Magic Cell Works New Marvels

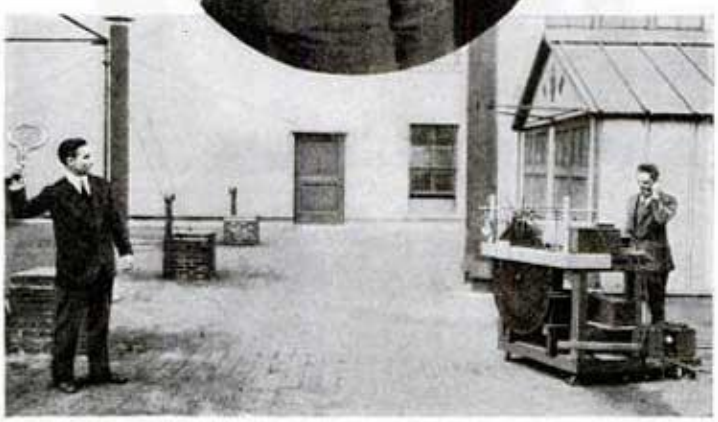
An Expert Tells How Photo-Electric "Eyes" Bring Television Nearer and Promise to Harness the Sun

By E. E. FREE

ONE sunny afternoon a few weeks ago a young man stood on the roof of a building in New York City waving a tennis racket in the air. He might have been doing his daily dozen, but he wasn't. He was exercising an eye—not his own eye, but the newest eye of science; the one that promises to make television really useful.

In a room of the Bell Telephone Laboratories a few floors below, visitors saw a virtually perfect image of the sunlit athlete swinging his racket. It was the demonstration of a supersensitive photo-electric cell, which for the first time makes possible the transmission of scenes illuminated by natural sunlight.

Television has been handicapped by the fact that natural illumination, even natural sunlight, was too weak for photo-electric cells. Powerful searchlights, or still more powerful pencil-thin light rays moving rapidly back and forth over the scene, were used. What Dr. Herbert E. Ives and his associates in the Bell Telephone Laboratories did was to make electric eyes more sensitive.



Broadcasting a daylight scene by television for the first time—an achievement that was made possible through the development by Dr. Herbert E. Ives and his associates in the Bell Telephone Laboratories of a new supersensitive photo-electric cell. The upper illustration shows Dr. Ives holding a cell that is used in television.

AT ABOUT the same time a German inventor, Professor Karolus, developed another new electric eye, capable of doubling the speed of translating impulses of light and shadow into corresponding electric impulses, and transmitting them. Heretofore the highest speed of television apparatus has been about 40,000 impulses a second, resulting in a motion picture only two inches square. Professor Karolus now claims to transmit 80,000 impulses a second, producing a motion picture three and a half inches square.

Shortly afterward came another triumph for the photo-electric cell when Westinghouse engineers transmitted radio motion pictures two miles, using new apparatus developed by Dr. Frank Conrad, Assistant Chief Engineer of the company. It was announced that motion picture broadcasting would begin soon.

Five years ago photo-electric cells were almost unknown. Today, connected with enumerating machines, they count traffic on the streets and number paper boxes as they roll out of the machines that make them. Others measure daylight or take note of clouds that drift across the sky. Still others work the "sunburn meter" that tells you each day how strongly the sunlight is charged with ultra-violet rays. Another cell transmutes the frozen sounds of the talking motion picture into words.

In chemical laboratories electric eyes follow the progress of reactions. Astronomers, wearied with long hours of gluing their eyes to telescopes, are fast relegating this task to photo-electric cells. Even the giving of vision to the blind and the catching of power from wasted sunlight are problems that scientific men expect these cells will help them solve.

There are photo-electric cells larger than a man's head; great, staring globes of silvered glass with pupil-like windows in front as though they were fossil eyes of some gigantic Cyclops. Others look like overgrown, half-transparent sausages. Some are smaller than a peanut. It is possible to make them no larger than a pea. All have the same essential secret. They can transmute light into electricity.

YOU might mistake one of the common kinds for an ordinary radio vacuum tube. There are the same sealed glass bulb and hard rubber base and metal terminals and a similar set of metal plates and wires inside. One of these inner plates, sometimes merely a thin coat of potassium, rubidium, or other metal on the inside of the glass, is the heart of the cell. It is a kind of henroost for electrons from which, like birds on a tree-limb, they can be scared off by light.

Electrons, of course, are inside everything, for they help to make up the atoms of matter. Usually they stay inside, which is well, for the few substances like radium which do emit them spontaneously are unpleasant companions. A small bit of radium carried in a pocket will burn into your body a hole which may not heal for years.

But sometimes man desires the electrons to escape. Radio is made possible, for example, only because electrons fly out by millions when the filaments of vacuum tubes are heated. An electric battery drives forth its electrons chemically. A dynamo flogs them with magnetic forces and pumps them around through its wires. The photo-electric cell, luring them out with light rays, is a light-ray dynamo.

Like so many other important scientific events, the discovery of this dynamo was accidental. The famous German physicist, Professor Heinrich Hertz, discoverer of the electric waves now used in radio, noticed that when an arc lamp was illuminated by rays of ultra-violet light from another lamp near by the electricity passing through it was increased. If two or three open electric arcs, like the old-fashioned street lamps, were placed side by side, all of them burned more powerfully and consumed more electricity.

Another German physicist, Dr. W. Hallwachs, traced this common fact to the emission of electricity from one of the metal rods used in the arcs. This was in 1888, and the electron had not yet been discovered, so all that Dr. Hallwachs knew was that electricity escaped. But the development of the marvelous photo-electric cells of the present day is directly traceable to his experiments.

Photo-electric cells must not be confused with the often-mentioned selenium cells, made of wires or plates of that semi-metallic element. What happens to selenium when light falls on it under proper conditions is that its resistance to the passage of an electric current decreases. Selenium cells can be used for some of the light-detecting and light-measuring duties of the true photo-electric cells, but most modern experimenters consider them less suitable.

THE present widespread use of photo-electric cells has been made possible in great measure by the development of modern radio amplifiers. The records of sounds, for example, which constitute the talking motion pictures are usually printed photographically on the edge of the motion picture film as tiny light and dark cross lines or lines of tiny waves.

A slender beam of light is sent through this succession of lines. As the film runs on, this beam varies in strength when it passes a dark mark or a light one. It then enters a photo-electric cell which converts these light variations into electric ones, just as sounds themselves produce tiny electric vibrations in the microphone of a broadcasting station. But amplifiers are necessary to magnify the feeble photo-electric currents thousands of times until they roll out in powerful volumes of sound to fill the largest theater.

DR. D. C. STOCKBARGER, of the Massachusetts Institute of Technology, has used combinations of photo-electric cells and amplifiers to telephone over a beam of light just as one ordinarily telephones over a wire—a procedure conceivably of much use in warfare, for communications could be sent over the beam of a searchlight and could not be read by the enemy.

In my own laboratory we have a photo-electric organ, built by Dr. Norman Hilberry and C. A. Johnson and first demonstrated before the New York Electrical Society. A beam of light is interrupted at regular intervals by passing it through holes in a rotating metal disk. This beam then enters a photo-electric cell, which emits a musical note fixed by the number of interruptions each second in the light beam. Few real organs produce more perfect or beautiful tones.

For the photo-electric burglar alarms so often suggested beams of light shine into concealed photo-electric cells. Let an intruder step between and promptly a signal goes to the attached electric amplifiers and an alarm sounds. If desired, such devices could be arranged to emit poison gas in front of a safe or to shoot down an intruder without waiting for the police to arrive. C. A. Johnson has developed a photo-electric timing device for races which is started and stopped automatically by contestants' shadows at the start and finish lines to an accuracy of a hundredth of a second as against a tenth of a second—the best attainable with a stop watch. Even greater accuracy is possible, for Drs. E. O. Lawrence and J. W. Beams have proved in the Yale University laboratories that the electrons respond three billionths of a second after the light ray strikes the cell.

Other arrangements of photo-electric cells, light rays, and amplifiers have been used in industry to ring a bell when the mercury of a thermometer rises to a given point, when a light spot reflected from any electric measuring instrument reaches a certain mark, and when factory smoke is denser than health laws permit.

Two extremes in photo-electric cells—the eleven-inch bulb made by L. T. Garner, University of Illinois, is said to be the world's largest. The other cell is an ordinary-sized one.

A photo-electric cell apparatus for measuring the light-transmitting properties of ornamental glass globes for street lamps—in use by General Electric Company.

This photo-electric cell is so sensitive that it will note the passing of the faintest cloud and set in operation a needle to record it on a weather chart.

The density of smoke can even be measured; for the blacker it is, the less light it will let into the cell and the less electricity the cell will produce.

Another application is the daylight meter; its cell is pointed at the sky instead of at a smoke-stack. At the General Electric Company laboratory at Schenectady, New York, Dr. L. R. Koller records every passing cloud on a chart attached to a photo-electric eye.

THE proportion of the healthful, invisible ultra-violet rays in sunlight and in ultra-violet lamps can now be determined by a special variety of photo-electric cell, and Dr. R. C. Burt, of Pasadena, Calif., uses the cell in a "sunburn meter" to determine how sensitive any person is to the sun's rays.

The General Electric Company uses the cell in tests to measure light of many kinds of lamps and to ascertain how much illumination passes through various types of ornamental globes. Thickness and transparency of cloth and paper and even shades of color are also measured in the mills by the cell, and with the colorimeter, devised by Professor A. C. Hardy, of the Massachusetts Institute of Technology, manufacturers can measure exact shades of color in dyes and dyed materials, and packers can sort fruits according to ripeness as indicated by color.

No less an authority than Dr. Ives suggests the possibility of catching the enormous energy of sunlight in giant solar dynamos working on the photo-electric principle, providing vastly more power than the world will ever need.

Even more interesting, because more definitely in sight, is the possibility that photo-electric devices may enable blind persons to read ordinary type "by ear." Each letter of a page, scanned by the photo-electric eye, would be translated automatically into a recognizable combination of sounds. If these remarkable cells did that and never anything more, it would justify their claim as one of the greatest gifts of science to mankind.