Proceedings

of the

Radio Club of America

Incorporated

June, 1934

Volume 11, No. 3

RADIO CLUB OF AMERICA, Inc.
11 West 42nd Street + + New York City

The Radio Club of America, Inc.

11 West 42nd Street - New York City

TELEPHONE—LONGACRE 5-6622

OFFICERS FOR 1934

President
H. W. Houck

Vice-President
R. H. Langley

Treasurer
J. J. Stantley

Corresponding Secretary
F. A. Klingenschmitt

Recording Secretary
J. K. Henney

DIRECTORS

E. H. Armstrong
E. V. Amy
L. C. F. Horle
B. F. Miessner
Frank King
H. Sadenwater
G. E. Burghard
C. W. Horn
H. H. Beverage
R. H. Barclay
J. H. Miller
Frank M. Squire
W. G. H. Finch

COMMITTEES

Papers—F. X. Rettenmeyer
Publications—L. C. F. Horle
Membership—C. W. Horn
Entertainment—F. Muller
Forum—R. H. Langley
Club House—G. Burghard
Publicity—W. G. H. Finch
Affiliations—Fred Muller
Year Book-Archives—R. H. Mariott
Finance Committee—E. V. Amy, J. J. Stantley, L. C. F. Horle
Business Manager of Proceedings—R. H. McMann

PROCEEDINGS
of the
RADIO CLUB OF AMERICA

Volume 11 June, 1934 No. 3

THE PHOTRONIC CELL & PHOTRONIC CONTROL

R. T. PIERCE*

The PHOTRONIC Photo-electric Cell represents the latest development in the photo-electric art. The position that it has in the art may best be shown by a brief review of the past development in photo-electric cells.

Photo-electric active materials have been known to scientists for over sixty years and a great deal of work was done originally on the selenium type of cell. This consisted of a plate of selenium which has the characteristic of changing its resistance under the action of light. A battery and meter, or relay, connected in series with this selenium cell allows the circuit to be adjusted so that the change in resistance under the action of light will change the current in this circuit enough to cause the instrument to deflect, or the relay to make contact. The selenium cell circuit, of course, is absolutely dependent upon the battery voltage and the current never goes to zero in this circuit, regardless of the condition of illumination on the cell. The selenium cell itself is quite sluggish in its operation and changes from time to time due to oxidation and other action which affects it chemically.

In 1885 a patent was issued which showed a method of holding a ship on its course by means of a light source and selenium cell used in conjunction with the compass needle. At that time no electric lights were available and this patent shows a kerosene lamp and a candle for the light source. In 1886 another patent was issued for controlling the level of water in a boiler using a selenium cell with a kerosene lamp and candle for the light source. It may, therefore, be seen that some of the early engineers and thinkers on photo-electric cells and photo-electric control were considerably ahead of their time.

Another type of cell that has been produced is the liquid type photo-voltaic cell. This is much the same as a wet battery having one electrode which is affected by light in such a manner that voltage is generated whenever this light hits the electrode. This is like any other battery in that the output changes as the electrolite ages and, under the action of generating voltage, gas is liberated which has been known to explode the cells with considerable violence.

With the advent of the vacuum tube various other types of photo-electric cells were produced in evacuated glass tubes requiring a voltage to produce a flow of electrons between the light-sensitive surface inside the tube and the collecting ring. Electrons were emitted from the light-sensitive surface which passed across the intervening space to the collector ring and this small current was passed on to the grid of a vacuum tube and the output amplified to obtain enough useful current for indication or control purposes.

There has been quite a bit of resistance toward the adoption of this type of photo-electric cell, by industrial establishments due to the fact that their experience with radio sets makes them somewhat hesitant about putting vacuum tubes on important control circuits.

THE PHOTRONIC CELL

About five years ago, the Research Laboratories of the Weston Electrical Instrument Corporation started investigating the possibility of providing a photo-electric cell or "electric eye" that would not require any auxiliary source of energy, and that would have sufficient power output to obviate the necessity of using amplifying circuits. That was the type of specification with which they started, and it must be admitted that at the start it seemed rather a hopeless task. However, their efforts were finally successful, and the result was the PHOTRONIC Photo-electric Cell.

The PHOTRONIC Cell consists essentially of a metal disc on the surface of which light-sensitive material is deposited. Contact fingers lead the current in and out of the cell by resting on the light-sensitive surface and also on the back of the plate on which it is deposited. Under the stimulation of light energy, electrons are emitted from the light-sensitive surface producing a current that flows into the plate beneath it, through the external circuit, and back to the cell again. It may be likened to a catalytic agent that transforms light energy into electrical energy without any deterioration of the cell.

*Weston Electrical Instrument Company

The cell output current starts from zero when the cell is in darkness, and increases, practically proportionally to the illumination, up to a value beyond the intensity of bright sunlight, when a low external circuit-resistance is used. This characteristic of the cell is very important both from the standpoint of light intensity measuring, and also from the standpoint of obtaining a control between quite narrow limits of illumination. The illumination-current characteristics of the cell are shown in Figure 1.

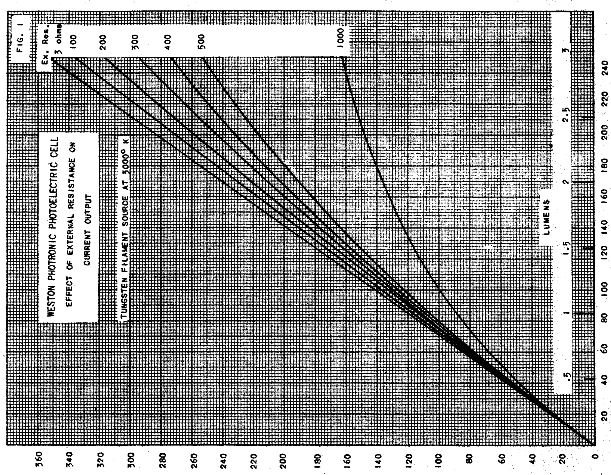

Fig. 1

Another important item in the specifications to be met by the cell was the spectral response characteristic. It was considered extremely important that the cell have a spectral response similar to that of the normal human eye. Such a cell would be much more useful for measurements of color, and for obtaining control by color change, than are other commonly available photo-electric cells. The PHOTRONIC Cell meets this requirement very well, as will be noted from Figure 2. Its peak value is a little more in the yellow than is that of the human eye, and it has up to 25 per cent response in the near ultra-violet and about a 10 per cent response in the near infra-red. Since it is above the human eye over the visible range, it is possible to equip it with a filter that will make it agree with the normal visibility curve.

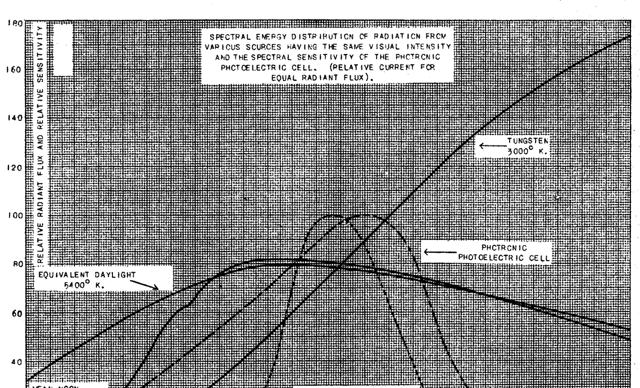

Fig. 2

Such a cell, in order to be useful in industry, should have a long life. The life of the PHOTRONIC Cell is practically unlimited, and its usefulness should, therefore, extend over a great many years.

The PHOTRONIC Cell is similar to a battery shunted by a high resistance. Due to the relatively low voltage generated, long leads may be used between the cell and the control relays without leakage affecting the accuracy of the control. This characteristic is very useful when installing control equipment in an industrial establishment. Also, like a battery, two or more cells may be connected in multiple to increase the output for a given light intensity.

In order to use this cell on measurement problems, whether they be the direct measurement of light intensity, or a measurement as applied to industrial process-control, it is only necessary to connect a microammeter, or relay, in series with the cell, no amplifying circuits being required as with most other photo-electric devices. In every other type of cell, except the photo-voltaic, an external source of electrical energy is required for purposes of excitation, and the accuracy of measurement, or control, is thus directly dependent on the constancy of the exciting power supply.

The PHOTRONIC Cell is almost instantaneous in its operation. One of the most interesting applications that has been made of this property, is the measure of the speed of rifle bullets by the Ordinance Department at Washington. Bullets are shot through several light beams, and the shadow of the bullet on the cell causes an indication on an oscillograph, which thus measures the relative speed of the bullet as it passes through these various beams. The cell has been used in sound-film work with a considerable degree of success, although, due to the fact that it is a good condenser, the output falls off at the higher frequencies. To compensate for this, changes in the conventional amplifying circuits are necessary and, in view of the number of these that are in use, it is not thought advisable to introduce the cell to this field at the present time. The quality of reproduction is very good, for the cell does not have the ground-noise that is present in the other types of cells, with which external excitation and high amplification are needed.

The circuits and circuit elements required for putting the cell to practical use are very simple. For measurement purposes it is only necessary to connect the cell directly to the terminals of a suitable microammeter. For control, the cell may be connected directly to the terminals of the sensitive relay. Usually, however, an additional and power relay is required for operating control devices. The power, controlled by the sensitive relay, and operating the power relay, may be supplied by batteries, or a transformer-rectifier unit, and thus requires nothing with which the average industrial electrical engineer is not thoroughly familiar.

MEASURING INSTRUMENTS

One of the first measuring instruments to be devised, including the PHOTRONIC Cell, was the illumination meter. Prior to its introduction, only the relatively crude comparison methods of the conventional photometers were available for illumination measurement. And, because of the complication of equipment, technique, and interpretation, the field of usefulness of such instruments was seriously limited by their cost, the need for skill on the part of the user, and in the interpretation of the data gathered. With the direct-reading illumination meter employing the PHOTRONIC Cell, however, these limitations are largely eliminated and the solution to a myriad of illumination problems, previously unattacked, made readily and economically available.

The Model 603 Illumination Meter, shown in Figure 3, was the first produced. It consists of two PHOTRONIC Cells connected in multiple, and mounted in a light target which is attached to the instrument by a 5 foot cord. Three ranges are obtainable in the simple instrument, and six ranges in some of the more elaborate instruments. The cells are some times equipped with filters which correct the spectral response to precisely that of the human eye, and enable accurate measurements to be made of any kind of light, such as that of neon, mercury vapor, or sodium vapor lamps, as well as tungsten, and other filament-type lamps.

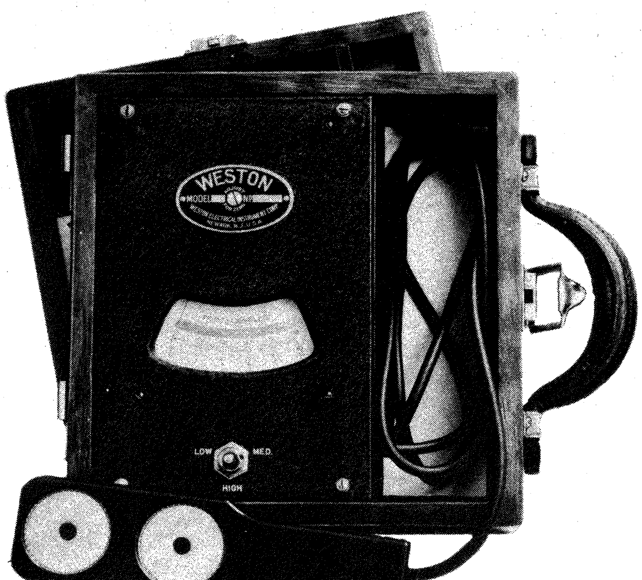

Fig. 3

Another application of the photo cell for measurement is its employment for the predetermination of the proper exposure in photographic processes. All prior, and commonly employed, exposure meters relied on the judgment of the human eye to distinguish between various degrees of brightness, since it is the brightness of the object at which the camera is directed, that is, the light reflected from the object at which the camera is directed, that determines the rapidity of action on the sensitive surface of the photographic film, or plate, and hence the proper time of exposure. The human eye, however, like the other sense organs of the human body, is capable of perception of, and accommodation to, a tremendous range of the intensity of stimuli, and is similarly seriously limited in recognition of minor differences in the intensity of the stimuli. More specifically for instance, the normal eye is found to be quite capable of reading the larger sizes of news print type in bright moonlight, and in bright sunlight the range of light intensities of which is of the order of a million to one. It is to be expected, therefore, that the eye can hardly be expected to judge of minor differences of light intensity with sufficient precision to suit the relatively narrow requirements of light intensity of the photographic emulsions commonly used in photography.

When the development of the Exposure Meter was started, it was found that there were very little data available on the relative sensitivity of the film emulsions as expressed in terms of brightness. It was therefore necessary to obtain data on the sensitivity of emulsions before the relation between brightness measurements and exposure could be determined. This involved a lengthy investigation, and many films were exposed in order to determine the limits of "under exposure" and "over exposure." After this was once accomplished, it was a simple matter to make a calculator, or translator, that would interpret brightness measurements in terms of exposure time. In order that the instrument might measure brightness, however, it was necessary to restrict the exposure of the PHOTRONIC Cell to a 60° cone, since this is, roughly, the angle included by commonly used camera lenses.

Figure 4 shows the Model 617 Universal Exposure Meter. This meter has proven to be a major contribution to the photographic art, and is replacing the judgment and skill of many years of experience of some of the nation's outstanding photographers.

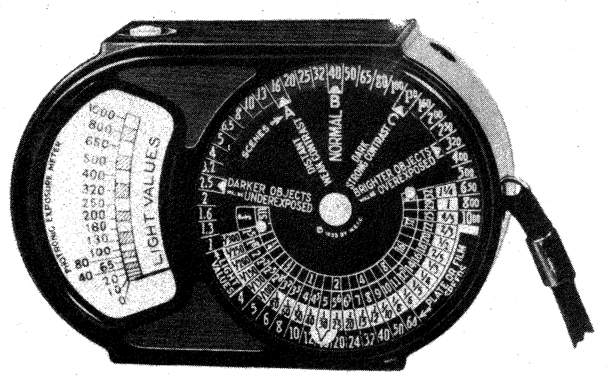

Fig. 4

A second type of Exposure Meter is provided for use with motion picture cameras, the scale of which is calibrated directly in terms of aperture for a given exposure, since in motion picture cameras the shutter operates at a substantially constant speed, thus requiring that the aperture be adjusted to accommodate the camera to the brightness to which it is exposed.

In various industrial processes, control may some times be accomplished by obtaining readings of changes in color or density of the material being processed. A simple combination of the PHOTRONIC Cell and an indicating instrument will give indications as to such changes in color or changes in density as a guide to process control, and many such devices are in use at the present time for such determinations.

PHOTO-ELECTRIC CONTROL

In controlling there are three basic principles that are involved. A light beam is a very useful link in mechanical motions, since it may be broken and re-established at will, for it has no inertia, nor does it mar delicate finishes. Furthermore, when using a cell that has a linear characteristic, it is possible to operate at such a point in its characteristic curve that control may be accomplished by slight variations in intensity. With a spectral response characteristic, such as that of the PHOTRONIC Cell, it is also possible to effect control by means of changes in color.

Thus, automatic control of processes may be obtained by:

(1) A cut-off of a light beam

(2) Change in light intensity

(3) Changes in color

One of the applications of a photo-electric cell that is usually thought of first, is the question of counting. Small pieces of material, such as paper, coming down a conveyor, that may be located in almost any position, cannot be counted readily by any mechanical means. A mechanical finger that might be placed in the path of the material, could not be operated from a small piece of paper, and the location of the other material might not be such that it could be accomplished without a very complicated arrangement. Also, highly finished materials that would be scratched by the mechanical finger may be counted by an interrupted light beam, and in no other manner. For the purpose of counting an especial system has been designed, and made commercially available. It consists of PHOTRONIC Cells in connection with suitable relays, and will operate the commonly-available electrically-driven counters.

Having a light responsive unit such as the PHOTRONIC Cell, it is natural that the question of illumination control should be considered. Street lights and sign lights have always been controlled by time switches. Time, however, does not take into consideration the changes in light intensity from day to day due to clouds, storms, and other natural conditions. Consequently, all too often, lights are not turned on when they are needed, nor are they turned off when they are not needed. It is natural, therefore, that an illumination-control device for street lighting, sign lighting, and also for interior lighting, in factories and office buildings should be considered. For this purpose an especial illumination control system, employing the PHOTRONIC Cell, has been developed, and has been applied quite successfully to many lighting control purposes. A large number of beacon lights on the American Airways are equipped with these units, so that the beacon lights are turned on whenever the daylight intensity drops low enough. Many lighthouses are equipped with these devices so that the ships may have proper guidance when daylight intensities are low. On such safety devices, it can be readily understood that automatic control in accordance with daylight intensity is the only type that is adequate. Similarly, street lighting circuits are being controlled by this type of equipment.

In this type of control equipment, the relay arrangement is slightly different from that used in counting. Counting equipment should operate quickly, but illumination control, where light intensity is changing slowly, requires a time delay so that when the lights are once turned on, they will stay on, and will not be effected by slight fluctuations due to passing clouds, and other atmospheric conditions. In order to accomplish this, a time-delay relay is placed in the circuit between the sensitive relay and the power relay.

A control that illustrates the principle of change in density is the smoke alarm. On this device a light beam is thrown across a smoke stack to a PHOTRONIC Cell, and when the smoke in the stack takes on a predetermined density indicating poor combustion, an alarm is given in the boiler room so that the attendant may correct the condition. By the use of such arrangements as this, not only is the industrial establishment assuring itself of the operation of its steam-raising equipment at greatest efficiency, but also it frees its community of the smoke nuisance otherwise difficult of riddance.

It may, therefore, be seen from the general discussion given above, that the combination of a PHOTRONIC Cell and two or three relays, make possible many types of control functions.

A new relay, that is far more sensitive than any other previously available, has recently been developed. This relay will make a positive contact at such low currents as 2.5 microamperes, and at 0.5 millivolt. It opens many new fields for the PHOTRONIC Cell. It is really a contact-making indicator so that indications of the conditions that exist even before contact is made, are evident from the scale of the device. The contacts will control a circuit of 5 watts at 110 volts. By using this new type of relay in conjuntion with a PHOTRONIC Cell, many many simple controls or alarm devices are possible.

Typical of the applications of the PHOTRONIC Cell are the following: Pieces of paper on a folding machine are being counted--this cannot be done in any other manner. Bags of sugar are delivered to the warehouse on a conveyor belt, and they do not necessarily place these on the same point on the belt every time. It is possible to count them by an interrupted light beam at a high degree of accuracy. Small pocket combs are being counted.

Another interesting application is on an elevator-leveling device. Through its use the elevator is brought quickly to the proper floor level with no special skill on the part of the operator.

In the Holland Tunnel is an installation for detecting any truck that attempts to go through there loaded too high. Frequently the main part of the load on the truck may be of the proper height, while some small piece projects above the rest of the load. This would jam in the tunnel, and might cause a traffic tie-up. A light beam is projected across the driveway, which is about 35 feet wide, on to a PHOTRONIC Cell in connection with an alarm circuit. When tested, it was possible to travel at 35 miles an hour, and detect the presence of a projecting unit that was only 1 inch wide. Since the detector is located at the toll booths, where the speed of the traffic is naturally only a few miles per hour, the system is extremely effective in detecting all projections above the allowable levels.

Another installation in the Holland Tunnel, is for detecting the presence of smoke. In this installation the PHOTRONIC Cell is about 5,000 feet away from the recorder that it operates. In this case, as in the case of many industrial applications, where it is necessary to locate the relays, or controlled equipment, remote from the source of control, the PHOTRONIC Cell showed itself to be especially effective.

PHOTRONIC Cells installed on weighing machines operate relays when a container is filled to the proper weight and the feed is automatically shut off.

In Detroit an automobile comes down the way to have the underside of the chassis sprayed. It is a completely assembled car, and care must be taken to see that the paint is not sprayed on the finished body. The car interrupts a light beam, and the PHOTRONIC Cell turns on a spraying machine, which covers the underside of the chassis, and yet, as soon as the car moves through this light beam, it stops immediately, and prevents spoiling the finish on the body.

In one automobile plant, there is a carrier for delivering the bodies to the assembly room. Oftentimes the chassis is not there for the body to be put on, and one will pass the point at which it is usually removed. These bodies used to go to the end of the conveyor and then would hit the wall, thus damaging them. A light beam was placed at a point just before the body would reach the wall, and if it were not removed before it got that far, the conveyor was stopped.

In a sewage plant a PHOTRONIC Cell and light beam were placed 5 feet below the surface of the water in the last settling tank. As the sludge level rose above this point, an air lift valve or pump was operated so that this sludge would be removed and placed back into the system. By using this automatic equipment, it was possible to operate this plant at a considerable overload with complete satisfaction.

In a film processing laboratory in the motion picture industry, the hypo solution that is used for fixing the film, becomes very rich in silver. For satisfactory operation, the silver should be removed and at the same time the amount of the reagent employed must be controlled so that the hypo is not seriously contaminated. This was accomplished by the PHOTRONIC Cell operating on the change in opacity of the liquid as the silver was precipitated.

Boiler-feed water has to be treated for the elimination of oxygen. This is done by the colorimetric method of hydrogen ion concentration control. The PHOTRONIC Cell watches the change in color, and adds just enough material to the boiler-feed water to eliminate the oxygen, and not enough to cause scale.

In roasting coffee, it is necessary that the degree of brownness be controlled very accurately. The PHOTRONIC Cell watches the change in color of the coffee bean, and when the proper brown has been reached, the alarm is given so that the operator may dump the roast. This is a very critical point, and considerable spoilage results when observation of the operator is depended upon completely. In order to obtain a high degree of sensitivity in this control, an interesting and effective expedient was resorted to in this installation. A coffee bean unroasted is green, and in its roasted condition is a deep brown. Brown color may be obtained by adding red to green. By placing a red filter over the cell, it was possible to control the amount of red that was added to the green to secure the desired brown with an unusually high degree of precision.

The PHOTRONIC Cell has opened many new fields of photo-electric measurement and control. The simplicity of the circuits involved, and the use of standard instruments and relays operating on well-known principles, largely eliminates the hesitancy of the industrial engineer toward the adaptation of photo-electric means to his control problems. New devices and methods will be developed, and the light beam will ultimately take its place with the gear, the lever, and the cam in the machinery used for the manufacturing processes of the world.

AUTOMOBILE RADIO RECEIVERS

The meeting of March 14, 1934, was devoted to a paper by Mr. J. T. Filgate, of the United American Bosch Company, Incorporated, on the subject of automobile radio receivers. Mr. Filgate discussed the problems of the design, installation, and operation of automobile radio receivers with especial emphasis on the causes and sources of ignition interference with radio reception, and those expedients which have been applied to the problem for the reduction, or elimination, of this type of interference. His paper included an unusually detailed analysis of those phases of automobile ignition phenomena, which give rise to interference, and pointed out in specific detail the peculiarly troublesome nature of this type of interference as well as the expedients, both useless and useful, which have been resorted to for its elimination. The influence of the type of location of the antenna on the intensity of the interference was brought out, and an explanation of the operating characteristics of several of the more unusual types of automobile receiving antenna was given. Of especial interest was a description of the influence of the bonding of the automobile body, and of the electrical wiring on the magnitude of the interference.

General discussion of the entire problem followed the paper, indicating a general appreciation of the part of the membership of the masterly treatment of the analysis given by Mr. Filgate.

REMOTE CONTROL OF RADIO RECEIVERS

A symposium on the subject of remote control of radio receivers constituted the meeting of April 11, 1934. Papers were read by Messrs. Virgil Graham, and Lee McCann, of the Stromber-Carlson Telephone Manufacturing Company, and by Mr. C. J. Franks of the Radio Frequency Laboratories. Mr. McCann's paper was devoted to a discussion of the type of equipment in which remote control is accomplished through the use of electro-mechanical means on centrally located selecting and amplifying equipment; while the papers of Messrs. Graham and Franks were devoted to a discussion of what has been characterized as remote tuning, in which selection, and high-frequency amplification, is accomplished at a point remote from the low-frequency amplification and reproducing equipment. Mr. McCann's paper was replete with photographic illustrations indicative of the especial adaptability of the systems described by him to incorporation in structural elements of homes. The papers of Messrs. Graham and Franks were especially detailed with respect to the problems met with in the incorporation of high-frequency transmission lines in the remote tuning type of equipment.

The discussion called attention to other types of remote control equipment, one of which was illustrated by a special demonstration by Mr. Franks.