses on the disc. The front focus can be found easier if an automobile headlight lamp is used temporarily, because one can then focus sharply with the incandescent filament.

For a screen, blotting paper is one of the best diffuse reflectors, although grinding the face of a mirror with fine sandpaper and turpentine makes the finest reflector screen possible; however, it has objectionable directive properties.

The lamp should be a concentrated source mercury arc, if possible, though a lesser size picture may suffice using a neon lamp of the positive glow, high-intensity type.



Showing comparative size of Jenkins Radiovisor and standard radio set and loudspeaker.

THE DRUM SCANNER

The Drum Scanner

In the art of transmitting pictures electrically, the accepted plan is to synthesize, as well as analyze, the picture surface in a linear consideration of the successive elementary areas of the surface.

For example, if the picture surface is divided into 48 horizontal lines, each of these lines is assumed to be divided into 48 elementary areas, or 2,304 elementary areas for the whole picture surface.

If the reception of the picture takes five minutes to be completed, obviously a recording surface must be employed; for example, a photographic film or plate, an electrolytic paper, or a plain piece of paper on which ink or other discoloring means is used.

However, if the speed of completing each picture is reduced to one-fifteenth of a second, and repeated every fifteenth of a second, no recording surface is needed, for, because of persistence of vision, the picture can be assembled directly on the eye, and radiovision, radiomovies, and television is an accomplished fact.

This is the method, fully described as long ago as 1884, which has been employed by all workers to the present time, I believe, except for the drum method described later herein.

The picture scanning mechanism employed in this 1884 device and by others since, consists of a rotatable disc with 48 miniature apertures therein, the diameter of each aperture being about 1/48th the length of the scanned line, or 1/2304th part of the whole scanned area, and conveniently termed the "elementary area" of the picture surface.

As each aperture in the disc lies on its particular radius, of 48 such radii, and each aperture located approximately its diameter nearer than its neighbor to the axis of the disc, namely, in a spiral, it will readily be seen that when the disc is rotated the locus of each aperture in succession produces a linear scanning of the whole picture area.

Because this scanning disc limits the illumination to the light which can pass through a single one of these tiny holes, a powerful source of light is required for adequate lighting, just as is required in a pinhole camera, with which it is comparable.

As such a powerful light was not available in my laboratory, I put a lens over each aperture in the disc, making the aperture as large as the working area of the lens, and a very small light-source, comparatively, e.g., an automobile headlight lamp, was then quite adequate. The necessary elementary area was attained by focusing the light source into a pin-point on the subject surface scanned.

This lens disc was shown in some of the illustrations used with an article descriptive of my work in *Radio News*, for December, 1923.

The same lens-disc was also used in a public demonstration of radiovision and radiomovies June 13, 1925, broadcast from Navy Station, NOF, Anacostia, and received in my laboratory in Washington, in the presence of Navy Secretary Wilbur, Acting Secretary Judge Davis, Commerce Department, Director Dr. George K. Burgess, Bureau of Standards, and many other government officials.

But the disc scanner, whether apertured disc or lens disc, has physical limitations in practical application, which seem, as at present employed, not to permit very much development.

In the scanning disc, the minimum separation of the apertures determines the width of the picture; and as the picture is approximately square, this aperture separation also determines the offset of the ends of the spiral.

A 36-inch diameter disc is required, therefore, for a 2-inch square picture. A 4-inch picture would require a 6-foot diameter disc—a rather impractical proposition in apparatus for home entertainment, even if it were possible to get power enough out of the house wiring to turn the disc up to speed.

To lay the apertures out in a multiple turn spiral does not help, for the picture size is still determined by the separation of the last two apertures nearest the axis of the disc. And such an arrangement requires a rotating mask or other complications, which more than offset any theoretical advantage.

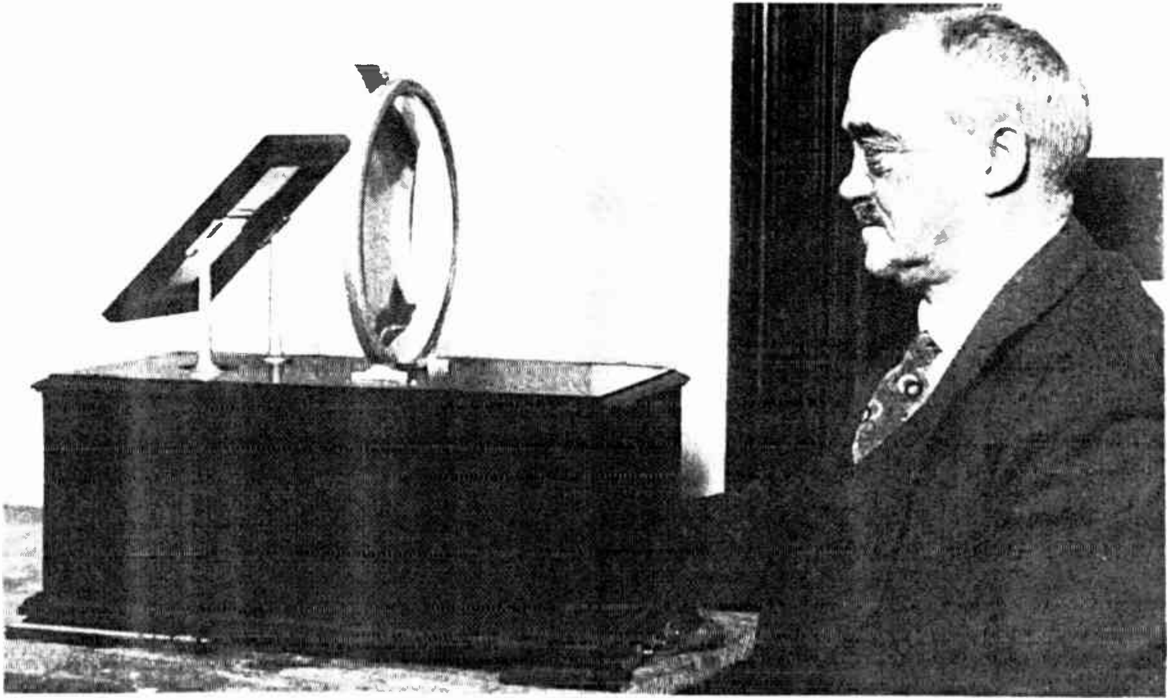
For a source of light to make up the picture in an apertured disc receiver, it is usual to provide a glowing plate cathode in a neon gas lamp.

This glowing cathode plate is looked at through the flying apertures of the rotating disc, the incoming radio signals modulating the cathode glow to build up the picture. The cathode plate for a 2-inch picture must, to provide a marginal latitude, be somewhat larger than the picture, say, 2½ inches square.

To light this 2½-inch cathode plate requires from 70 to 90 milliamperes of current, necessitating special amplification of currents obtainable from the plate of the last amplifier tube of usual radio sets.

And so the proposition as a whole does not look very enticing to the amateur experimenter. And it was for these reasons that I never employed the elementary-area apertured scanning disc. The lens disc was the nearest I ever came to it.

The drum method, however, is much more promising,



Jenkins Radiovisor (drum type) showing control switches. Picture appears through the large magnifying lens; for entertaining the whole family.

for a cylinder or drum has none of the limitations of the disc, and has some very meritorious features of its own.

To get a mental picture of the drum, structurally, let us image a hollow cylinder, about 7 inches in diameter, 3 inches long, and 1/16 inch wall; with a hub, hollow for the length of the drum, and about 1½ inches inside diameter. The hub has an extension outside the drum which slips on the ½-inch shaft of a small motor.

There are 48 scanning apertures punched or drilled in the peripheral wall of the drum, each aperture of elementary area, say, 1/32-inch diameter. The apertures are arranged in four helical turns and spaced 2 inches apart circumferentially, the turns being ½ inch apart.

Inside the drum-hub a 4-target cathode-glow neon lamp, 1-1/8 inches in diameter, is held, by a clamp mounted on the motor platform, at the open end of the drum, preferably.

Between the lamp and the periphery of the drum are tiny quartz rods, each rod ending under its particular minute aperture in the drum surface.

A quartz rod has the peculiar property that light flows through it like water flows through a pipe; that is, the use of quartz rods avoids the light loss due to the inverse square law.

The cathode targets are located one each under each of the rows of quartz rods, and are lighted in succession through a 4-segment commutator, by current from the plate of the last tube of the radio receiver-amplifier.

Because the movement of the inner ends of the rods is so short, these cathode targets need be only about 1/8 by 3/16 inch size, or, for ample latitude in setting the lamp, say, 3/16 by ¼ inch.

Such small size targets obviously require only a very small amount of current compared with the current required for the 2½-inch square cathode plate of a disc-scanned picture; say, 3 to 5 milliamperes. The light-modulation of these small cathode targets seems to be just as easily done, if not more easily, than a large plate.

The quartz rods are employed to avoid the light-loss due to the inverse square law. And to discover how effective they are, one has but to remove the rods, for no picture can be seen without them, though every other condition remains the same.

The miniature cathode targets lie about 3/16 inch from the inner end of the quartz rods, which at this point have relatively small movement. The size of the picture, however, is limited only by the arcuate distance from the outer end of one rod to the outer end of the next. But as the light at the outer end—that is, the picture end—of the rods is just as intense as it is within 3/16 inch of the light source itself, we get an acceptably lighted picture, for there is no loss of light in its travel along the quartz rods.

Neither does the drum scanner have another of the limitations of the disc; that is, the scanning apertures in the drum may be arranged in a plurality of helical turns without in any way changing the spacing between any of the apertures.

A 7-inch diameter drum with scanning apertures in four helical turns gives a 2-inch picture. Magnified, the picture appears about 6 inches square; and in daily use it has been found that five or six people, the whole family, can very conveniently enjoy the story told in the moving picture.

The same size drum with six helical turns gives a

3-inch picture, unmagnified; which is more than twice the area of any picture possible with a 36-inch disc.

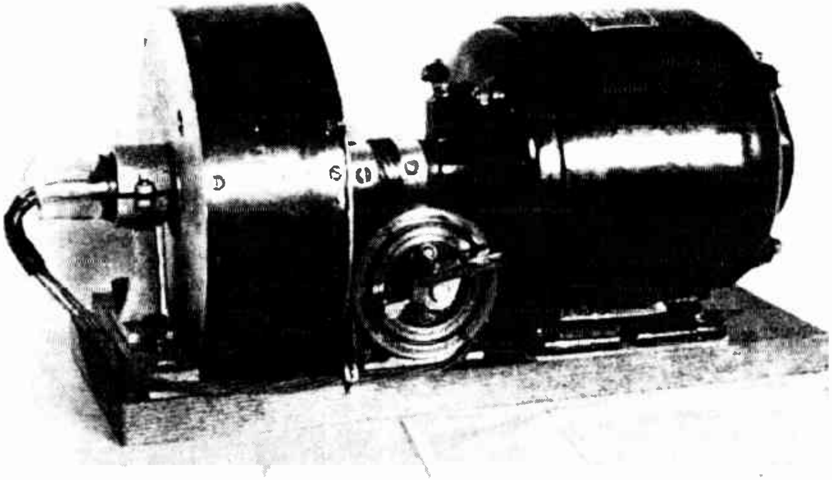
If the drum is increased to 10½ inches diameter and turned six times per picture, the picture is 4 inches square; magnified, it appears about 10 inches square, and 12 to 15 people can watch it.

The light intensity is the intensity of the tiny cathode source, which, because it is so small, requires but little current for a definite light intensity and a given size picture, the picture generated by the outer ends of the quartz rods being a virtual magnification of the light source.

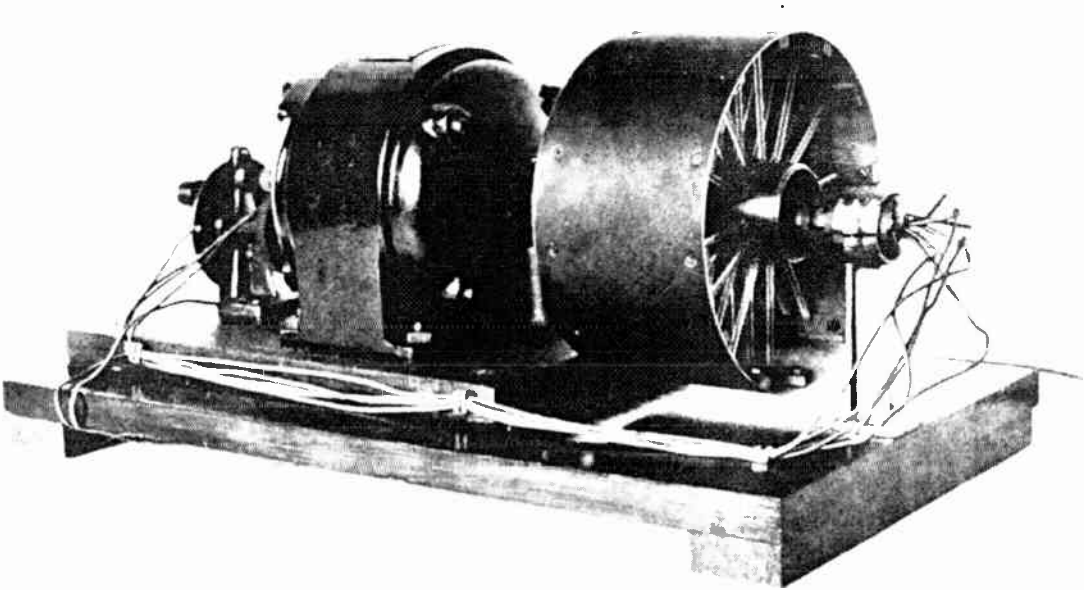
The light source need be but little larger than the elementary area of the picture, for the arcuate movement of the outer end of each quartz rod through which the light is flowing is comparable to the movement over the picture area of this small light source itself.

An increase in the size of the picture does not, therefore, require an increase in the light source, namely, the size of the cathode, but only a lengthening of the quartz rods; for the width of the picture is determined by the length of the arc of the angle subtended by radially adjacent quartz rods; and the height of the picture by the number of parallel lines, each the locus of the outer end of a quartz rod from which the light emerges undimmed by its distance from the source in the hub of the drum.

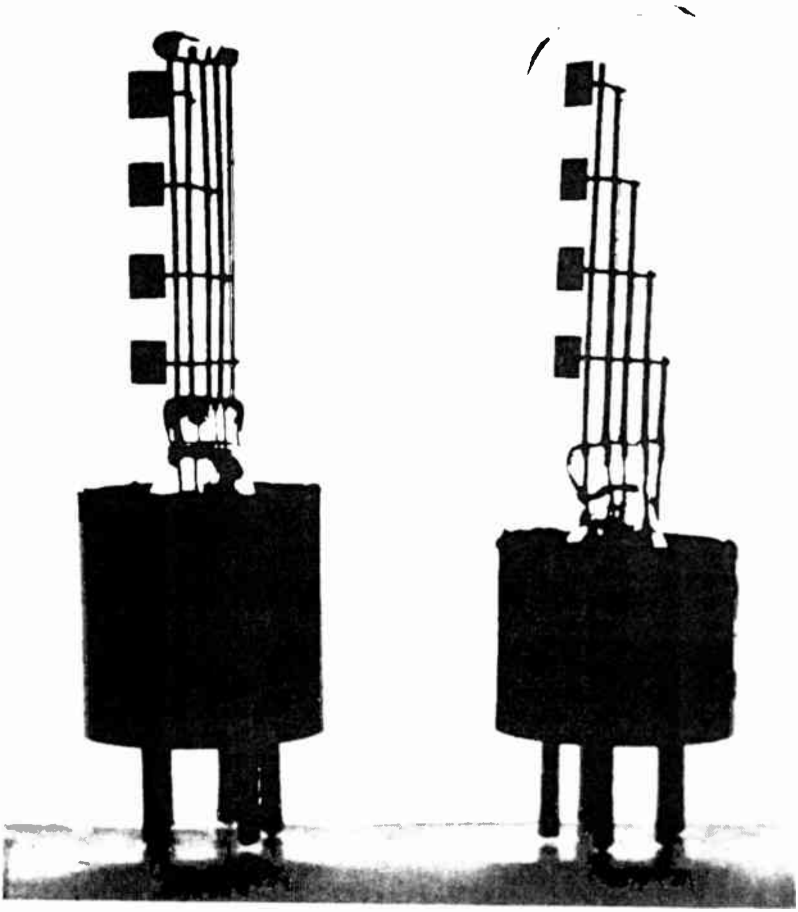
The motor we most use to turn the drum is just a 60-cycle synchronous motor, for there are more homes in the A.C. district of cities than in the D.C. district. Even 60 cycles in separate cities often gives little trouble in the one-fifteenth of a second that it takes to complete each picture of the composite



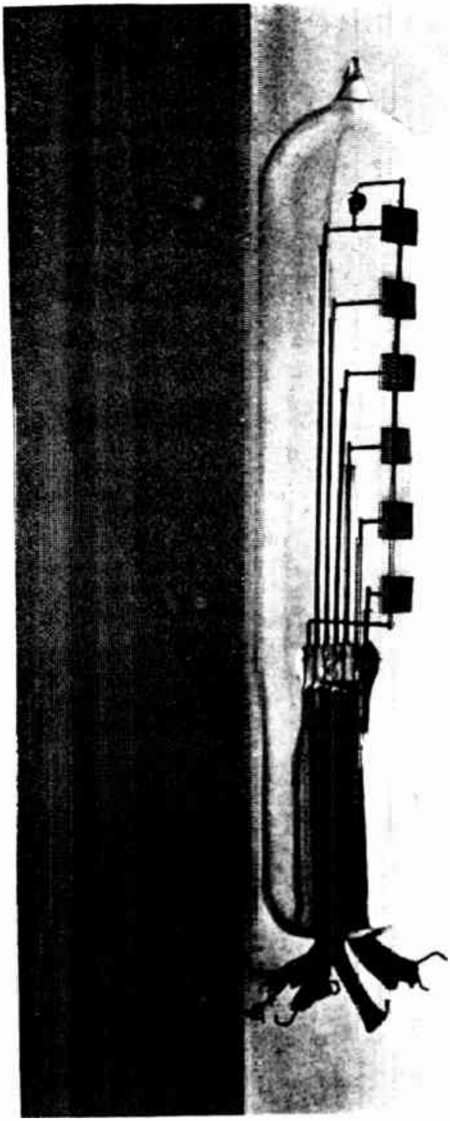
The mechanism of the Jenkins Radiovisor. Motor rotates the drum for scanning the picture.



Early form of drum-scanner. Lamp is in the hub. Quartz rods extend from lamp cathode glow-targets to miniature holes in drum surface. Picture is developed by rotation of drum and the radio-controlled light of lamp.



Four-cathode lamp used in the Drum-scanner of the Jenkins Radiovisor (2-inch square picture, unmagnified).



Six-cathode lamp making 3 x 3 inch picture unmagnified; (with three-power lens makes a 9 x 9 picture) using but 5 milliampers of current.

movie story. We have tried synchronous motor transmission and reception between Chicago and Washington successfully, and also between Washington and New York. Radiovisors for use in D.C. districts are fitted with a D.C. motor with an adjustable friction control with quite acceptable success. Someone adjusts the drum speed as he watches the picture. If he sees a picture at all, the receiver is in approximate synchronism with the transmitter; a little further adjustment makes the picture stand still. If he does not see a picture, he is out, and turns the adjusting screw until he has a picture in frame. Synchronism in radiomovies is much more simply attained than in still pictures. We also have automatic synchronizers, but they are no part of this drum description.

Looking to the possibility of future development in this art, may I again cite for consideration the impeding fundamental in this method of picture production, namely, that each elementary area is lighted, if and when it is lighted, only 1/2304 part of the whole time.

Obviously, therefore, in the case of the single plate cathode neon lamp scanned by a disc, the current required is at least twenty-five hundred times more than it need be if it were possible to apply all the light to each elementary area in succession.

It will readily be seen that my drum method is a step in this direction. And while we have made a great gain in the multiple-target-lamp-quartz-rod combination, we are still a long way from my ideal.

And please let me remind you also that the apparent intensity of illumination of the whole picture is the intensity of the light coming to the eyes from a single elementary area, divided by the elementary time fraction, which is also equal to the number of elementary areas, namely, 2,304. That is why the picture seems so dully lighted when the machine is running, though the scanning spot is very bright when the machine stops.

Multiplying this light reduction by the fractional inefficiency of the current, it will be seen that the total current-light efficiency on the eye in the scanning-disc method is less than 1/50,000 of 1 per cent.

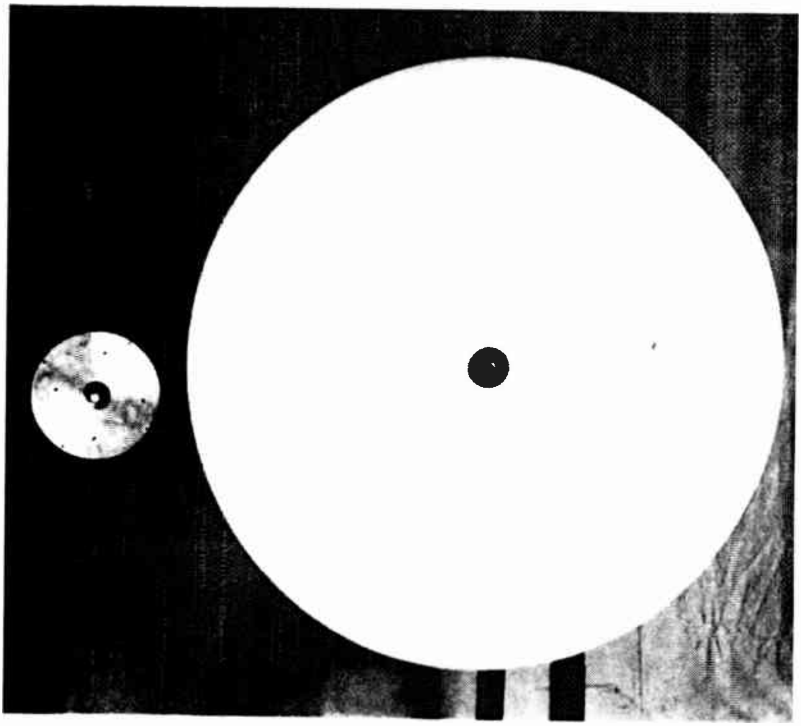
Doubtless, this discouraging handicap explains why the art has been so long in coming into useful service.

But I am confident the solution is possible. For example, I am attacking the problem in still another, way, namely, by substituting persistence of light for persistence of vision.

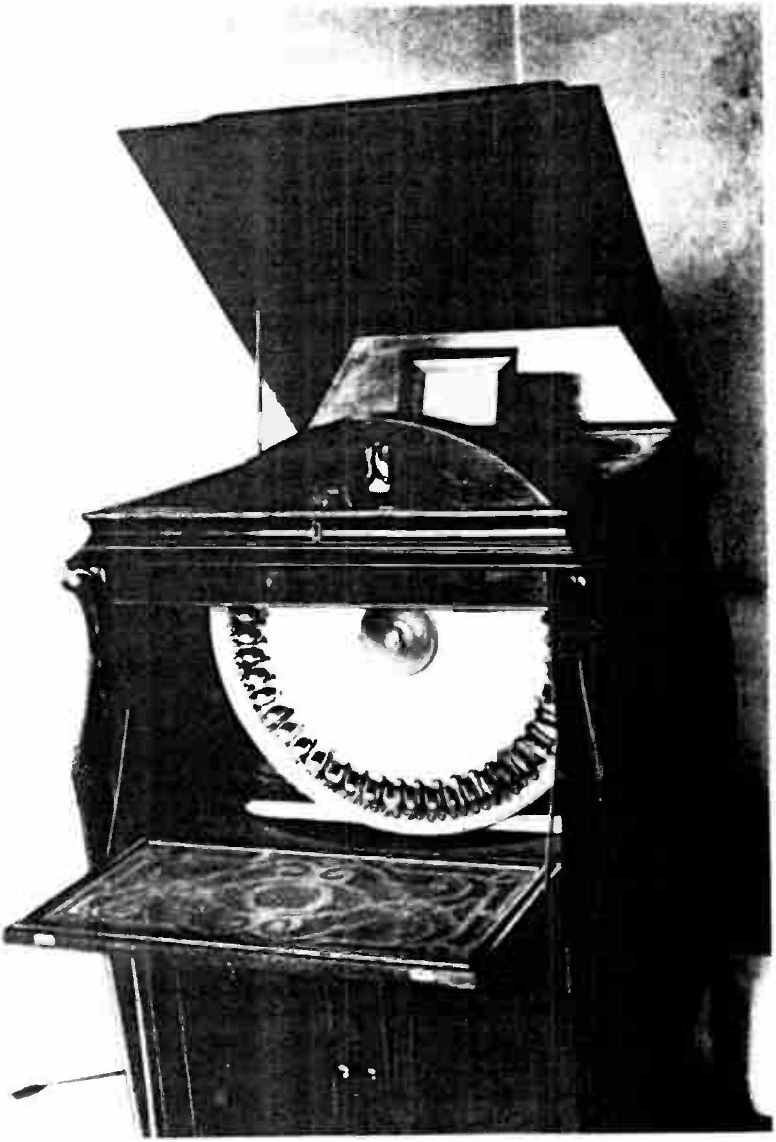
This new principle is incorporated in a radiomovies receiver I am now building, in which the light of each elementary area persists for an appreciable time, say 1/10 of a second, after the exciting current has passed on.

Actual tests of the fundamental mechanisms involved have convinced us that we will have more light available than is now employed for illuminating present picture-theater screens. And the light is white light, not neon pink; and fortunately the light source is readily available in open market.

This same principle applied to picture transmission, namely, the substitution of persistent for transcient elementary area illumination, will bring into the home the long-promised radiovision reception of inaugural ceremonies, baseball games, flower festivals, mardi-gras, and baby parades.



This Jenkins 7-inch diameter drum scanner (left) and the 36-inch diameter disc scanner (right) make the same size picture



Cabinet type Lens-disc receiver.

July 25, 1894.]

THE ELECTRICAL ENGINEER.

TRANSMITTING PICTURES BY ELECTRICITY.

BY C. FRANCIS JENKINS.

One of the most interesting subjects before scientific societies at the present time is the problem of transmitting images to a distance by electricity. I offer for what it is worth a theoretical device which may be added to the methods already suggested for the accomplishment of this object. My scheme contemplates the use of selenium for a receiver, and the apparatus is substantially as follows:

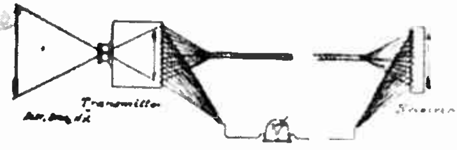


DIAGRAM OF JENKINS' PHANTOSCOPE.

A rectangular or circular non-conducting plate is set up behind a lens in such a manner as to receive the image or scene to be transmitted. This plate or board has upon its back a number of small short wires of selenium or sulphur, one end of each of which is thrust through the non-conducting board and immediately turned back, coming out again upon the same side and very near where it was thrust through. [illegible] board is covered with these little loops, one [illegible] each of which is joined to a common conductor, the other ends having separate conductors extending over the distance intervening between the transmitting and receiving stations. At the receiving end is a large flat electric lamp of ground glass with filaments in number and position corresponding with the loops at the transmitting station—a filament for each loop and in circuit with it. We now have a number of selenium loops, each upon a separate circuit, which are affected by the light passing through the lens at the transmitting station, and in circuit with these loops, filaments in a lamp common to all the circuits. As the conductivity of each circuit is affected by the light impinging upon the selenium loop at the transmitting station each circuit carries a different quantity of the electric current generated by a dynamo in the wire common to all the circuits. The result is that all of these little filaments glow, but each with a different intensity and the light diffused over the flat surface of the ground glass lamp at the receiving station appears brighter in some parts than in others, the bright parts corresponding in position to the bright parts of the image projected upon the board by the lens at the receiving station.

The scheme, if practicable when necessary modifications are made, is objectionable in that it contemplates a multiplicity of conductors, but as a basis for study the method has its merits. I should be glad to learn of the success of such an experiment by some one, as I cannot at present test it myself.

Moving Picture News
Published by
EXHIBITORS' TIMES, Inc.

Vol. VIII September 27, 1913 No.

MOTION PICTURES BY WIRELESS

WONDERFUL POSSIBILITIES OF MOTION PICTURE PROGRESS

IN the next number of the *Exhibitors' Times*, we will print an article of transcendent interest upon a theme with which we dealt in the second issue of the paper. This article was headed the "Transmission of Motion Pictures by Wire." A method of accomplishing this is attributed to Mr. C. Francis Jenkins, of Washington, D. C. Mr. Jenkins has been good enough to give us a special and exclusive interview in which he outlines a method whereby the sending of motion pictures over the wire as one sends an ordinary telegraphic or telephonic message has the possibility of being transcended in practical interest by an even greater advance, namely, the transmission of motion pictures by wireless.

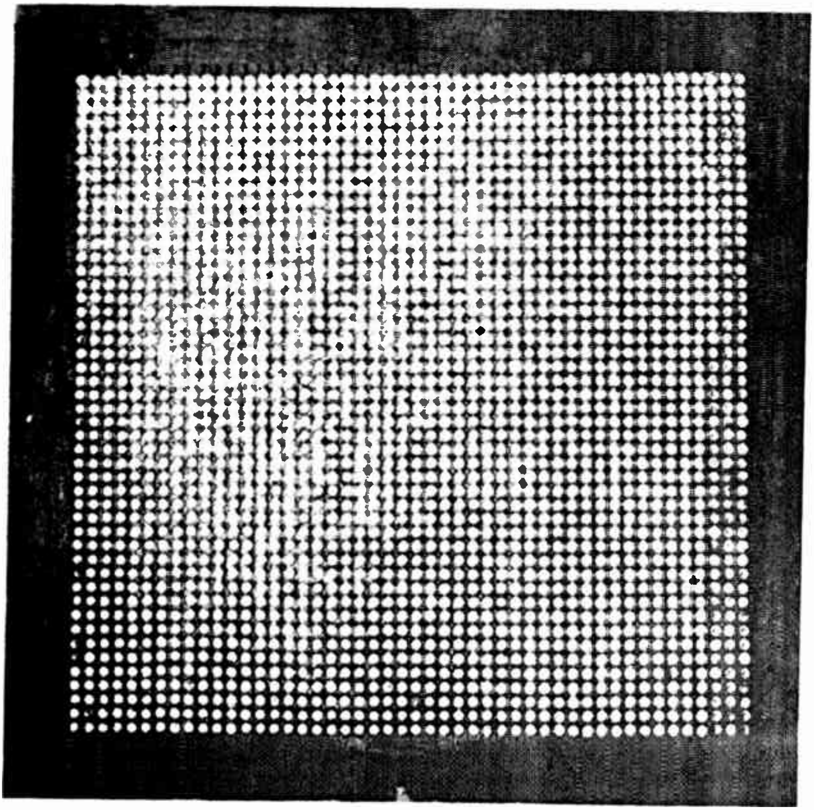
Not to anticipate the interesting details with which Mr. Jenkins has supplied us, we go so far as to say that, in our opinion, the time is not far off when this theoretical marvel will be made a practical accomplishment.

Within the memory of living people, such modern utilities as telegraphic and telephonic messages were considered not merely impracticable, but impossible. Only a few years ago the idea that photographs could be sent by wire was considered in the nature of a wild dream, and yet as we have pointed out already, thanks to the enterprise of Mr. William Randolph Hearst, photographs have been sent by cable from New York to London.

And now, writing in the popular and not the strictly scientific sense, it is just as feasible for motion pictures to be sent by wire as it is for ordinary still photographs. Even more so, it is just as feasible for motion pictures to be sent by wireless as it is for simple written messages to be so sent.

We refer the reader, however, to Mr. Jenkins' own description of his method which will be printed in our pages next week.

THE PLATE RECEIVER



Face of the Jenkins Plate Receiver. It has 2,304 elementary-area light-sources, arranged in 48 rows with 48 in each row. Persistence of light of each elementary area is substituted for persistence of vision, of the old spirally arranged disc-aperture method.

The Plate Receiver

The disc-scanning receiver, with 48 elementary area apertures in the disc, has a current-to-eye efficiency of less than 1/50,000 of one per cent; and while interesting results may be obtained with the scanning disc, there is not much opportunity for practical development of this method.

This extremely low efficiency comes about because of two basic errors of concept of the problem involved; namely, (1) that each elementary area light-source should be as large as the whole area of the picture itself; and (2) that persistence of vision of the eye should be depended upon for an assembly of the elementary areas of the picture.

Theoretically (*a*) no more light current is actually required than that needed to illuminate a single elementary area at any moment considered; and (*b*) a real picture should exist in the receiver whether there is a human eye to see it or not; that is, it should be possible to photograph the received picture with a snapshot camera. This cannot be done with the disc-scanner method.

The plate receiver, however, is designed and built to embody both these essentials, and consists of a picture plate divided into 2,304 elementary areas.

In the construction illustrated the picture area consists of 48 horizontal rows of flash-light lamps, with 48 lamps in each row. These lamps are inserted in a corresponding number of holes in a plate supported, preferably, in a vertical position.

The lamps are divided, electrically, into four banks. Each lamp is individually wired to its particular contact of the switching gear. All the lamps in each bank have a common return connection.

The switching gear is a four-part device, each of the parts being connected to its particular bank of lights. Such a division permits the construction of a commutator but one-fourth as large as if it were a single commutator structure. A 3,600-R.P.M., ½-h.p. synchronous motor is quite suitable for driving the commutator brush, in city service.

In operation, the motor being started, the incoming amplified radio signals are distributed to the several lamps in succession, fully lighting some of them, lighting others to partial brilliancy, and leaving others unlighted. The result is a picture built up in lights and halftone and shadow on the face of the plate.

The picture on the plate is made up of glowing lamp filaments which persist in light value for an appreciable time, say, a tenth of a second. But as the exciting impulse is applied every fifteenth of a second, the lamp is aglow for the whole time the corresponding elementary area of the scene at the transmitting station is alight.

That is, in this scheme, persistence of light is substituted for persistence of vision, and the whole of the received picture is on the plate all the time instead of only a fractional part (1/2304), i.e., an elementary area of the picture.

The amount of light available is the average light of a single lamp multiplied by the number of lamps. The average light of a single lamp can be approximately the normal lumens of the lamp because it can be flashed with a very much higher voltage than if the voltage were applied continuously.

Assuming a ½-inch diameter lamp, the multiple lamp plate would be 2 x 2 feet square. In front of this light source a lens is mounted for projecting it onto a theater screen. As the light source is the picture itself, the only loss of light in the projection is the reduction in foot-candles which results from the magnification. And fortunately the light is the usual color, i.e., white light, not the pink light characteristic of neon.

Such a receiver-projector will ultimately enable the producer to distribute motion pictures to the theaters by radio instead of film, doing away with the profit-consuming film exchange.

As practically all optical systems are reversible, an excellent transmitter can be made of this receiver by substituting light-sensitive cells for the lamps.

THE SENSITIVE PLATE TRANSMITTER

The Sensitive Plate Transmitter

As already observed, most optical systems may be reversed. The reverse of the "plate receiver" is thus practical and operable, for by substituting light-sensitive cells for each of the lamps in the receiver plate, an excellent transmitter system is had many thousand times more effective than the single-cell transmitter.

In this scheme persistence of elementary area energizing is substituted for transient elementary area energizing by the impinging light of the object-image. That is, each elementary area is energized by the image light all the time, delivering a current to the radio channel many thousand times greater than has heretofore been possible.

By this method selenium or thalium-oxide light-sensitive cells may be substituted for the potassium hydride cells employed in the old scheme. The sluggishness of this resistance type of cell is advantageous for its charged condition persists for an appreciable time, giving smoother continuity in action pictures.

Again, selenium and thalium cells give a hundred times more current for a given light flux, which, obviously, is also very advantageous.

Structurally the active area of this transmitter plate consists of a sensitive area 2 feet square, studded with ½-inch square light-sensitive cells; i.e., arranged in 48 horizontal rows, with 48 cells in each row.

Each of the cells is individually connected, electrically, to its particular contact segment of a rotating switching gear. The cells are divided into four banks, and all the cells of each bank have a common return.

Dividing the cells into four banks permits making the switching commutator but one-fourth as large as would be required if the cells were in one bank and a common return were employed.

Across each cell circuit a small condenser is connected, the function of which is to accumulate a charge from the constantly light-excited cell between the unloading contacts of the collector brush of the switch. This again greatly amplifies the current possible from a given light intensity, for it is active all the time, not just 1/2304 part of the time, as in the old scheme.

The function of the switching gear is to put into the radio channel, successively, the charge each condenser accumulates from its particular light-cell, every fifteenth of a second.

The charge accumulated by each condenser every fifteenth of a second is proportional to the intensity of the light falling on its particular cell, which, in turn, represents the light value of that particular part of the object-image impinging thereon.

In front of the sensitive plate a large lens is mounted at its focal distance therefrom. This focal distance is adjustable as in an ordinary camera; and extraneous light is kept off the plate by a bellows-like covering from lens to plate, in the usual manner.

The structure is in fact, a camera in which the image-receiving plate is electrically light-sensitive, instead of chemically light-sensitive, as in a photographic camera.

This light-sensitive plate is divided into 2,304 elementary areas, as explained, upon which the lens images the scene or subject at which the lens is pointed. The electrical charge each cell generates by reason of the image-light falling thereon, is put onto the carrier wave of the radio channel, by the switching gear.

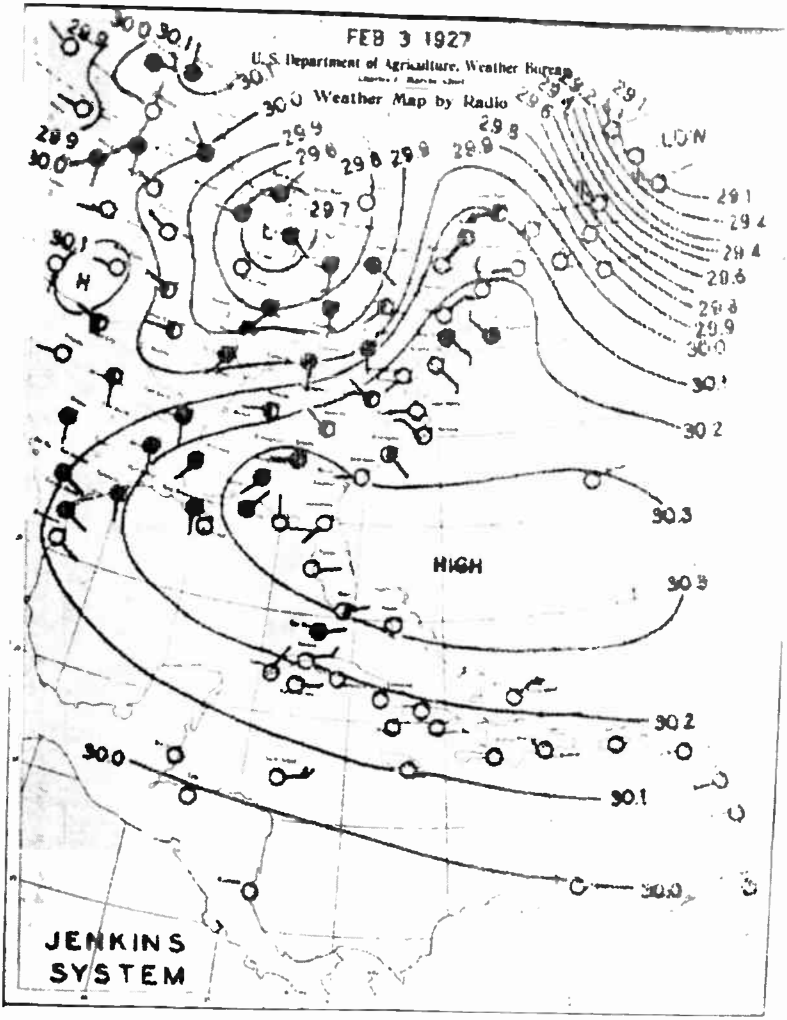
When these radio signals are picked up, by any radiovision receiver of 48 line picture frame, scanned from left to right and top to bottom fifteen times a second, they reproduce the scene or subject at which the lens of the camera transmitter is directed, and at distances determined by the power of the broadcast station equipment, and the characteristics of the radio frequency of the carrier wave.

This new plate transmitter and its amplifier are carried by a truck when outdoor events are to be broadcast, much as such an outfit is equipped and used in audible broadcasts.

This transmitter is somewhat complex in its wiring, but so is a telephone switchboard, and is therefore no more a handicap in one than in the other mechanism. Also it is crude, as now constructed, but it performs, and I believe that because of the latitude possible therein, this method—i.e., persistence of light activity for transient activity of elementary areas—will ultimately survive.

It certainly brings us a long step nearer our ultimate goal when world events may be watched by millions of our citizens from comfortable seats thousands of miles distant from the scene itself.

WEATHER MAPS BY RADIO



Weather Map by Radio
(original 8 x 10-inch)

Weather Maps by Radio

On July 15, 1926, Captain Ridley McLean and Captain S. C. Hooper, of the U. S. Navy, and Professor C. F. Marvin, of the Weather Bureau, met in the Jenkins Laboratories for a conference on the practicability of a weather map service by radio to ships at sea.

After some discussion Mr. Jenkins agreed to design and build the special machines required, and to have them ready to install and operate within five weeks. The Weather Bureau agreed to furnish a current weather map every morning; and the Navy was to furnish a radio transmitter at Arlington wireless station, and the ships required to carry the map receivers in this triangular experiment.

Within the time specified two weather map transmitters and six receivers were ready. One transmitter was set up in the Jenkins Laboratories, 1519 Connecticut Avenue, N.W., Washington, D. C., and attached to a short-wave radio broadcast instrument; the other was set up in the Recreation Room of the Arlington Wireless Station, where it was operated on 36 KC until cold weather, when it was moved into the Navy Building, in Washington, and set up in a room off "Radio Central" in the Bureau of Communications, and connected with Arlington by wire.

One of the receivers was located in the Jenkins Laboratories for checking purposes; another in the Navy Building; one in the Weather Bureau; one in Chicago; one aboard the flagship of the Atlantic fleet, the U. S. S. *Trenton*; and one on the U. S. S. *Kittery*, Naval Operations Base, Hampton Roads, Virginia, from which point she made cruises to Guantanamo

Bay, Porte au Prince, St. Thomas, and other points in the Caribbean Sea, a territory noted for its severe static disturbances.

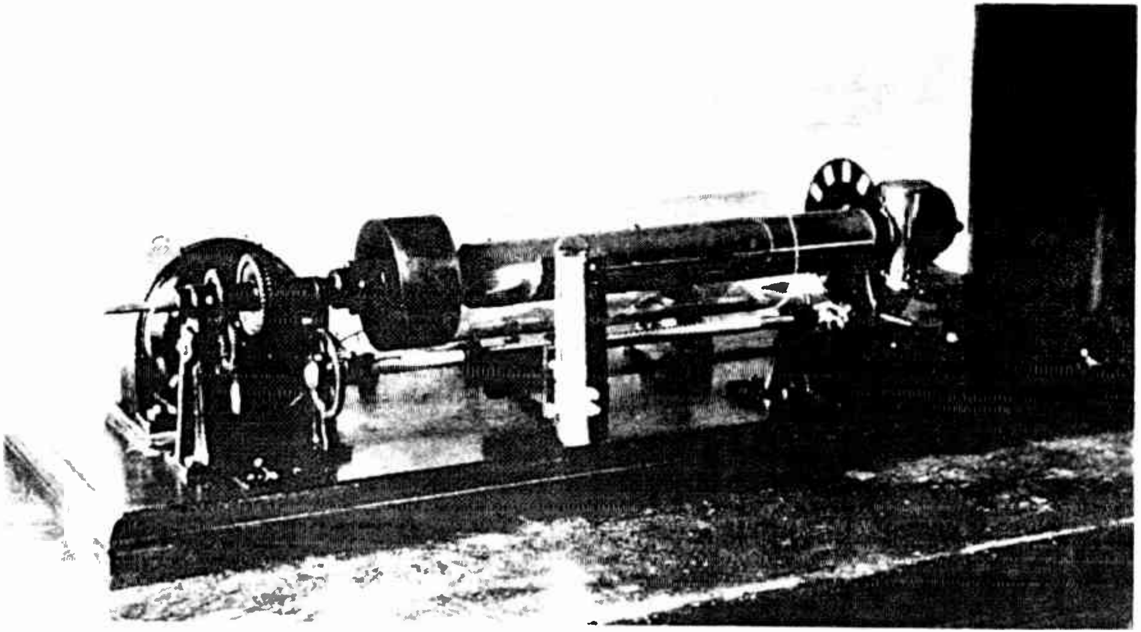
Mr. John Ogle supervised the building of the two transmitters and the six receivers required, Mr. Stuart Jenks installed and operated the receiver aboard the U. S. S. *Trenton*, Mr. Paul Thomsen that aboard the U. S. S. *Kittery*, Miss Florence Anthony was in charge of the check-up receiver in Washington, while Miss Sybil Almand performed as liaison officer—all members of Mr. Jenkins' staff.

The transmitter consisted of a motor-rotated glass cylinder upon which a photo-negative of the ink-drawn weather-map was wrapped. As the cylinder rotated, a light was projected into the glass cylinder and thence reflected outward through the transparent lines, figures, and letters of the map, where it impinged on a light-sensitive cell moved by a geared screw longitudinally of the cylinder and in contact therewith. The light-sensitive cell translated the impinging light into electric signals, which were then amplified, rectified and used to control the output of the radio broadcast equipment. The light which impinged on the cell was interrupted at a frequency which bore a definite relation to the rotation of the motor; the interruptions being about one thousand a second, a frequency selected because it gave the sharpest signals through the transformers used. The weather map had a border, the upper left-hand corner of which was employed to transmit a signal by which registration aboard ship was attained.

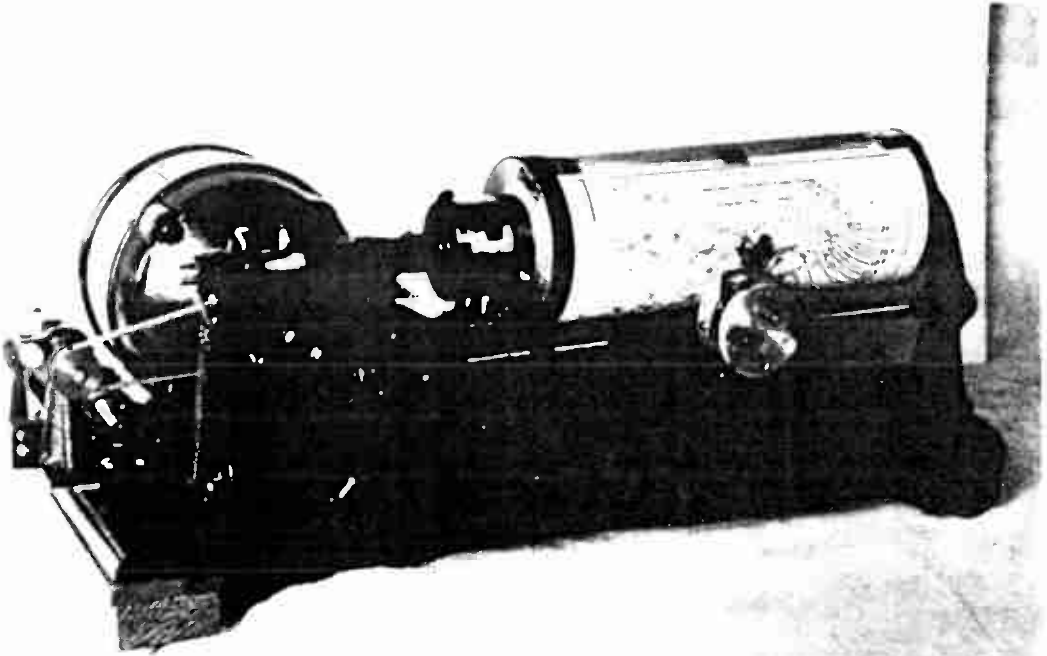
The receivers were rather simple machines and weighed but 35 pounds. Each consisted of a motor-rotated cylinder upon which was fastened a base map of the Western Atlantic and Eastern United States, printed in brown. A pen-box was mounted to move longitudinally by a screw along the surface of the base map. The point of the pen was normally spring-held just clear of the map surface. A steel pen of special form and adjustable nibs was finally developed which proved very satisfactory. It was fed with ink through a capillary wick. An experimentally mixed red ink was found very satisfactory, which always marked the paper no matter how fast the pen-arm moved.

Synchronization of receiver with the transmitter was accomplished by an electric governor on the motor and an automatic check device on the cylinder carrying the map. The motor current was taken directly from the light-and-power current supply of the ship, and the weather map signals from the code-communication radio receiver in the ship's radio shack.

To operate the weather map receiver, the radio operator takes his place at the machine, and tunes-in on the station known to be transmitting a weather map at that scheduled hour. After the usual code announcement he is told to "Stand by for a weather map." Thereupon he cuts out his loudspeaker and cuts in the map machine. The motor is not running, and the cylinder, which is friction driven, has been set with the pen point a little above the map border. With the first or second tap of the pen on the paper the operator starts the motor, for he knows this movement of the pen is caused by an incoming signal representing the transparent line at the top of the weather map negative on the transmitter in Washington. If the operator has started his motor within 10 per cent of the right moment—and he is considered clumsy indeed if he doesn't do much better than that



Jenkins Radio Weather-map Transmitter. May be attached to any broadcast station equipment, of any wave length or frequency. Built for 8 x 10 inch Weather Map, and used from September, 1926, to March, 1927, inclusively, in a cooperative experiment by the Jenkins Laboratories, the U. S. Navy, and the Weather Bureau.



Jenkins Radio Weather Map Receiver. Used in daylight aboard Navy vessels by the radio operator; no dark room or photographer was required. The Weather map was received in red ink on a brown printed base map. Perfect registry was attained aboard a rolling ship 2,000 miles at sea.

—then the next incoming radio signal automatically sets the machine in exact register with the transmitter so that all subsequent marginal ink dots will fall on the upper border line of the base map, or upon a marginal extension of it. After some six or eight more registering dots are put on the paper, a line about an inch long instead of the dot is drawn by the pen.

If this line is not on or very near the left vertical border of the map, the operator picks up the pen-box and moves it a screw-thread or two to the right or left until the next stroke does fall on the border line. The registering of the incoming radio weather map on the printed base map is now attained, and thereafter the completion of the map requires little attention from the operator, for the machine automatically keeps itself in rotative synchronism with the distant transmitter (by signals from the broadcast station) until the map is complete. It is then removed from the machine, and handed to the navigator of the ship for his information.

The first cruise of the U. S. S. *Kittery* with the Radio Weather Map Receiver aboard covered the time of 1926 "Florida Hurricane." The hurricane was recorded on the 15th, 16th, and 17th of September, three days before it struck the Florida coast. Only a casual inspection of these three maps showed that if the ship held her course she would encounter the maximum fury of the storm with consequent jeopardy of lives, cargo and ship. The southerly course of the ship was changed temporarily to an easterly course and the ship rode out the blow safely, though many other ships went down.

The success of the Radio Weather Map experiment is attested by the radio reports from the captain of the ship, copies of which are appended.

NAM NR 4 Z LARK V NHW N BOND COIN GR 11
FROM: USS KITTERY
TO ACTION: OPNAV
INFO: BUENG HYDRO.
1009 FIRST WEATHER MAP RECEIVED AT SEA INTERMEDIATE FREQUENCY PERFECT 2230.
JT 1028

------

1 DN V PT Z LARK V NHW N BOND COIN GR 17 BT
FROM: USS KITTERY
TO ACTION: OPNAV
INFO: BUENG.
1011 MAP OF LABORATORY PERFECT TODAY WITH TWENTY SIX DEGREE ROLL OF SHIP 0100
718 AM—I—38773.

FROM: USS KITTERY
ACTION: OPNAV
INFO: HYDRO BUENG
1015 YOUR 1914 1215 HIGH FREQUENCY MAP LABORATORY PERFECTION 1015
19 ORIG 20 B 20 C BUENG HYDRO:
2045 DH.

FROM: USS KITTERY
TO ACTION: OPNAV
INFO: BUENG HYDRO.
1019 MAP FORTY FIFTEEN KCS EXCELLENT 0715.
DR—416 I—44332.

NAU 383 Z LARK V NHW N BOND COIN GR 17
FROM: USS KITTERY
TO ACTION: OPNAV
INFO: BUENG HYDRO.
1015 ALL WEATHER MAPS FOUR THOUSAND FIFTEEN KCS EXCELLENT 2336 BC
19 ORIG BUENG HYDRO—42888

FROM: USS KITTERY
ACTION: OPNAV
NIFO: HYDRO. BUENG.
1016 REF YOUR 1914 1215 SECOND HIGH FREQUENCY MAP PERFECT 0225
0–35863

……

FROM: USS KITTERY
TO ACTION: OPNAV
INFO: BUENG HYDRO WASHN.
1023 FORTY FIFTEEN KCS MAP EXCELLENT 1455.
DL 1826.

……

FROM: USS KITTERY
TO ACTION: OPNAV
INFO: BUENG HYDRO WASHN.
1023 FORTY FIFTEEN KCS MAP EXCELLENT 1455.
DL 1826.

……

FROM: USS KITTERY
TO: OPNAV
1022 MIDNIGHT MAP EXCELLENT RECEIVED DURING LOCAL THUNDER SHOWER 1400.
2034 MM.

……

FROM: USS KITTERY
TO ACTION: OPNAV
INFO: BUENG HYDRO.
1020 NIGHT MAPS EXCELLENT ON FOUR THOUSAND FIFTEEN KCS 0010.
1154 Z I–4406.

……

FROM: USS KITTERY
TO ACTION: OPNAV
INFO: BUENG HYDRO.
1029 BOTH MAPS THIS DATE EXCELLENT 1432.
XL 1529

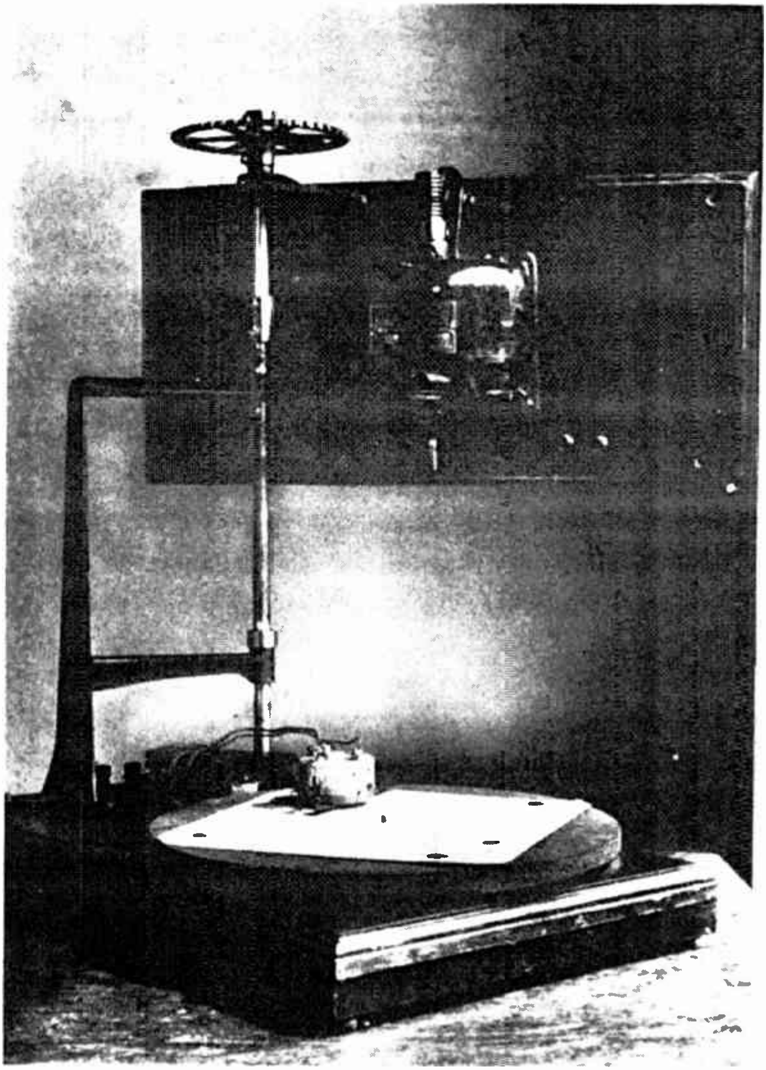
FROM: USS KITTERY
ACTION: OPNAV
INFO: BUENG HYDRO
2028 ALTHOUGH UNABLE READ WEATHER BULLETIN AT TEN THIRTY DUE STATIC DURING HAILSTORM COMMA RECEIVED EXCELLENT JENKINS MAP 36KCS NOON 1345.
1549 NX.

FROM: USS KITTERY
TO ACTION: OPNAV
INFO: BUENG HYDRO.
1026 FOUR THOUSAND FIFTEEN KCS MAPS TWENTY FOUR AND TWENTY FIVE MARCH EXCELLENT 1825.
DI—2154

L DN V PT Z LARK V NHW N BOND COIN GR 17 BT
FROM: USS KITTERY
TO ACTION: OPNAV
INFO: BUENG.
1011 MAP OF LABORATORY PERFECT TODAY WITH TWENTY SIX DEGREE ROLL OF SHIP STOP STATIC RECORDER OK 0100.
718 AM—I-38773.

FROM: USS KITTERY
ACTION: OPNAV
INFO: HYDRO. BUENG.
1016 REF YOUR 1914 1215 SECOND HIGH FREQUENCY MAP PERFECT STOP STATIC RECORDER ALSO OK ACCORDING THEORY 0225.
0-35863

PREDICTING HURRICANES



Static Recorder invented, designed, and built by Mr. Jenkins; initially installed for test aboard the U. S. S. *Mayflower*, then at Bellevue Naval Laboratories. Later installed on the U. S. S. *Kittery* and operated by a member of the Jenkins Laboratories staff on her March cruise to the Carribean Sea.

Predicting Hurricanes

If, as is now rather generally believed, static is a product of storms, it would seem feasible to locate storm centers by a process of detecting static radiation areas.

The author believes that the electric phenomena we call static, or atmospherics, is caused by the violent vortical movement of the wind, which results in a highly charged condition in the whorl.

But as the whorl is not charged to a like potential at all places, the charge is continually trying to shift its position to produce equilibrium and we hear the resultant crashes and snapping noises attendant upon such equalization.

Just as with a Franklin or Wimhurst static generator, the potential of the charge is proportionate to the speed of the influencing elements, the violent wind of a hurricane produces a charge potential of very high order, which is capable of being detected at great distances by our radio sets.

The distance at which this charge can be detected is so great, with respect to the diameter of the whorl in which the charge resides, that the storm center and the static center can be assumed to be coincident.

If, therefore, readings of static direction are made simultaneously, every few hours, at two or more rather widely separated stations, and these bearings reported to a coordinating office, the bearings can be plotted on a chart to determine with certainty the location and direction-of-movement of the hurricane.

By adding devices for measuring the intensity as successive readings are made the violence of the storm can also be reasonably well ascertained.

With the successive readings from all the station reports laid down on the chart, it quickly assumes the form of a plotted course of the hurricane and its degree of violence.

From this data, warnings can be broadcast by radio so that ships in the path of the hurricane may change course to avoid it, or otherwise prepare for a blow.

This method of discovering a hurricane early, perhaps at a location far removed from ships or other agencies which might report them, to be followed in direction and rate of movement as it grows in violence, should ultimately prove of the greatest value to shipping, and in the saving of life and property.

In February, 1926, an officer of the Navy suggested that if I would design, build and operate such a static recorder they would cooperate with me in its test. I did this, and the recorder was temporarily installed aboard the U. S. S. *Mayflower*, at Washington, D. C. The close proximity of the Navy Yard wireless towers made the results undependable, however. So the instrument was then moved to the Naval Research Laboratories, at Bellevue, where readings were made, the first one detected being a static center in Canada, a fact confirmed by the Weather Bureau the next morning.

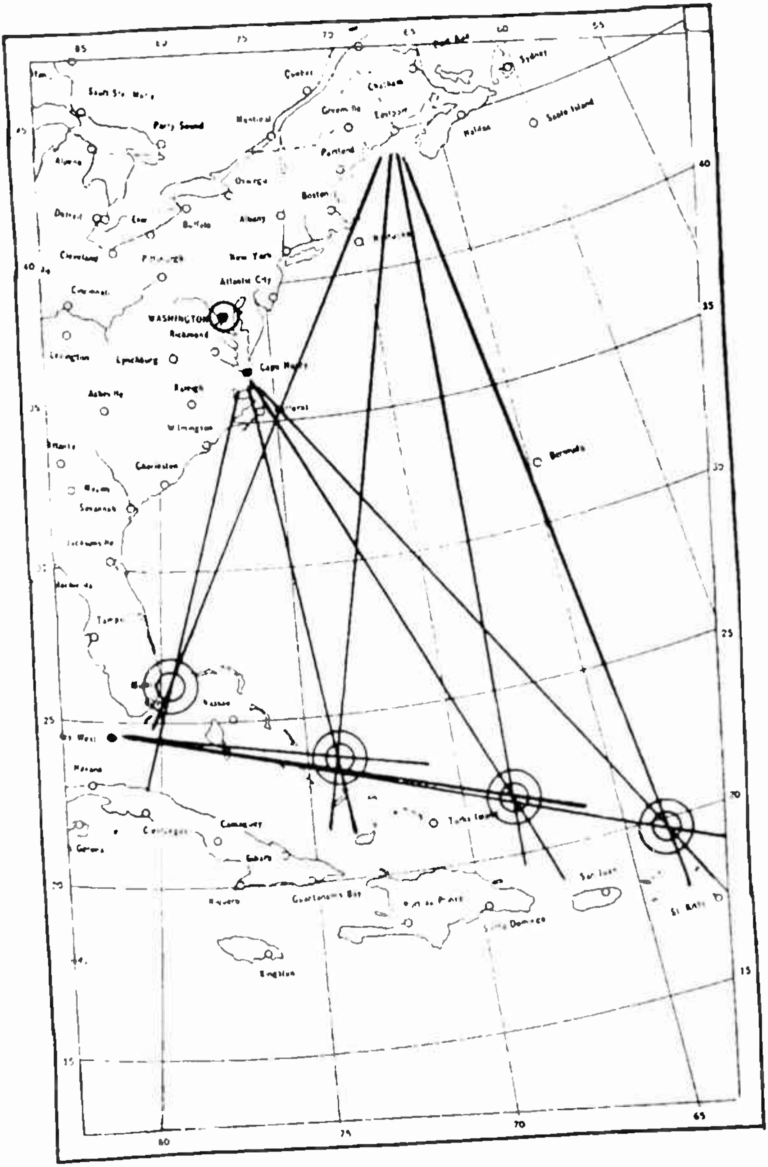
Several such readings were made, when it was decided that the instrument should be put aboard the U. S. S. *Kittery* and sent to sea on the next weather-map cruise. This was done and the results were reported in radiograms from the captain.

L DN V PT Z LARK V NHW N BOND COIN GR 17 BT
FROM: USS KITTERY
TO ACTION: OPNAV
INFO: BUENG.
1011 MAP OF LABORATORY PERFECT TODAY WITH TWENTY SIX DEGREE ROLL OF SHIP STOP STATIC RECORDER OK 0100.
718 AM—I-38773.

FROM: USS KITTERY
ACTION: OPNAV
INFO: HYDRO. BUENG.
1016 REF YOUR 1914 1215 SECOND HIGH FREQUENCY MAP PERFECT STOP STATIC RECORDER ALSO OK ACCORDING THEORY 0225.
0-35863

This static recorder consisted of a cork-topped table to which a printed compass card is fastened with thumb-tacks. The table is turned by a motor taking current from the ship's lighting system. The motor also rotates the ship's radio compass loop. Over the compass card on the table a pen-box is supported to move toward the center of the table in a three-turn spiral. This is to give a repeated record of three turns of the table, making the record more certainly correct and easier read.

To operate the instrument a compass card is tacked to the table in such a position as to coincide with the direction of the compass loop. The pen being attached to the radio set, the motor is started. As the compass loop swings around and picks up the static signals the pen is agitated to mark the compass card at a point on the card indicating the cardinal direction of the loop. The compass loop is allowed to rotate two or three times before the motor is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Cleveland
Pittsburgh
New York
Atlantic City
Cincinnati
WASHINGTON
Richmond
Lexington
Lynchburg
Cape Henry
Asheville
Raleigh
Wilmington
Atlanta
Charleston
Bermuda
Macon
Savannah
Jacksonville
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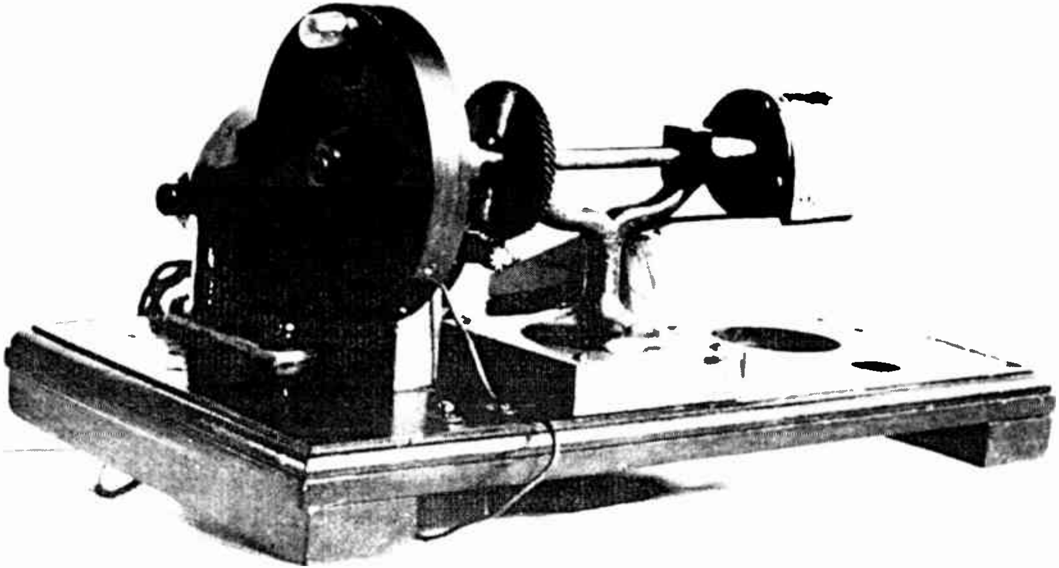
stopped. The card, therefore, has a double or triple record thereon of the compass direction from which static signals were received. The hour and date are then added, a radio report made to headquarters for charting, and the card filed for future reference.

The compass loop arrangement was not designed to give unidirectional readings. This was not disadvantageous, however, because like readings must be taken from one or more additional stations anyhow in order to get a "fix," when plotted on a chart blank to locate the storm centers.

While but little work was done with this recorder, it conclusively proved its usefulness in locating hurricane centers, and confirmed the correctness of the theory on which it was based.

It is my belief that this method is far superior to the barometer-reading method of locating storms at sea. It provides a ready means of continually sweeping the ocean areas for storms, and doing this from land stations far outside the disturbance itself.

THE JENKINS LANDING ALTIMETER



Jenkins Airplane Landing Altimeter

Crude model of airplane landing altimeter (1926). A snapping sound is made every half second by the hickory blade hitting the cam. The sound is directed toward the ground by a megaphone located in the opening at the right. The echo is picked up by a special microphone in the tail of the plane and flashed the tiny lamp on the disc (at the left.) The lamp rotates behind a glass on which is a calibrated scale (not shown), giving a direct reading of the constantly lessening distance between plane and ground as the pilot glides to a landing.

The Jenkins Landing Altimeter

It will quite readily be guessed that, in the many years I and my staff of assistants have been working toward the realization of practical methods and mechanism for vision by radio, many collateral ideas have resulted. Some of these ideas have seemed of immediate useful application, should opportunity present, while others have been so radical and their probable acceptance by the public so remote, that they will not be mentioned at this time.

One of the former is an airplane landing altimeter which enables the pilot to confidently glide to a landing in a fog. It often happens, especially in the mail service, that the landing field can be located by the quadrangular glow-spots in the fog which mark the four corners of the field. But the fog is so dense that the ground cannot be seen, and, therefore, the pilot has no means of determining the exact moment when he should flatten out in his glide to a landing.

The purpose of this landing altimeter is to give the pilot this information; and it is done by providing a calibrated scale upon which he reads his exact distance above the ground at half second intervals as he glides down. With his exact altitude known all the time, he has no difficulty in flattening off at the right moment to set his plane down in a perfect landing.

The mechanism by which this is attained consists of a sound-making device at the small end of a megaphone which directs the sound toward the ground; and means for picking up the echo, and making it visible on a calibrated scale indicating in feet the constantly changing distance from the plane to the ground.

In the crude model tested the sound device consisted of a hickory clapper snapped by a rotating cam, the clapper being just over the small end of a megaphone pointed groundward.

The cam was on one end of a shaft rotated by a 6-volt motor. On the other end of the shaft a disc is mounted, and near the periphery of the disc a tiny neon lamp is carried.

In front of, and parallel to the plane of rotation of the lamp, a glass plate (not shown in the illustration) is arranged, of a width somewhat greater than the diameter of the orbit of the lamp. This glass plate is circularly calibrated.

In the tail of the plane a special megaphone is mounted, with the big end pointed toward the ground, and having in the small end a special microphone. The megaphone has walls deadened to prevent reverberation.

When the machine is started, and the echo of the measuring sound is picked up, the amplified signal flashes the lamp. As the lamp is in rotation, the flash occurs somewhere around the circular scale. And as the sound was made when the lamp was at zero of the scale, the flash of the lamp constantly indicates on the scale the changing distance from the plane to the ground.

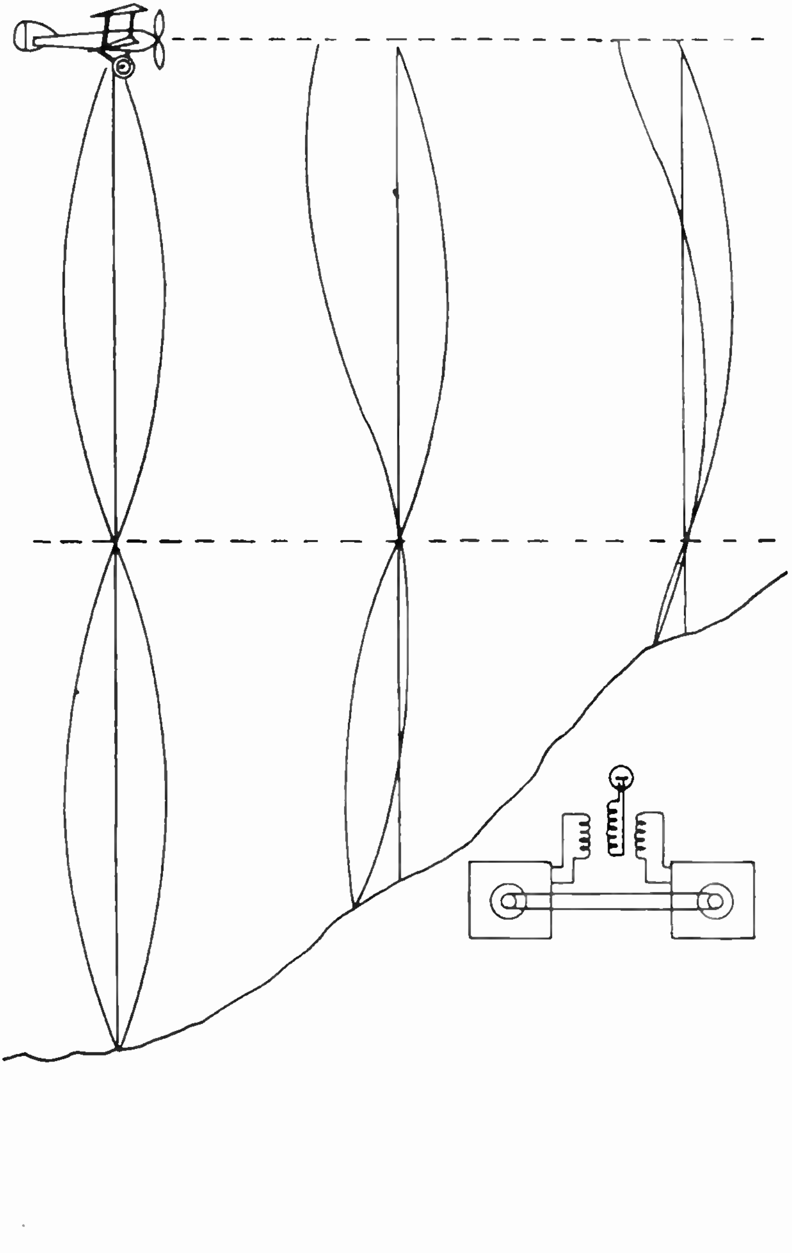
The flashes occurring every half second, for example, give correspondingly frequent readings of the constantly shortening distance from plane to ground.

As this acoustic altimeter is effective only within a few hundred feet of the ground, it is not switched on until the pilot has come down to within that height as shown by his aneroid altimeter.

By substituting a spark for the neon lamp a very small unit can be made, with the calibrated scale on the instrument board, and a spark-coil replacing the tube-amplifier required by the neon lamp.

The distance over which this instrument will work is not yet determined, but would seem to be limited only by the sound-producing means.

If used only in fog landings, motor noises may be ignored, as has been determined by experiment, for the motor is idling.



A Radio Crash Warning

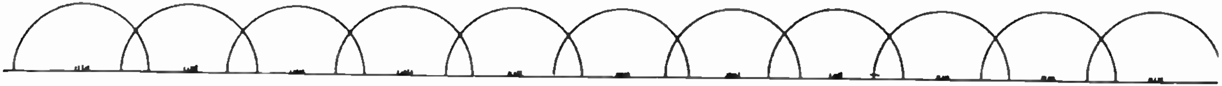
A further collateral development is a device for measuring distances by short-wave radio signals and reflections of them.

The method consists of the directional transmission of a given frequency and wave length from an oscillator carried by the plane, and picking up the return wave reflected from the ground. The concurrence of the two waves actuate an indicating device, preferably a visual one, as for example, a lamp, or plurality of lamps differently colored to denote different distances from plane to ground.

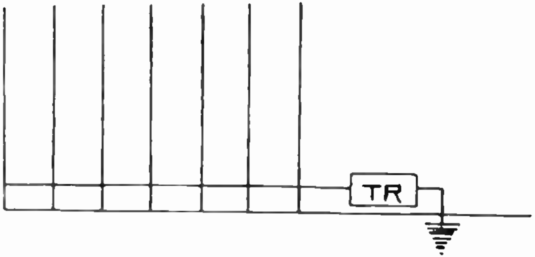
Thus, in its simplest form, if the oscillator energizes a given lamp, through an impedence which only permits a dull lamp-glow, the ground-reflected wave adds its energy to the lamp to bring it up to full brilliancy; while if it were out of phase by 180 the returning energy would oppose the initial energy and the lamp would go black.

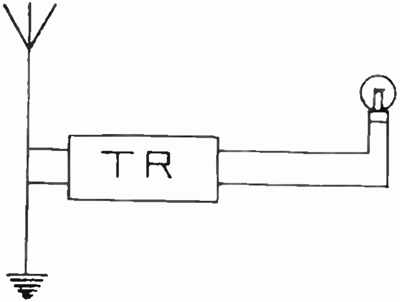
Modifications of this mechanism will readily occur to the radio-engineer, whereby airplane-to-ground distances may be measured during flights in low visibility weather, or fog-landings may be readily measured, as the light changes during the glide to a landing. However, the sonic landing altimeter is much simpler, more easily read, and believed to be better adapted to this purpose.

But the greatest value in this device is its warning of head-on crashes in fog flying. For example, when entering fog in doubtful territory the pilot switches on his instrument, and continues his course sure in the knowledge that directional warning of an approaching mountain will be received several thousand feet ahead of actual contact, so that he may avoid the impending crash.



A RADIO-MARKED AIRWAY





Airplane Radio Channel

A further application of radio in the service of the pilot is as a guide to keep him on his true course when flying in low-visibility weather.

The application herein proposed consists of (1) a series of low-power high-frequency current generators set up at lamp-beacon stations, the latter located about 25 miles apart; and (2) of a receiver aboard the plane to pick up current from these transmitters when within the influence of the successive stations, indicating that the plane is following this marked course.

All the transmission stations have bi-directional radiation, in overlapping order, and of a power, say, for a 20-mile radius. This arrangement gives an energy radiating channel of short-reach power-units, a channel which can, therefore, be changed in direction as frequently and in as short sections as mountainous territory or other regular course change may require.

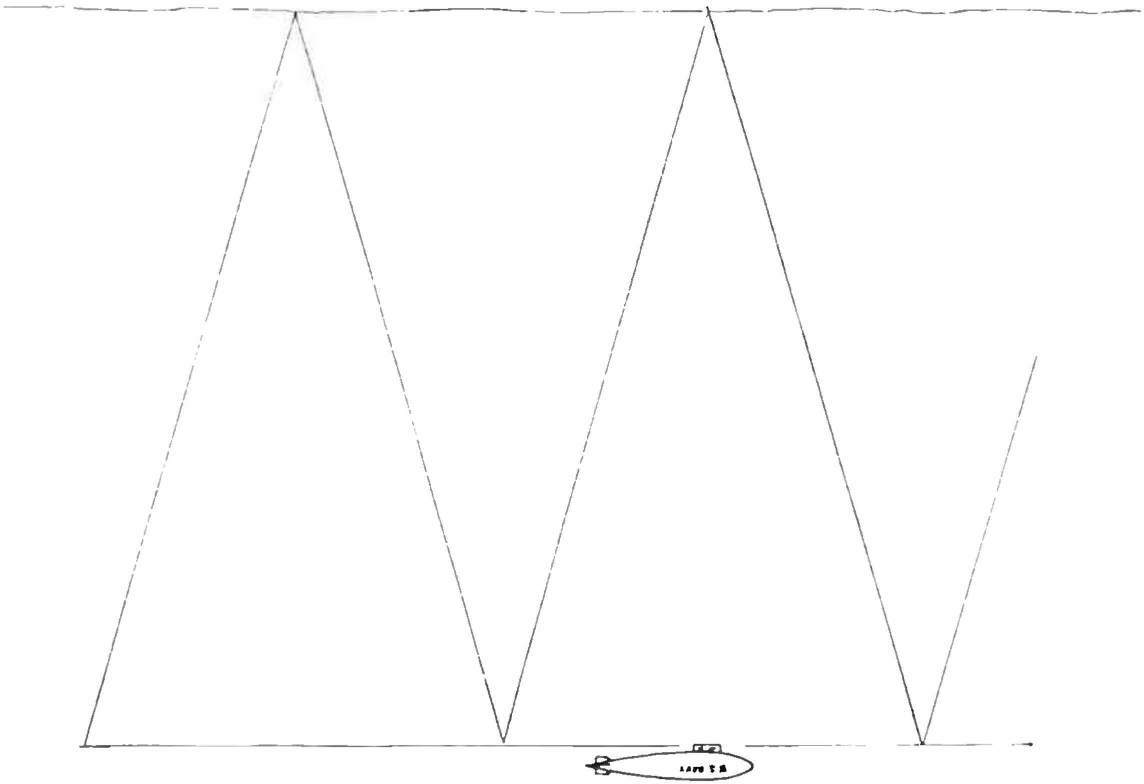
In this radio channel the pilot flies, carrying in his plane an instrument which is excited by this ground-radiated energy. This receiving instrument when so energized lights a glow-lamp located in a shielded position on the instrument board.

When the pilot is in the channel his lamp glows; when he deviates the lamp dims, going out entirely when he gets out of the channel. The pilot's reaction to these light changes is obvious, i.e., he comes back into the channel by steering his ship accordingly.

These radio installations are very simple, inexpensive units, and easily installed and maintained in automatic operation. They start in the evening and stop in the morning, and also by a change in the visibility of the weather, as by fog, dense snow or rain, much as isolated marine beacons are now automatically operated.

The merit of this system lies in its simplicity, low cost and dependability, but particularly in the opportunity of changing the direction of the channel in short stretches. Aboard the plane the receiver also is of the simplest character, requiring no tuning or other attention, and dependable, having no moving parts.

GROUND SPEED METER



Ground Speed Meter

Another of the collateral developments is a ground-speed meter for airships and transport planes, which can be read directly in miles per hour as an automobile speedmeter is read.

It depends for its success upon the use of the prismatic ring, which in 1922 to 1924 was used so successfully in still pictures by radio. It is a glass prism which gives an oscillation to a beam of light passing therethrough.

It behaves as though it were a solid glass prism which changes the angle between its sides; that is, a stationary beam of light on one side of the prismatic ring is given an oscillating motion on the other side of the ring.

Structurally, the ground speed meter consists of a pair of prismatic rings, a motor to rotate them, an eyepiece through which objects on the ground may be seen, and means for adjusting the speed of the motor after the instrument has been set for altitude.

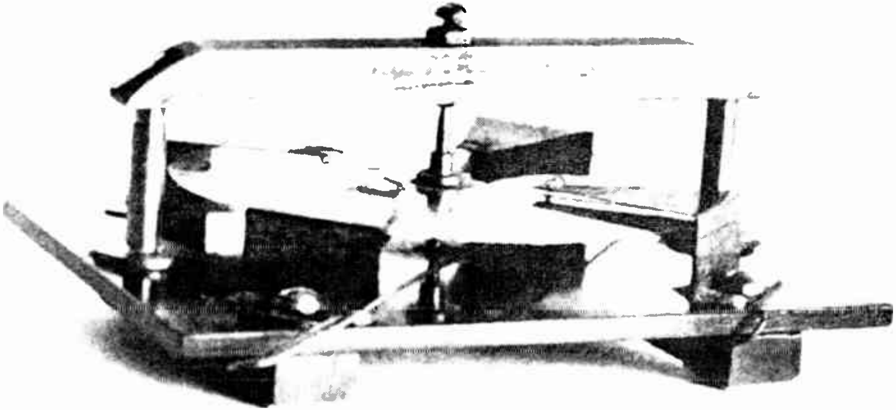
The operation of the instrument is as follows: Assuming the ship to be flying at an altitude of 2,000 feet, for example, the altitude dial is set for readings at 2,000 feet. Then, sighting through the eyepiece at objects on the ground, the speed of rotation of the prismatic rings is adjusted until objects on the ground seem to stand still as they appear successively in the field of the eyepiece; the speedometer scale then indicates the miles per hour, ground speed, at which the ship is flying.

And this reading requires no correction for drift or wind velocity, for the instrument is oriented to read in miles per hour in the true direction of flight.

The principle on which the instrument operates is a method of "inverted triangulation," in which the apex of an isosceles triangle rests on the ground. With the altitude and the apex angle known, the areal base line along which the ship is flying can be mechanically calculated. And as this base line is repeated over and over again, with each revolution of the prismatic ring, the number of ring revolutions per minute can readily be mechanically translated into miles per hour, just exactly as the revolutions per minute of an automobile wheel can be read in miles per hour on an automobile speedometer.

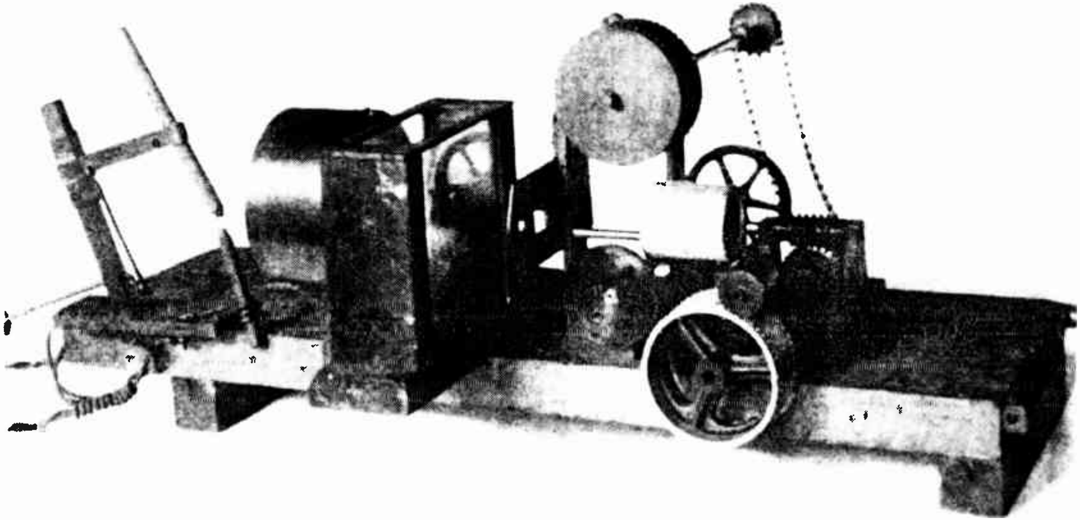
As the ground angle of the inverted triangle is always the same, and determined by the fixed angle of the prismatic ring, obviously the higher the ship the longer the base of each succeeding triangle, and the slower the rotation of the prismatic rings for a given indicated miles per hour of the ship's ground speed.

Conversely, if the ground speed of the ship is known by any means whatever, the altitude can be read off the dial of a comparable instrument, and irrespective of changes in barometric pressures during flight.



A motor which rotates by power taken from incoming static charges. The field consists of four poles in crossed pairs. One field pair is attached to an aerial, the other to the ground. The rotor consists of five segments, so that the motor is self-starting. Tinsil brushes on the field poles charge the rotor segments, starting the motor. The brushes then reverse the charge as they pass the next field poles. The alternate attraction and repulsion produce continuous rotation, the speed being in proportion to the strength of charge.

This motor was designed and built by Mr. Jenkins during a rest period, but is believed to be based on sound reasoning. A power which can split great oaks should be harnessed for useful service to man, just as the windmill harnesses the transient wind.



This machine is the prototype of the motion picture projector in universal use the world over, the result of experimentation begun by Mr. Jenkins in 1890; the machine finished and publicly exhibited in 1893 and 1894. Later shown before the Franklin Institute, and thereafter in the U. S. National Museum. When it has completed its service in the Laboratory office, the Franklin Institute Museum will be the final depository.

The accompanying cuts show the Elliott Cresson Gold Medal awarded by the Franklin Institute, of Philadelphia, for a machine exhibited before the Institute in 1895 by Mr. C. Francis Jenkins.

Later, in making a second award, that of the John Scott Medal, "in recognition of the value of this invention," the Institute Committee said: "Eighteen years ago the applicant exhibited a commercial motion picture projecting machine which he termed the 'Plantoscope.' This was recognized by the Institute and subsequently proved to be the first successful form of projecting machine for the production of life-size motion pictures from a narrow strip of film containing successive phases of motion."

VISITORS

Grace Coolidge

John Coolidge

Calvin Coolidge Jr.

Mrs. F. W. Stearns

Mary Vaux Walcott

Mary Roberts Rinehart

Mrs John Hays Hammond

C. D. Walcott

Cap'n J. P. Ault

Vernon Kellogg

Marlen E. Pew

J. McK. Cattell

Edwin E. Slosson

Orville Wright

James G. Harbord

Ernest Henderson

W. J. Mayo

Walter Hinton

[illegible]

W. G. McAdoo

Margaret Oliver-Holmes

Burton Holmes

Wing Commander [illegible]

Gelasio Caetani

Sao Ke Alfred Sze

Isaburo Yoshida

VISITORS

Ira E. Robinson

O. H. Caldwell

Sam Pickard

Harold A. Lafount

W. D. Terrell

H. M. Turner

Lee de Forest

Emile Berliner

Roger W. Babson

Mrs. Roger W. Babson

W. A. Moffett

D. W. Taylor

S. S. Robinson

S. C. Hooper

A. Hoyt Taylor

Geo. O. Squier

Chas. Saltzman

Major J. O. Mauborgne

Général Ferrié

Stuart Jenks   Elwood Russey   Vera Hunter   John Ogle   Paul Thomsen
Sybil Almand Windridge   C. Francis Jenkins   Florence Anthony Clark

JENKINS LABORATORY STAFF

Visual Radio Patents

Jenkins

1,697,527
1,695,980
1,694,065
1,693,509
1,693,508
1,684,736
1,683,137
1,683,136
1,679,086
1,677,590
1,667,384
1,667,383
1,663,308
1,662,677
1,660,711
Re 16,888—1,521,192
1,659,736
Re 16,882—1,530,463
1,659,200
Re 16,818—1,525,548
Re 16,790—1,537,087
Re 16,789—1,521,191
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Re 16,767—1,525,550
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Re 16,733—1,525,554
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THE LAW OF FREE MOVEMENT

The Law of Free Movement

C. Francis Jenkins

On occasions I have wondered if there are not daily phenomena so familiar to us that we accept them as facts without stopping to study the underlying law, and thus overlook the possibility of useful application elsewhere.

Just for example, there is the fluttering flag with which we are all familiar since our youth. Why the flutter? Why doesn't the flag stand out straight from the staff like a piece of tin? A flag does not flutter in water. So where does the flutter come from?

The only explanation I now recall I found many years ago in "Alice in Wonderland," where she tells us that the Old-Man-in-the-Mountain supplied flutters for flags, rustles for silk dresses, and a very superior quality of post-hole.

But when I reached man's estate I did not find Alice's explanation quite satisfactory, and so began to puzzle out a reason for myself, and to my surprise I found it fitted many other observed happenings, of interest to all kinds of folks—to you, and to me, to insurance men, to airplane designers, to engineers in general.

So for my own guidance I wrote the explanation into a physical law which I could apply, and which is, practically, the Bernouilli theorum in the workable phraseology of the man of the street, as follows:

Any object free to move in a fluid will move toward that part of the fluid having the swiftest motion.

That is why the flag flutters, that is why leaves are "sucked up" from the ground, and that is why frame buildings are often pulled apart in violent windstorms.

The ball stays in the stream of air issuing from the pipe.

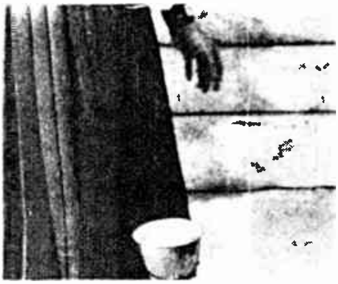
The law also explains why great plate-glass windows are "blown out" in high winds. In normal conditions of quiet air the pressure on each side of the glass is equal; but as the wind grows in velocity, the air-pressure decreases on the outside, the gusty side of the glass, until the static pressure inside the window overcomes the strength of the plate and the whole gives way with explosive violence, the thousands of pieces being blown outward onto the sidewalk. The precaution is obvious: i.e., if you would save your plate-glass windows during storms, leave a door open.

During the latter part of the war two airplane hangars stood near each other on a flying field. On the approach of black clouds indicating a violent storm, hurried efforts were made to close the hangars, but there was time to close only one of them. The open one weathered the storm safely, but the sides of the closed hangar were sucked out in the wind and the heavy bridge-truss structure of the roof dropped down on the planes, wrecking them.

It is no uncommon thing, as many of you know, to have the tin covering pulled off roofs. But the tin is never pulled

She pushes the ball down the air-stream into the cup without touching the ball.

off old buildings, which are open because the windows have been broken out.

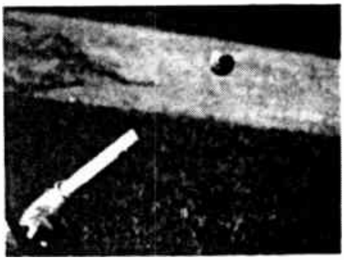


The ball cannot be blown out of the cup by the stream of air issuing therefrom.

A little neighbor of mine delights to spring on the unsuspecting a trick of her own which depends upon this reduced pressure effect of moving air streams. Sticking a pin through a visiting card, she drops the pin into the hole through a spool, and dares anyone to blow the card off the end of the spool by blowing through the hole. One can't do it; to blow hard only makes it stick the closer. The quiet air above the card holds it hard down on the moving air escaping in a thin stream between the card and the spool end. If, however, the quiet air above the card is disturbed by air leaking past the pin, or one blows over the card, then the card is easily lifted off.

There is abundant evidence that the law applies equally well to liquids also, explaining the peculiar behavior of bodies in moving water.

Why, for example, a log thrown into a swiftly running stream is quickly "drawn" to the middle and rides on the crest of the freshet, the crest itself resulting from the same cause. I think one would naturally expect the log to



Showing how stream of air at 45° will hold ball suspended above ground.

be pushed aside by the rushing water.

A light canoe going through the rapids does not collide with the ugly looking rocks, but is carried therebetween, and comes safely through if it does not upset.

A jet of air cannot hold a square box in the air stream, as it does a sphere.

Every summer we read of strong swimmers drowned in the ocean undertow. Into the outrunning water next to the smooth sandy bottom the swimmer is pushed and held down by the relatively motionless water at the surface.

A speed-boat sinks by the stern for the same reason, i.e., the water under the boat is thrust aft by the propeller faster than the surface water, and so the stern sinks, deeper and deeper as the speed increases.

Buoyant bodies going over a waterfall come to the surface only in the quiet water of the stream some distance away; though a like bolt of wood dropped endwise into a quiet pond jumps up immediately.

You have all seen the bobbing ball in the water fountain on the lawn. But do you know that only a round ball will stay up? A small square box will not stay in the stream, whether the jet be water or air. Walter Johnson cannot curve a hexagonal ball; nor can the Flettner

Walter Johnson can throw a curve only with a spherical ball.

ship use rotating square cylinders to get power out of the wind.

Did you ever drop a small marble into the funnel-shaped end of the lawn hose nozzle and discover that the water cannot dislodge it. It can't; and the more the water pressure the more resistant the marble is to dislodgment, which is a surprise to most folks.

Put a stiff visiting card (with a pin in it) on the end of a spool.

The law applies as well to two dissimilar fluids, water and air, for example, and that is the reason for the waves on the ocean, which are higher the stronger the wind. The passing wind lifts the water into a wave; this wave hump slows up the air movement; and as this robs the air of its lifting power, the wave collapses, releasing the wind to movement again, and to again pick up a wave. And this is repeated over and over again as long as the wind blows.

The steam injector I believe to work on exactly the same principle, although I am aware that it is usually explained otherwise. It is the velocity of the water, sucked forward by contact with the high velocity steam, that carries the water into the boiler, the steam being

The card can't be blown off by blowing through the spool (if the corners of your mouth don't leak).

dissipated by condensation in the cold stream.

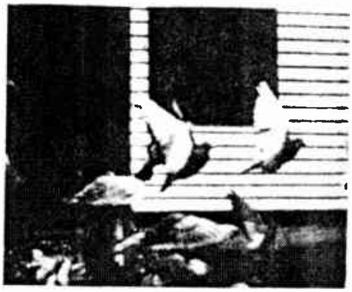
Blowing gently across the top of the overturned scale pan will lift it.

Liquids may also capture air. When one draws a glass of water at the kitchen sink, the stream carries air down into the glass and the glass is filled with water plus air, bubbles of which latter rising to the top escape to leave the glass less than full, when the glass is quietly removed from under the running faucet.

A very simple air-pump is made on this principle, a pump without moving parts. Vertical pipes are set under a waterfall, and the water capturing the air carries it down the pipes, to be collected in a chamber below, the air pressure being proportional to the height of the waterfall, and the area of the water exit from the chamber.

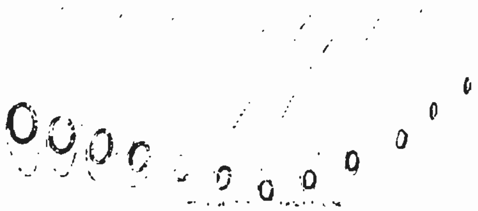
The grain-elevator man employs this same principle to move tons of wheat, by pouring a stream of it onto a swiftly running flat belt conveyer. The wheat humps itself up into a ridge in the middle of the belt as soon as it takes up the belt speed; not a grain falls off.

This law also explains why soaring birds ride the air with little effort. The



The forward stroke sustains the pigeons; the backward stroke advances them.

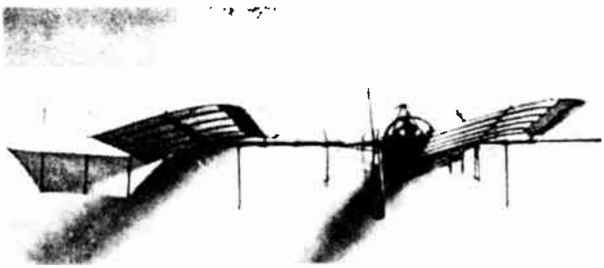
eagle is noted for this gift of nature, though he soars too high for convenient observation. But seagulls and the albatross perform low, where their movements can be studied easier. Into the wind each seems to advance without effort, going up and ahead on motionless wings.



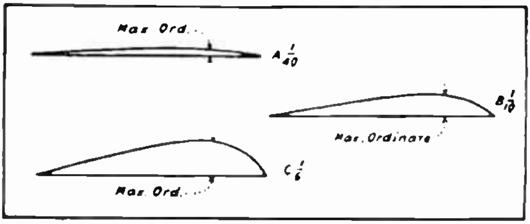
Cross sections of eagle's wing showing camber of wing.

On occasions when the wind is blowing from the Canadian side down into the gorge just below the falls at Niagara, one often may observe gulls glide into this down-air stream and be carried out of the gorge, up over the edge into the wind.

The thick leading edge of the bird's wing with its eddy-forming hollow underneath, just behind the bone, tends to slow up the air stream below, while the "down hill" slope of the smooth upper surface of the wing increases the wind velocity above. So



The Langley tandem monoplane with cambered wings.

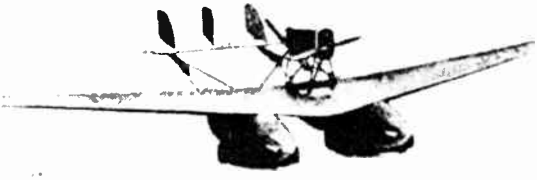


Diagrams show increased depth of cord for increased lift.

with the air movement increased above and retarded below we find a great upward pull on the wing. More than 90 per cent of the support of the bird is in the air passing above the wings, while the air beneath, slipping out from under the bent-up feathers of the wing tips, propels him forward.

Professor Langley incorporated this hump on top of the wing of all his models, but whether or not he copied from the outstretched wings of the soaring eagle he had mounted for his study of aerodynamics, I do not know.

It is now well understood by the designer of gliders, as well as powered planes, that 75 to 80 per cent of the lift of the plane is obtained from the air passing over the wing, and but 25 to 20 per cent of lift from air striking underneath. And an increase in the camber of the aerofoil increases the lift; and so we find planes designed for carrying heavy loads have



Santa Maria with engines so high the whole slipstream passes over the wings.

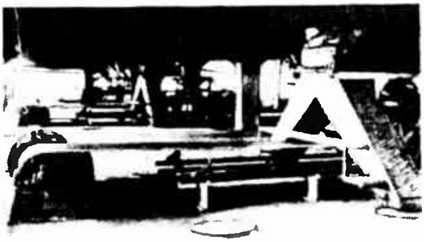
very thick wings.

Speed boat with submerged propeller sinks by the stern.

With the lift proportional to the air speed above the wing, one naturally concludes that the greatest lift and the greatest fuel economy should result from passing the whole of the propeller slip-stream above the aerofoils.

And such is the case. The British light-plane distance-and-fuel-economy contests of 1923 were won by monoplanes with the propeller elevated on stilts until the whole of the slip stream passed above the wings.

The Italian-built flying boat, *Santa Maria*, in which Col. Marchese de Pinedo flew from Italy to South America; over to Savannah, Georgia; across the United States and back again; and thence home, a 30,000-mile trip, had all his motors located high above the wings. His fuel economy was surprising.



Flat belt for grain conveyor.

The great 60-passenger German Dornier has its motors similarly placed. Here in America we don't yet build to economize on gasoline—it's too cheap.

To those research laboratories now experimenting on jet propulsion for aircraft instead of the usual propeller, may I suggest that, whether jet propulsion is sufficient or not, the jet will lift more if the air stream is directed across the top of the aerofoil. So directed, the thrust will be just as great, while the lift will be more than if the stream is directed beneath the wing.

In 1894 I patented a camera through which I am running 200 feet of motion picture negative film per second. The mechanical problem of moving the film, and the optical problem of sufficient exposure, were readily enough solved, but I worked for twenty-five years before I learned to successfully hold the film in the exact focus of the lens during exposure; for when the film at that speed contacted with the light tension spring members usual in other cameras, the film would catch fire. But in time I found that film moving 200 feet a second attracts air to its surfaces and holds it with "bulldog" tenacity. So I solved my problem by building a narrow channel through which the film should pass in the focus of the lens, held exactly in the middle of the channel by the film of air clinging to each face of the motion picture negative. The camera has worked perfectly ever since.

It is all very plain when we remember the law; i.e., that the pressure is always toward the rapidly moving body; and that this force is increasingly powerful as the difference in velocity increases.

I believe engineers generally will find many useful applications for this phenomena when they come to think of it as familiarly as they do other physical laws—the law of gravitational acceleration, for example.

So now we know why flags flutter. With the elastic air passing down the sides the bunting moves to the fastest side. The hump thus formed slows up the flow of air on that side, and the bunting moves over into the swifter air of the other side. This hump in turn slows up the air on that surface and the action is repeated, over and over again, as long as the wind blows. And so, with the air moving down opposite sides of the bunting in alternating pulses,. the flag moves from side to side in successive waves down its length from staff to trailing edge. The stream of elastic air makes humps and hollows in the bunting, waving or fluttering the flag as the wind is gentle or is strong.

And it is thus "Old Glory" flies from many a proud staff.