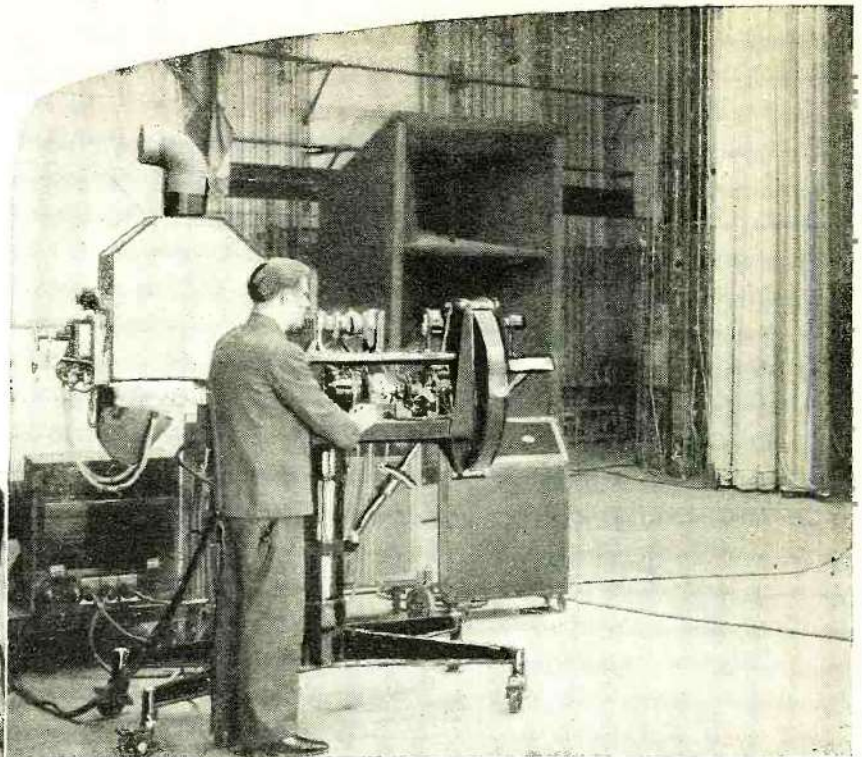
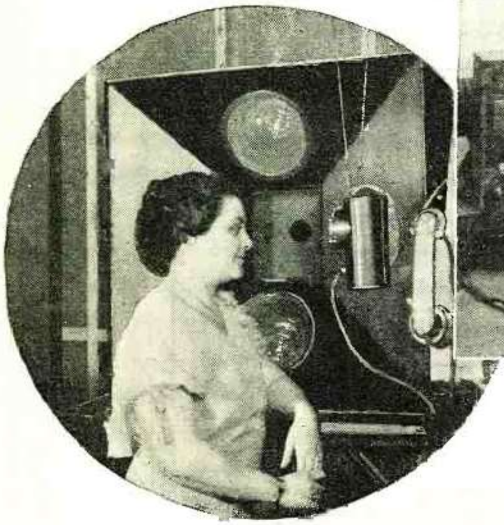
To the right, R. D. Kell, one of the assistants of Dr. E. F. W. Alexanderson, of the General Electric Company, operating the television theatre projector, showing how the picture is projected from backstage. Below, Matilda B. Russ, soprano, before the television camera and "mike" in the G. E. laboratory





TELEVISION

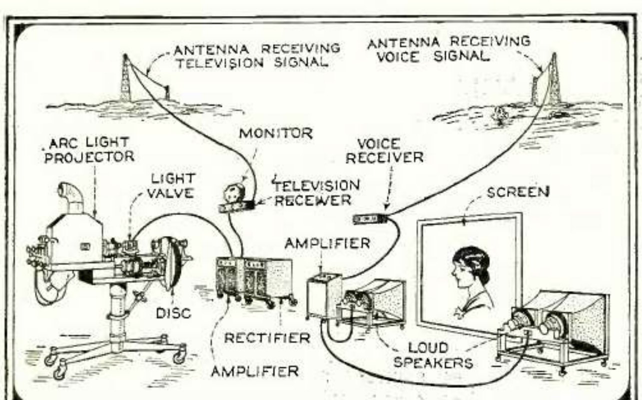
from Peephole

Most people are accustomed to think of along one of these days, but at present streaked picture which is viewed through ments have shifted the scene from

By Edgar

THE spectacular character of the recent television demonstration at the RKO theatre in Schenectady tended to overshadow the real significance of the event. A human face projected on a screen six feet square proved so startling a contrast to the best one-foot image heretofore seen at laboratory demonstrations and radio shows that its size was naturally emphasized in the newspaper accounts rather than the fundamental technical improvement disclosed.

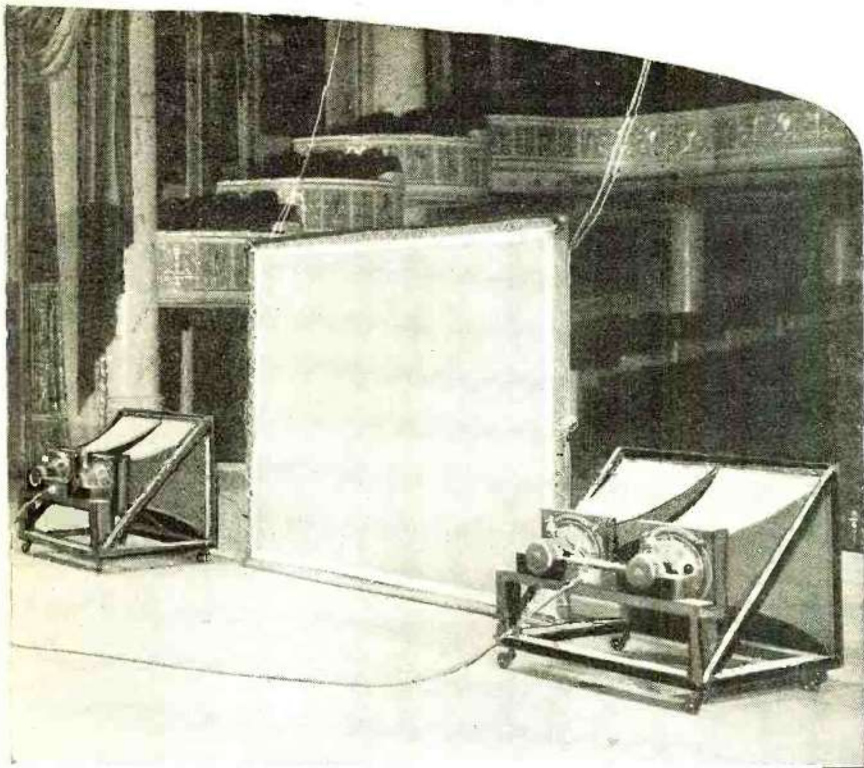
After the audience of the first television performance in a regular theatre had been seated, the curtain rose, exposing a screen six feet square, approximately one-fourth the area of the standard motion picture screen. To one side of the screen was a pedestal with a telephone, where the host announcer stood awaiting a connection with the television studio in Dr. Alexanderson's laboratory in the General Electric buildings nearly a mile away. The smiling face of Merrill Trainer, one of Dr. Alexanderson's laboratory assistants, soon appeared on the screen, much larger than life, answering the telephone at the other end, while his voice echoed realistically from the loud speakers back of the screen. Then a series of vaudeville actors took Trainer's place. Each did his act with his partner at the other end of the telephone line, the audience seeing and hearing one actor in person and the other through television projector and loud speaker. The finale of the program was an orchestra number with the conductor directing from the television studio a mile away.



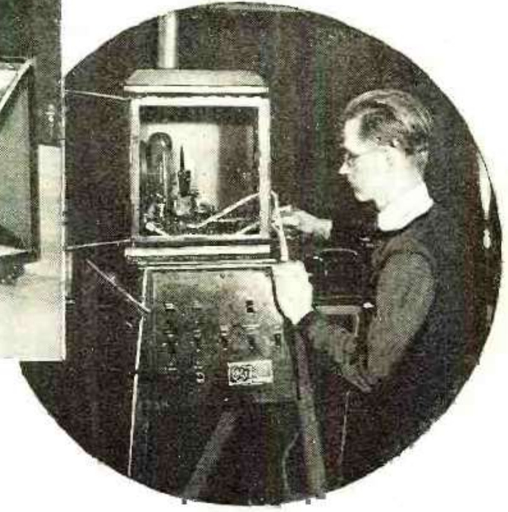
This pictorial drawing shows the apparatus which is employed at the receiving end of the radio-television set-up. Two receivers, one for radio voice reception and one for the television signals, are used

Quality of Reproduction Attained

The range of brilliancy of illumination seemed to be about half that to which we are acustomed from motion pictures. Good reproduction of the entire range of shading between the limits of illumination was retained. The artists were placed close enough to the television pick-up to avoid scanning more than a half bust view, which includes the head and neck, not



To the left, the battery of dynamic loud speakers is shown placed alongside the television screen. These speakers reproduce the radio voice which accompanies the picture. Below, a view of the incandescent lamp, which shines on the face of the person televised, in its housing



ADVANCES

to Screen

television as something that is coming provides only a quite indistinct, wobbly, a peephole. However, recent develop- the laboratory to the theatre

H. Felix

quite the entire width of the shoulders and down to about the position of the middle button of a man's coat.

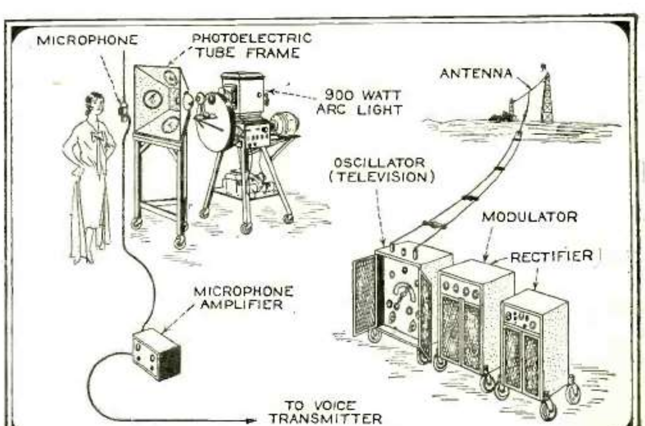
Because of the large size to which the image was projected, it was easy to analyze the defects due to insufficient detail attributable to course scanning. Apparently, judging from the results of 48-line television suitably projected, 100-line television would give clear enough reproduction of simple subjects, such as close-ups of one or two individuals, to offer permanent and pleasing entertainment of a commercial character, provided, of course, that the use of television reproduction is justified by an element of real news value.

The Scanning Process

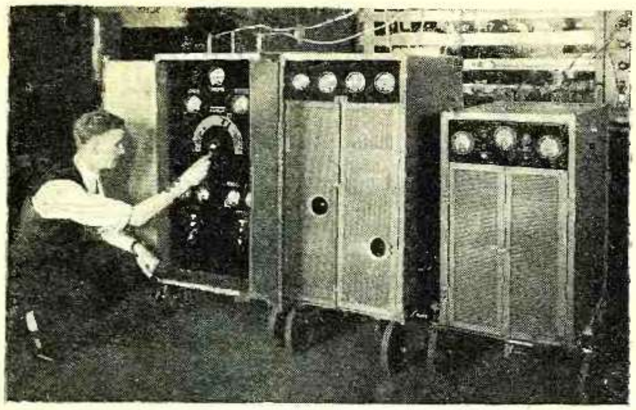
The television system used at Schenectady involved conventional equipment up to the point of projection. The subjects stand before a spot of light projected through a 48-hole scanning disc which explores the field of reproduction about sixteen times a second. The light from the subject is reflected to a bank of photoelectric cells. Since the total reflection is largely influenced by the reflection of the exploring beam and that, in turn, depends upon the shading of the spot being illuminated at each instant, the photoelectric cell amplifier output is proportionate to the shading of the area being scanned. The picture signal, after requisite amplification, was transmitted by wire line to South Schenectady and there projected by a 140-meter short-wave transmitter to the receiving antenna atop the theatre in the heart of Schenectady, a mile away. The radio receiver had a special audio system capable of amplifying the frequencies as high as 20,000 cycles, the maximum picture signal frequency. A small monitoring reproducer of the disc type as well as the new projector were supplied with the television signal picked up by the radio receiver.

The Significance of the Light Valve

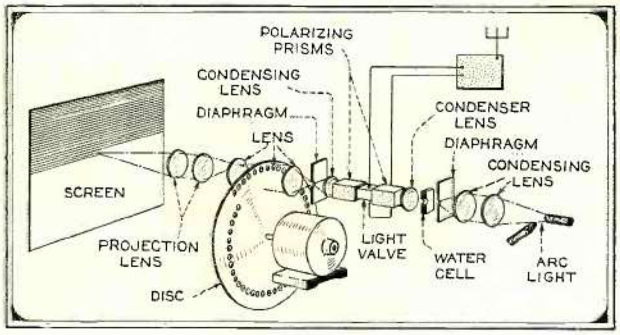
The importance of a projector having a high-frequency light shutter controlling a local light source is difficult to appreciate



Here is shown the arrangement of the apparatus employed at the transmitting end of the circuit. Two transmitters, one for voice and one for television, are used



The transmitter of station W2XCW, operating on 139.5 meters for sending out the television signals from the General Electric Company's laboratory, is shown here. The units, from left to right, are: power amplifier, modulator and rectifier



This drawing serves to illustrate the rather complicated optical system employed in the scanning section of the televisor

at this stage of development of television. The invention of the grid by De Forest was also but little appreciated at the time of its discovery. Yet that invention relieved radio communication of dependence upon the energy from a distant transmitter to determine the volume of signal reproduction. By means of vacuum tube amplifiers, any signal can be used to control any amount of local energy required by the reproducing system, the limit of amplification being only the parasitic noise introduced through the ether as interference and atmospheric disturbance and that set up within the receiver itself. The important feature of the vacuum tube amplifier is the fact that a large amount of local energy is controlled by a small amount of applied energy.

The invention first practically demonstrated at Schenectady is both analogous to and quite as significant to the development of television as the invention of the grid to electronic amplification. The projector accomplished for the first time high-frequency control of a local light source by a non-mechanical means. The light projected on the television screen originated from a commercial motion picture arc.

Limitations of the Neon Tube

Heretofore the only practical method of converting television signals to light depended upon bringing a rarified atmosphere of neon gas to luminosity by means of the two-element neon tube, the invention of Dr. D. McFarland Moore. The neon tube is amazingly rapid in its action and fully capable of handling picture signals representative of much greater detail than has so far been attained by any television system. At the two-way wire television demonstration conducted by the Bell System in New York recently, using 72-line scanning (double the number of picture elements of 48-line scanning), the reproduction was an optically enlarged view of a reproduction about two inches square. To produce this image, a somewhat larger neon tube than has been used heretofore was developed, capable of handling 200 milliamperes. It was necessary to employ water cooling, so large is the energy dissipated in heat.

Yet this was still "peep hole" television, limited to a single observer. Hence, when we consider the requirements of projection on the screen with the neon tube, it rises to the impractical proportions of a power device.

If a neon tube could be made to produce a maximum light as intense as the arc, it would be a simple matter to project its ray upon a screen through a scanning disc by merely reversing the scanning process at the transmitter. But such a powerful neon tube does not appear to be an early prospect.

The salient and outstanding feature of the General Electric development is a light valve controlling a powerful illumination source from a radio signal. Projection is accomplished by passing an intensely powerful beam of a standard 175-ampere motion picture arc through a high-frequency light valve through a scaning disc to a transluscent screen to the eyes of the observers. The operation of the light valve is analogous to that of the grid of the vacuum tube by means of which a small incoming impulse controls a relatively large space current obtained from a local plate battery. The light valve, like the grid, has no apparent inertia and can handle picture signals of any conceivable frequency.

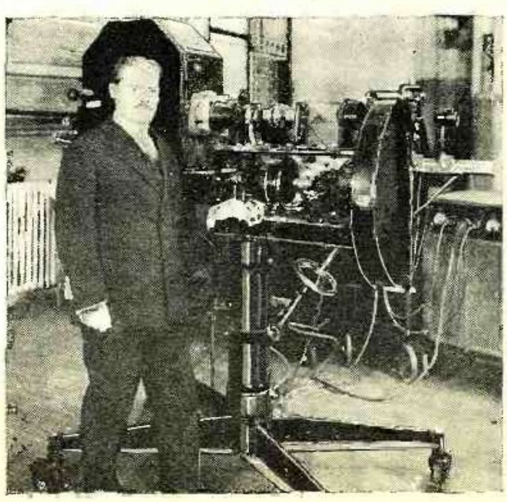
The apparatus, which was built under the direction of Dr. E. F. W. Alexanderson, is expected to be as effective in handling television signals having frequencies up to a million cycles as it proved to be with light changes with a maximum rate of change of a twenty thousandth of a second, involved in 48-line television.

The Kerr Effect

A principle long known to science is applied in this light valve. It is the discovery of a Scotchman, John Kerr, whose interest in physics was developed as a student and protégé of William Thomson, the great English physicist. Kerr observed that the direction of polarization of a beam of polarized light can be altered by passing it through an electrostatic field. Faraday had previously observed a similar phenomenon in connection with intense magnetic fields and the pioneer, Nipkow, who evolved the working fundamentals still used in present-day television systems, suggested the use of that phenomenon for projecting television. Kerr's electrostatic bending of polarized light was embodied in a practical light control device by Dr. August Karolus of Leipsig, Germany. The General Electric Company has obtained American rights to Dr. Karolus' inventions, which Dr. Alexanderson has built into a practical television projector.

The Nature of Polarized Light

It is difficult for the layman to understand the difference between a beam of polarized light and an ordinary ray. It is indeed a subtle distinction but worth understanding because polarized light exhibits properties of great prospective importance in television. A beam of polarized light can be deflected by magnetic and electrostatic fields in the same way that a stream of electrons in a vacuum can be controlled. Small changes in the direction of the beam of polarized light projected through certain crystals produces great changes in their intensity. The angle of maximum projection is determined by the structure of the crystal. By rotating the crystal about the angle of maximum light (*Continued on page* 268)



Dr. E. F. W. Alexanderson, engineer in charge of the radio consulting department of the General Electric Company, with his television receiver which projects the picture on the theatre screen

Television Advances

(*Continued from page 230*)

projection, that is, the axis of the crystal, or by varying the direction of the beam itself in relation to that angle, the intensity of the resulting light projected beyond the crystal is readily controlled.

If we project a powerful light beam through a shutter with only a pinhole aperture, a tiny spot of light can be projected to a screen. The spot, however, is not perfect. There is always slight diffusion. The cut-off from black to white is not as sharp as might be expected. Apparently, in the motion of an ordinary beam of light, there is not only motion in the direction of projection, but a component of transverse motion. Passing light through a crystal of proper construction, it is possible to divert the transverse component in a ray separate from that moving forward as a plane. A Nicol prism is a crystal device of special construction which completely isolates the component of transverse motion from that of forward motion, producing a beam of polarized light.

Crystal structure comprises a rigid arrangement of electrons. Their orbits of motion are restricted to very definitely limited directions. The atoms of crystals are arranged in perfectly orderly array so that the entire crystal structure has the characteristics of a single crystal atom. When a source of energy, such as a light beam, is projected through a crystal, only that component of energy coinciding with the crystal structure is successfully projected through it. The sun, rising upon a city of tall buildings, projects light through it only in the proportion that the light energy coincides with the direction of the streets. Obviously slight alterations in the direction of a ray of light projected through a street will make significant differences in the amount of light reaching to the other end.

Application of the Kerr Effect

The light of the arc passed through the Karolus projector is first formed into parallel rays by means of a lens system. It then passes through a Nicol prism, which disposes of all of the transverse energy in the light ray, leaving only a plane polarized ray to be projected through the light valve. The polarized ray then passes through a transparent nitrobenzol solution which forms the dielectric of a condenser. The television signal is impressed on the plates of the condenser, bending the polarized ray according to the intensity of the television signal which, in turn, corresponds to the light value being scanned at each instant. This bending is only a minute angle, but is sufficient to produce a substantial effect upon the total light passing beyond a second Nicol prism, to which it is then directed. Thus we obtain a powerful ray of light varying in proportion to the television signal.

The rest of the projection process is easy to visualize. The intensely powerful ray is projected to the screen through a scanning disc revolving in synchrony with the transmitting disc. It covers the entire surface of the screen with sufficient rapidity so that the eye, through its property of persistence of vision, collates the separate impressions into a single picture. A new revised scene is flashed on the screen in so short an interval that motion is blended smoothly, without the jumpy action of the early moving picture films.

Distortion in 48-Line Television

Certain distorting effects were observed by the more critical and experienced technicians, but these defects did not detract from the glory of the achievement. They were due entirely to the fact that 48-line scanning does not resolve the subject into sufficient detail. The scanning spot of light covers the subject in horizontal sweeps. When important elements of the scene presented a small angle to the direction of scanning, distortion was observed. This type of distortion is present in any 48-line system, but has never been so emphatically brought forward because of the relatively small projection heretofore used. When the mouth is in its normal position, for example, coinciding with the direction of the scanning line, the lower lip, the white space indicating the position of the teeth and the upper line may be represented by three parallel lines, black, white and black respectively. If the actor slowly tilts his head, so that the mouth deviates from the horizontal position, these three parallel lines tend to become jagged, making them appear like a step of a stair. With a somewhat narrower scanning path, like that of a 100-line scanning system, the minimum angle that a straight line presents to the scanning path to be reproduced as a straight line is considerably reduced.

Another interesting point developed by the demonstration was the insufficiency of 60-cycle synchronization for holding the reproduced image in frame. The scene swung before the eye like a pendulum of slow period, a defect hardly noticed in such an amazing demonstration but one which would arouse criticism if not disposed of before television reaches the commercial stage.

The press reports frequently mentioned the perfect synchronism of speech with motion. This constituted a considerable problem with talking pictures, where synchrony is maintained between a film and a phonographic disc. But with microphone and photocell pick-up, no recording of any kind is involved, both processes having the instantaneous and uniform character of electrical transmission through identical channels. More remarkable than maintaining synchrony would be the phenomenon of appreciable lack of synchrony.

When Is Television Coming?

One of the questions most frequently asked at the demonstration was, how difficult would it be to control sufficient light to project the image to full motion picture screen size? Dr. Alexanderson stated that only a more powerful arc is required as a light source. While this would accomplish full screen illumination, it must

(*Continued on page 269*)

Television Advances

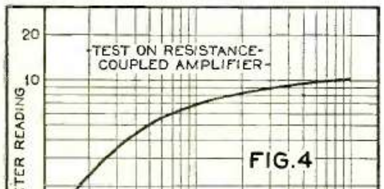
(*Continued from page 268*)

be borne in mind that the information conveyed to the eye is dependent upon the number of picture elements. Projection merely changes the distance that the reproduction may be conveniently viewed. A 48-line image, viewed ten inches from the eye, reproduced as a one-inch square, is as clear as a six-foot image of the same television signal viewed fifty feet from the eye. In both cases, 2,304 picture elements (48×48) contribute to each reproduction and convey the same information to the eye. If the audience remains at a fixed distance from the screen and projection is increased to full motion picture screen size, the image becomes more blurred and diffused, just as the appearance of a half-tone is impaired by looking at it through a powerful reading glass. The Karolus cell is adapted to full screen projection, but to retain only the present standard of quality requires increasing the scanning to 200 lines. That means 40,000 picture elements per image instead of 2,304, and, with twenty images per second, a communication channel of 400,000 cycles instead of 23,000 for faithful reproduction of the signal. The improvement of television therefore resolves itself into a communication problem. Considering the time it has taken to develop faithful reproduction of 10,000-cycle channels involved in broadcast music, a great deal of work is yet to be done before we can handle a signal band of 40,000 cycles faithfully. But the terminal apparatus, from photocell to projector, is available. We await only amplifiers and communication channels for good quality theatre projection of commercial character.

Home Laboratory

(*Continued from page 254*)

The experiments which have been described in this sheet have only scratched the surface. An almost unlimited number of experiments can be made with the aid of some simple set-up of apparatus as we have described. Old and new transformers



can be checked for their response at 60 cycles, the effect of using high-mu tubes in a transformer-coupled amplifier can be determined, experiments on the effect of changing the capacity of the coupling condenser in a resistance-coupled amplifier can be made, the effect of changing the value of the grid resistor can be noted, etc.