SCIENCE NEWS

DR. LANGMUIR ON ELECTRON EMISSION

RECENT discoveries in electron emission and current-control were described in a series of three lectures by Dr. Irving Langmuir at Carnegie Institute of Technology, Pittsburgh, on November 27, 28 and 29. Dr. Langmuir's auditors during the series were scientists, engineers, industrial executives and students of Carnegie Tech, and his world-wide reputation as a research physicist with the General Electric Laboratories at Schenectady attracted capacity audiences. Synopses of Dr. Langmuir's three lectures follow:

ELECTRON EMISSION FROM HEATED METALS

When metals are heated in high vacuum, electron, or atoms of negative electricity, evaporate from their surface. If there is another electrode in the evacuated space which is given a positive charge the electrons drift over to this electrode (anode) so that a current flows between the two electrodes. Dushman has recently derived an equation which should supersede the well-known Richardson equation, giving the relation between the electron current and the temperature of the cathode. The advantage of this new equation is that there is only one constant which we need to know for each different cathode material, instead of two constants which were necessary for the Richardson equation.

The electron emission from a large number of different materials has recently been measured. The thoriated tungsten cathode gives a current at a temperature of 1,500° absolute, which is about 130,000 times greater than that from ordinary tungsten. Measurements have also been made of cathode materials that have even much greater emissions.

In order to get all the current that a cathode is capable of giving, it is necessary to apply to the anode a high enough voltage to overcome what is known as the space charge effect. By putting in gases positive ions are formed in the space between the electrodes, and these neutralize the negative space charge and allow the current from the cathode to pass across the space with much lower anode voltages. In other words, the effect of gases is to increase the current-carrying capacity of the two. Such an effect is used in the Tungar rectifier. Care must be taken what gas is used for the purpose, for many gases have the effect of poisoning the cathode, and cutting down its emission to a small value.

If very high voltages are used on the anode, so as to produce intense electric fields, it is possible to pull electrons out of the cathode. In fact, it is possible to pull electrons even out of cold cathodes, that is, cathodes at ordinary temperatures. The currents obtained this way from the cathode come from very minute areas, but in these areas the current density amounts to more than one hundred million amperes per square inch.

ELECTRON EMISSION FROM THORIATED FILAMENTS

The thoriated tungsten filament is a tungsten filament containing one or two per cent. of thorium, usually in the form of oxide. When such a filament is heated, to about 3,500° Centigrade, a little of the thorium oxide is changed into metallic thorium. In the meantime, however, any thorium on the surface of the filament evaporates off, leaving only pure tungsten. If the filament temperature is then lowered to about 1,800°, the thorium gradually wanders or diffuses through the filament, and when it reaches the surface, if the vacuum is very perfect, remains there and gradually forms a layer of thorium atoms which never exceeds a single atom in thickness. The thickness of this film is therefore about 1/100,000,000 of an inch, and yet this film increases the electron emission of the filament more than one hundred thousand fold.

Of course this useful film is very sensitive and needs some protection to keep it in good condition. Very slight traces of water vapor or other gases would oxidize this film and destroy it. This can be avoided by putting in the bulb some substance that will combine with the water before this has a chance to attack the thorium film. Such a substance is metallic magnesium. Furthermore, it is necessary to avoid heating the filament to too high a temperature for otherwise the film might evaporate off. It is therefore best to operate such filament within a rather narrow range of temperature close to 1,700° C., where the ratio of evaporation is very small, and where the temperature is high enough for the thorium gradually to diffuse to the surface and continually repair any damage done by the effect of slight traces of residual gases.

The thoriated tungsten filament opens up many new fields of scientific investigation. By measur-

ing the electron currents, it is possible to determine accurately exactly how much thorium is present on the surface. An amount of thorium corresponding to only 1/1000 of the surface covered with a layer one atom deep is easily measurable in this way. It is possible to knock off a thorium film by bombarding it with positive ions, moving at high velocities, and in this way the true nature of this bombardment can be determined.

METHODS OF CONTROLLING ELECTRON CURRENTS IN HIGH VACUUM

Most of the applications of high vacuum tubes have depended upon the control of electron currents, as, for example, by the grid in the three electrode tube. The action of the grid is due to the charge on the grid modifying the space charge effect. This is the action that is employed in practically all tubes used to-day for radio transmission and receiving. There are many other methods, however, of controlling electron currents. A very important method is that used in the magneton, where there are only two electrodes in the evacuated space and the control is obtained by means of a magnetic field generated by an external coil of wire. A still simpler form of magneton suitable particularly to very large power tubes, consists of a very large filament in the axis of a cylindical anode with very large straight filaments. The magnetic field produced by the current through the filament is enough to prevent electrons flowing between cathode and anode. By heating the filament with alternating current, the current periodically falls to low value and at these times current can flow to the anode. This gives a pulsating or oscillating current, which can be used for radio transmission. A 1,000 kilowatt tube of this kind is in process of development; preliminary tests have been in every way satisfactory.

Another form of tube by which electron currents can be controlled is the Dynatron. This depends upon subjecting one of the three electrodes in the tube to electron bombardment in such a way as to cause electrons to be splashed out of it, just as water can be splashed out of a cup by attempting to fill it too rapidly from a faucet. A tube of this kind acts like a real negative resistance, and can be used for producing electrical oscillations with considerable efficiency.

One of the most important applications of electron discharges from hot cathodes is in the Coolidge X-ray tube which is now almost universally used as a source of X-rays. These tubes were first made about 1913 and are gradually being improved in many respects. The latest type of tube, suitable for use by dentists, is a small tube weighing only a few ounces, and only about three inches long. Because of the special features of this tube, the entire X-ray outfit, including the transformer, lead screen, regulating apparatus, etc., weighs only a few pounds and takes up a space of only a small fraction of a cubic foot. One very great advantage of this new form of tube, besides its convenience, is its absolute safety, even in the hands of inexperienced operators, for there are no high voltages in any part of the apparatus which is accessible.

EYE HOLDS SECRET OF TRAFFIC SAFETY

Science Service

A "LOOK-ONE-WAY" traffic system as a preventive of many of the frightful automobile accidents of America's deadly streets has been suggested by Dr. Raymond Dodge, authority on visual psychology and head of the psychological section of the National Research Council. Traffic signs, signals and routes should be determined according to a thoroughgoing study of what the human eye can see easiest.

"In the present regulaton of traffic, both driver and pedestrian never cover less than forty-five degrees of visual angle and may be required to look over an angle of over two hundred degrees. Such a range of vision is humanly impossible without moving the head from side to side. This always involves an interruption in the view of the part of the street from which trouble may come. One of the greatest dangers in crossing the street comes from vehicles that suddenly emerge from a side street.

"As a matter of safety there are grave doubts as to whether the present regulations that limit pedestrians to a narrow street crossing at exact intersections of streets is the best practicable solution. It may be more convenient for drivers, but the exact intersection of streets is most dangerous for pedestrians. Behind waiting cars is safer than in front of them. Twenty feet from a cross street would diminish the probability of being surprised by turning cars.

"Use of all parallel streets as one-way streets would be a great advantage. There is a slight but real difference between the sides of the street for pedestrians. It can be demonstrated that the left-hand sidewalk is safer. When the pedestrian is on the left sidewalk about to cross a street he has to watch only automobiles on his left and to the right of him, while a walker stepping off the right hand sidewalk across a street has to be alert

to possible danger on his left, to his left rear, and to his right. It is well known that the left hand side of the street should be used by pedestrians when there is no sidewalk.''

There is a very real and important problem with respect to the ideal construction of a traffic sign. How many words would be read in the available time? What would be the minimum size of letters? What should be the structure, place, color and content of signs? He contends that there is already a body of practical experience and scientific information available which would only need to be adapted to highway use and experimentally justified.

For instance, he said, it has been thoroughly demonstrated that adults do not read familiar words letter by letter but by familiar letter groups. Yet, here in Washington, we have signs reading ''Slo.'' Dr. Dodge said that when he first saw that strange sign it took him many times the effort and time to understand and interpret it that would have been sufficient for ''Slow.''

''The nature and time of hand and arm signals by automobile drivers should be also regulated. They are sometimes short, and sometimes long, sometimes early and sometimes late. The continuous indication of a driver's intentions beginning at least five seconds before a movement is executed and continuing until a movement is completed would be a great advantage.''

Traffic policemen should wear white sashes and trolley posts should be painted in alternate bands of white and black to increase their optical usefulness.

PREDICTS WINTER WEATHER BY SUMMER-TIME TEMPERATURES

Science Service

FORECASTING the rainfall for the coming winter and spring from the past summer's ocean temperatures, Dr. Geo. F. McEwen has predicted that the Southern California coastal region will receive about one half inch less than its average rainfall during the season 1922-23. He suggested the possibility of applying the same system to predictions over more extensive areas. Dr. McEwen is neither a goose-bone prophet nor a crystal gazer, but the oceanographer connected with the Scripps Institution for Biological Research. He bases his system of forecasts on carefully worked out observations during the last six years.

These observations show that when the ocean temperature averages colder than usual the rainfall is heavier than usual and when the summer seas are warmer than the average the subsequent rainfall is smaller than the average rainfall. A fall of one degree in temperature corresponds on the average to an increase of about two inches in the rainfall.

Rainfall in the Southern California coastal region depends mainly upon the flow of the moisture-laden air from the Pacific and is proportional to the amount of the air transferred.

This in turn depends on the formation of a belt of high air pressure over the continent, he explains. In summer the barometric pressure is greater over the ocean than the land for two reasons. The wind velocity over the smooth water surface averages two or three times as great as that over the relatively uneven land and in summer the air flows from the land. But as the season advances to winter, air flows over the land from the water and carries a great mass of air from the Pacific Ocean to the North American continent.

Enough pressure measurements over the North Pacific on which to base predictions being unavailable, Dr. McEwen used the known relation between pressures and surface ocean temperatures. The velocity of the winds which move clock wise over the Pacific depends on the air pressure and the upwelling of cold bottom water along the coast and therefore the rate of cooling of the surface water is proportional to the wind velocity. The lower the ocean temperature at or near the surface during the late summer and autumn, he declares, the greater must be the intensity of the ocean belt of high air pressure and accordingly the greater will be the expected seasonal rainfall over the coastal region of Southern California.

When asked which days would be the rainy ones, Dr. Ewen explained that long range forecasting is only done at the sacrifice of details and for daily information he advised waiting for the regular government forecast issued twenty-four to forty-eight hours in advance.

Another example of successful long range forecasting is the prediction of the monsoon rainfall of India, months in advance, by means of observations on atmospheric pressure distributions over vast areas of land and water.

ECLIPSE EXPEDITIONS IN AUSTRALIA

By Isabel M. Lewis, U. S. Naval Observatory

Science Service

NEVER have eclipse expeditions been favored with fairer skies than spread over the entire continent of Australia on the eventful day of the total solar eclipse of last September. From

Wallal on Ninety-Mile Beach in northwestern Australia to Goondiwindi and Stanthorpe in Queensland all forms of eclipse observations were made by a host of astronomers from many lands.

Shadow-bands, fleeting lunar shadow, a never-to-be-forgotten pearly coronal light, four, enormous, equatorial streamers, petal-formed and arched, a million and more miles in length, five brilliant planets and a star of first magnitude, Spica, near the sun, eclipse paraphernalia of all kinds and shapes manipulated by leading astronomers from many lands, even a governor in attendance, were features of this eclipse. And what more was to be desired to make a perfect success of a perfect eclipse day?

The most important feature of the eclipse from the astronomical point of view was the successful exposure of many photographic plates with astrographic telescopes at all points of observation in Australia. These plates, it is hoped, may reveal the slight displacements of the star-images from their normal positions known as the Einstein effect, due to the bending of light rays by the sun's gravitational field, which is a vital test of the Einstein theory.

At Wallal, where observations were made by Canadian astronomers, by an expedition from the Lick Observatory under Director W. W. Campbell, and by observers from New Zealand and various observatories in Australia, particular attention was given to this problem. Owing to the great clouds of dust that arose after totality was over it was impossible to develop the plates at Wallal and they were shipped to Broome, where they were developed later. The sailing of their ship made it necessary for the American astronomers to embark for home before these plates were developed. It is only recently that these developed plates arrived in the United States and the scientific world is now awaiting with the liveliest interest the announcement of the results of the measurements of these plates which it is hoped will be forthcoming before many days have passed.

Astronomers from observatories in eastern Australia who made observations at Goondiwindi and Stanthorpe, though enthusiastic about the eclipse as a scenic feature, deplore the fact that the "seeing," as astronomers call that state of the atmosphere that is such a vital factor in determining the value of observations, was particularly bad. As a result they are pessimistic as to the value of the measurements of the star-images that will be made on plates taken at these places. The eclipse occurred at these points in the late afternoon so the altitude of the sun was much lower than at Wallal where the eclipse occurred about 1:30 P.M. The effects of atmospheric refraction and other atmospheric disturbances were consequently more pronounced in eastern Australia than at Wallal. It is generally felt that the most valuable results will be the ones obtained from plates taken at Wallal, though Director Dodwell, of the Government Observatory at Adelaide, is said to have made some excellent observations at Cordillo Downs in central Australia.

Instruments were transported to this point from the railroad terminus by camel train, an arduous undertaking which took six weeks time. It is reported to have been attended with complete success, though no results of the reductions of plates in Australia are yet available.

SCIENCE ITEMS

Science Service

A FARM which raises diamond-back terrapin for the market by thousands has been conducted for many years near Savannah, Georgia.

ELEVATOR screenings, which grain elevators have been paying to get rid of, have been successfully used to fatten sheep in Canada.

FORTY THOUSAND separate and distinct species of locusts, the historic pests which annually cost the world about $100,000,000 have been identified and collected by American scientists.

THE reddish color of Mars is supposed to be due to great stretches of desert on that planet.

THE ZR-1, the airship now being built for the U. S. Navy, will be 680 feet long, 78 feet in diameter, and have twenty gas bags with a total capacity of 2,155,200 cubic feet.

BY making synthetic thymol, a drug that is used extensively as an antiseptic and a specific against the hookworm disease, Department of Agriculture chemists have again vanquished Nature at her own game. Thymol is now imported from India, where it is found in the seed of one of the plants growing there. The chemists have found that artificial thymol identical with the natural product can be made from cymene, a waste product in the paper industry. Thymol is now sold for $4.50 a pound, but it is estimated that the synthetic product can be made for about $2.50 a pound. As there are 2,000,000 gallons of cymene wasted annually in this country and Canada, chemists expect that this country will soon be able to produce all the thymol consumed here.