

# Recent Advances in Lighting

The Modern Illuminating Engineer: Artist, Electrician, Chemist and Psychologist

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**D**URING the past few years the Great War has had some influence upon lighting progress. Developments along certain lines were necessarily curtailed, for the facilities of laboratories were generally concentrated upon war-time problems. There were many developments such as signal lamps, search-lights, and other special devices which have less extensive applications in peace time, although normal activities will profit by them. One of the greatest benefits that lighting received from the war was a greater appreciation of the value of adequate and proper lighting in increasing production.

In a brief consideration of recent progress in lighting the electric incandescent filament lamp still demands chief attention. The luminous efficiency of this type of light-source increases very rapidly with increase in the temperature of the filament and until the limit is reached there will be a diligent search for new filament material or for ways in which older materials can be operated at a higher temperature with satisfactory life. No new filament material has been used in this type of light-source since the practical development of the tungsten filament; however, by developing ductile tungsten it was possible to wind the filament into a very small helix with great practical results. The filament now possessed, in effect, a relatively much larger diameter which made it possible to operate at a much higher temperature by immersing it in an inert gas; and the resultant gain in luminous efficiency outweighed the loss due to the cooling by the gas. The increase in efficiency was due to the fact that the greatly reduced evaporation of the filament permitted a large increase in the filament-temperature. Thus with the same filament material the luminous efficiency of the tungsten lamp has been greatly increased in the past decade.

It is interesting to note that the output of carbon-filament lamps in this country decreased in 1920 to only 4.3 per cent of the total number of lamps made as compared with 7 per cent in 1919 and 97 per cent in 1907. This lamp is now practically extinct in general lighting. However, great possibilities are inherent in the carbon filament because carbon melts at a very much higher temperature than the metallic filaments which have replaced it. It will not be surprising to find carbon return some day to its old importance in light-production.

Even after the great step had been made from vacuum to gas-filled tungsten lamps many minor improvements have extended the fields and satisfactoriness of the tungsten lamp. By increasing the efficiency and providing a special dense blue glass the tungsten lamp has invaded the portrait studio. By a similar procedure an approximation of average daylight has resulted which makes this kind of artificial light more satisfactory where daylight quality is best. Diffusing glass and coatings have been developed to reduce the glare from bare filaments. Other developments pertaining to colored bulbs, coatings and accessories are extending the applications of light in signs, theaters and elsewhere. By improvements in construction of filaments and by the adoption of a hard glass for bulbs the electric-filament lamp is now widely used for projecting moving-pictures and lantern slides. Another conspicuous improvement has been made in the gas-filled lamp for automobile headlights. Careful attention is given to the position of the filament and to its concentration, thereby increasing the accuracy of focusing. Extensive applications of the tungsten filament lamp have been made in a variety of projection apparatus. The highest temperature of the tungsten filament found in commercial lamps of to-day is about 3300 degrees. This is obtained in 900-watt tungsten filament lamps developed for projecting moving-pictures. This filament operates at 0.46 watts per spherical candle-power.

Incidentally electric filament lamps are now being rated in terms of lumens per watt instead of watts per candle. This is a great advantage because the total output of light can be determined by multiplying the watts by the luminous efficiency. The older method of watts per candle did not afford a measure of the

total output of light because the intensity was usually given in a single direction or as an average in a certain plane. This new method makes it much simpler to solve illumination problems because when the output of the light-sources is known it is only necessary to provide certain factors which represent the efficiency of the lighting unit and the utilization-factor for certain combinations of systems of lighting and of reflection-factors of surroundings.

The arc-lamp has practically disappeared from interior lighting, and with the exception of the magnetite arc is decreasing outdoors. The magnetite arc is now used in some places for high-intensity lighting in the more congested portions of cities. The arc-lamp of various special designs has gained ground in moving-picture studios. The Beck arc-lamp and modifications of it have greatly increased the beam candle-power of the large searchlights. In this type carbons are relatively small and a blast of alcohol vapor or of air is directed upon the arc. This makes it possible to obtain a very small source of light of extremely high brilliancy. These two factors are necessary for obtaining powerful beams of light by means of parabolic reflectors. The largest searchlight reflectors developed during the war were five feet in diameter. In recent years special flame carbons have been developed so that the arc-lamp has found some further applications in photography, dye-testing, and other photo-chemical processes.

The low candle-power neon vapor lamp has been

to obtain higher luminous efficiency because the quartz withstood the higher temperatures of higher current densities. It has been difficult to seal the leading-in wires into the quartz, but recently a method of connecting quartz through intermediate steps of glasses has been developed which makes better seals.

Minor improvements have been made in gas-burners in recent years. Very little gas-lighting is entering new residence districts in this country as compared with electric lighting. Owing to economies forced upon different countries by the war there have been some gains and some losses in gas-lighting. Owing to the oil shortage some time ago, and to other causes, there was a tendency for some gas companies to produce gas of lower illuminating value. This led to the elimination of many open burners and to the substitution of mantles. It is surprising that in this age of adequate lighting so many open gas-flames were found. In recent years high-pressure gas-lighting has made some headway, and considerable progress has been made in automatic gas-lighters and extinguishers and in the development of fixtures. Considering the greater difficulties inherent in the gas-burner the developments in gas-fixtures are worthy of commendation.

As an example of the changes due to necessity may be mentioned the revival of the old lime-light in Germany. In that country, temporary restrictions having been placed upon the use of electricity, the lime-light has been used to some extent for cinema projection. The button of lime has been replaced by a disk of rare

earths which is heated by an oxygen-acetylene flame. The acetylene is produced from calcium carbide and the oxygen by gently heating a patented material sold in small metal tubes enclosed in the ordinary steel bottles.

During the past few years the greatest developments in lighting have been made in the utilization rather than in the production of light. In fact, the interest displayed in proper and adequate illumination before the war increased greatly in such fields as manufacturing during the war. Now in this country the cause of good lighting is again progressing in all its phases. In the industries the tendency is toward higher intensities and toward proper reflectors which shade the lamps. Metal reflectors have been well standardized in design and leading manufacturers of such lighting equipment meet the specifications. For direct lighting it was also necessary in many cases to equip the bowl of the lamp with an opaque or dense diffusing-glass cap in order to eliminate glare from it. To eliminate this access-

sory, leading lamp manufacturers have placed on the market a bowl-enamelled lamp. This is the first superficial coating to withstand the temperature of the bulb of the gas-filled lamp. In factories where an illumination of one or two foot-candles has been common in the past, it is now not unusual to find intensities ten times as great.

For years lighting was based almost entirely upon the foot-candle intensity on a horizontal working-plane, but with the development of the science and art of lighting various other factors have been given attention. Glare reduces the ability to see, thereby increasing spoilage, decreasing production, and increasing the accidents in the industries. The size, position, and number of light-sources determine the shadow effects which are now known to play a large part in visual discrimination. The lighting expert now studies the work to be illuminated and determines the desirable intensity of illumination, the character and brightness of the background, and also whether or not local light-sources are to be used supplementary to general lighting. However, general lighting of fairly high intensity is the most desirable and general solution. It is now realized that the speed of visual discrimination depends upon the intensity of illumination. It is perhaps due partially to a general stimulation of alertness in the worker as well as to an increased ability to see. The expert also gives attention to the character of the surrounding surfaces, such as walls, desk-tops, etc., for if these are glazed they operate to some degree as

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**W**HEN the electric light was first being freely introduced into our homes and offices, it was such a startling contrast to the guttering oil lamp and the feeble open gas flame which had been in general use before it, that the public of the late 90's might well have been pardoned for supposing that the ultimate in artificial lighting had been achieved. But how mistaken they were will appear to the present generation if we will but take one of the good old-fashioned carbon lamps with the simple looped filament—always supposing that we can find one—and attempt to read by it. In the light of present experience with the 50 and 75 and 100 candle-power bulbs that are seen on every lighting fixture of 1921, the "wonderful" 16-candle-power light of 1900 is altogether dim and ineffective; it is surpassed by fully as wide a margin as it in its heyday enjoyed. Unless we have actually made this comparison we are apt not to realize what enormous strides the past decade has seen in the art of illuminating. Mr. Luckiesh, one of our foremost illuminating engineers, tells us in this article of what this advance has consisted and how it has been effected.—THE EDITOR.

introduced in England. In principle these are vacuum tubes, although the bulbs are generally spherical. The candle-power is relatively low for the 110-volt lamps. One neon lamp made in Germany is designed for use with alternating current at one ampere and 220 volts. In order to strike the arc a vacuum interrupter is connected in parallel with the lamp, a small choking coil being inserted in the common portion of the circuit. An inductive impulse set up by the automatic action of the interrupter by means of a magnetic coil causes a discharge through the lamp. This lamp is claimed to operate at 0.5 watt per candle-power, and can be started and stopped as often as 400 times a minute. The resistance of such lamps as determined by voltage and current is not fixed, but varies with the intensity of the discharge. A lamp for 20 milliamperes direct current has about 10,000 ohms resistance. In general, a consumption of 4 or 5 watts is sufficient for many purposes. Quite a variety of these lamps has been placed on the market in Europe. Although this type of lamp is not yet of sufficiently high candle-power to be used for general lighting, its use has been suggested for signs, for emergency lighting, in parallel with a fuse to detect and show burnout, as a position indicator for switches, as a distant indicator of the condition of a motor, and for many other purposes.

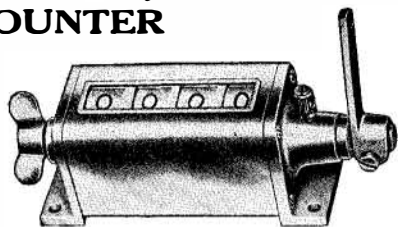
Only the usual incidental improvements have been made in recent years on the mercury-vapor arcs. These have not been such as to open new fields for this lamp. The introduction of the quartz tube made it possible

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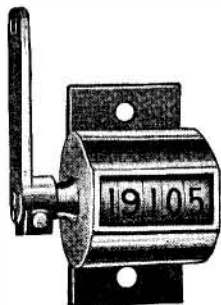
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## Recent Advance in Lighting

(Continued from page 27)

mirrors and reflect images of light-sources into the visual field even though the sources are hung high.

In the design of fixtures for stores, offices, and similar fields there has been a strong tendency toward dust-proof fixtures. As a result a number of fixtures are available with enclosing glassware of ingenious design. They possess clear and diffusing areas properly located so that the lamp is screened from view but there are clear areas for the emission of light. Such units, if well designed, are more efficient than a mere enclosing globe of diffusing glass. Installations of such units have widely multiplied during the past few years, illustrating the rapid advances in lighting. In the design of such a fixture it is also aimed to have the clear areas in such a position that dust cannot easily settle upon them. Attention is also given to the design of ventilated fixtures in order that they may not be dust-traps. The importance of dust-proof fixtures is apparent when it is realized that the output of a lighting installation in an average location may decrease 25 per cent if not cleaned for a few weeks.

Ten years ago, if one lived in the country out of reach of electric service, as most farmers did, the acetylene plant was the only isolated lighting plant available. During the past few years a number of country-home electric-lighting plants have been developed. These generally consist of a gas-engine, an electric generator, and a storage battery. These plants have been very widely installed during the past few years and have reached beyond the frontier as far as Kodiak Island, Alaska. What cheer science has brought to those long winter nights!

The number of outlets in the modern electrical home has greatly increased recently. A few years ago wall-switches and convenience outlets were rare. In fact, in any large city today there is only about one base-board outlet per residence on the average. Today the middle-class home is not properly wired without 15 to 30 such outlets.

There is still a tendency among fixture manufacturers to use unshaded frosted lamps or glassware which is insufficiently diffusing. Glare is the result, and as the public becomes acquainted with the finer things in lighting it demands subdued light-sources.

With the advent of the modern tungsten lamps it has become possible to produce accurate artificial daylight of sufficiently high efficiency to be practicable. Of course, science hopes for the day to come when daylight quality will be produced directly by the light-source, but until that day arrives the modern color-matching units will do the work required. Now accurate artificial noon-sunlight and north skylight are available through the development of glass color-filters. Such units have been widely installed where accurate color-discrimination is necessary. The public finds them in stores, where merchandise can be examined as to color without going to a door or window; but the layman little realizes that Liberty bonds are examined under them, that dyers depend upon them when dyeing millions of dollars worth of textiles, that the artist paints under them, that cigars are sorted under them, and that they are serving in hundreds of other ways.

Color is gradually coming into its own in lighting, as it has long ago in other fields, but owing to the lack of lighting artists it is not generally used in the best manner. With the advent of the gas-filled tungsten lamp it is now possible to obtain colored light of adequate intensities; however, the lamp colorings which were satisfactory for the vacuum lamp do not withstand the heat of the gas-filled bulb. Only recently have superficial colorings been developed for this purpose, therefore various colored media have been devised as accessories. Colored glass plates and caps, also colored gelatines, are now being used in show-windows to obtain colored light. In the larger moving-picture theaters spectacular effects of colored light are to be seen. Much can be done by the lighting artist who understands what might be termed the language of color.

Colors have many psychological influences which can be utilized. A theater in the summertime seems cooler if illuminated by blue-green light instead of ordinary light. Conversely, a warm tint, such as that of the candle-flame, makes an interior more cheerful except in very hot weather. It is beginning to dawn upon users of light that light is an expressive medium of great potentiality. It can produce a certain mood in a room which can be altered instantly by switches. This realization is evidenced in modern homes, restaurants, theaters, show-windows and many other places by the many lighting effects which are installed.

It is interesting to note that in many of the elaborate signs of the great white ways the lamps of low wattages are rapidly being replaced by large gas-filled tungsten lamps. Many signs which were designed for 10-watt lamps now contain 75-watt lamps. This is evidence that light is gaining in prestige even in advertising. No better indication of the widening interest in lighting is available than that of lighting legislation. Until recently laws contained at best only meager and incidental references to lighting. Today several states have separate codes pertaining to factory, school, and emergency lighting and there are many laws pertaining to automobile headlights. These codes show that proper and ade-

quate lighting is a great factor in the prevention of accidents and in the conservation of vision. Even insurance companies are contemplating a lower rate of insurance in factories which are well lighted, for, as one of the insurance experts has put it, "during a one-year period in this country the number of accidents due to inadequate or improper lighting exceeds the yearly rate of our casualties in the recent war." Owing to the lack of proper and adequate lighting over 100,000 men are continually absent from work in this country owing to disability. Thus it is seen that even though science contributes much toward the production and distribution of light, there still remains the necessity of an awakening on the part of the public to proper utilization of these developments.

## Liquefying Coal

AT the Chemical Congress recently held in Stuttgart, the well-known technical expert, Dr. Friedrich Bergius, gave an interesting account of an important new process devised by him and his associates by means of which it is possible to transform gas oil, crude oils containing large percentages of asphalt (e.g., Mexican petroleum), etc., almost completely into light oils without the formation of coke.

The development of this transformation of heavy oils into light oils, such as benzine and gasoline, has been considered one of the most important problems presented to petroleum technologists. At the present time in this country the light oils used for driving motors are prepared by the so-called cracking processes, which are based upon the fact that when the crude oils are heated at a high temperature under increased pressure, the heavy oils break up into light oils, this action being accompanied by the formation of coke and gaseous hydrocarbons. One of the best known of the cracking processes is that formulated by Burton. This is suitable, however, only for medium heavy oils, especially for gas oil, since in the case of very heavy oils and of those rich in asphalt there are serious losses of gas and coke, and also because the large amount of coke formed introduces technical difficulties. For these reasons the cracking process is not applicable to those oils which contain large amounts of asphalt, though these constitute a large part of the world's output.

The formation of coke during the cracking process is due to the separation out of hydrogen and of gases rich in hydrogen during the process of heating. Consequently many attempts have been made during the last few years to overcome this difficulty by the introduction of hydrogen, and naturally catalytic methods suggested themselves as appropriate for this purpose. Since, however, it was found impracticable to make use of catalysts for the hydration of impure crude oil, it was necessary to devise a special method of accomplishing this reaction.

In 1913 such a method was devised in the laboratory of Dr. Bergius, a method, that is, for preventing the impoverishment of the oils in hydrogen during the cracking process. This is accomplished by performing the cracking in the presence of hydrogen under a high degree of pressure. With a sufficiently high pressure and a suitable temperature, it was found easily possible to obtain the desired effect without the presence of catalysts.

Dr. Bergius states positively that this reaction has been found applicable to the most various kinds of oils, oil residues, and even to coal. It is this principle upon which is based the commercial technical process known as the Bergin process. This process can also be adapted to such products as brown coal or lignite generator tar. The loss of material through the formation of gas is trifling; moreover, by suitable alterations in the duration of the reaction, greater or smaller amounts as desired of benzine and petroleum may be obtained.

Because of this adaptability of the process, the crude oil can be broken up at will into light or medium products, according to the demand of the market at any given time.

Dr. Bergius goes still farther. He states that by the use of this same method of operation the hydration and liquefaction of mineral coal is possible. Berthelot, indeed, proved that coal is reducible, by treating the carbon with hydriodic acid.

Because of the experiments made by Dr. Bergius and his colleagues with regard to the production of coal from cellulose and the resultant views formed by them as to the chemical nature of coal, they came to the conclusion that under the proper conditions a reaction could be obtained between coal and hydrogen. Such a reaction was discovered in the summer of 1913 and a patent was applied for on August 9th of that year—it is described as follows:

By heating coal in the presence of hydrogen under a pressure of 100 to 200 atmospheres, the coal can be almost entirely decomposed. If the proper conditions of operation be observed, about 85 per cent of a specimen of coal yielding 85 per cent of ash can be liquefied.

It was necessary, of course, to spend years of work in order to obtain a practical method of making use of this brilliant achievement. The first commercial plant for this purpose has been erected in Mannheim-Rheinau during the last year or so.

Convincing proof has been given, says Dr. Bergius, that the very great difficulties at first encountered in the endeavor to obtain a practical commercial development of the results obtained in the laboratory, are capable of being overcome and that if the high pressure apparatus required be properly constructed the process is both simple in operation and certain in results from the commercial point of view.