AMAZING STORIES

Science Fiction

Vol. 8 OCTOBER, 1933 No. 6

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Our Cover

depicts a scene from the story entitled "Men Without Shadows," by Stanton A. Coblentz, drawn by Morey.

Published Monthly by
TECK PUBLICATIONS, INC.
4600 Diversey Avenue, Chicago, Ill.
Executive and Editorial Offices: 222 West 39th Street, New York, N. Y.
Lee Ellmaker, Pres. and Treas. Abner Germann, Sec'y
Warren P. Jeffery, Vice-Pres. Huston D. Crippen, Vice-Pres.

 Entered as second-class matter at the postoffice at Chicago, Illinois, under the Act of March 3, 1879. 25c a copy. $2.50 a year. $4.50 in Canada. $3.50 in foreign countries. Subscribers are notified that change of address must reach us five weeks in advance of the next date of issue.

Printed in U. S. A.

AMAZING STORIES

THE MAGAZINE OF SCIENCE FICTION

VOLUME 8

OCTOBER, 1933 No. 6

T. O'CONOR SLOANE, Ph.D., *Editor*
Editorial and General Offices: 222 West 39th Street, New York, N. Y.

Extravagant Fiction Today . . . . . Cold Fact Tomorrow

The Early History of the Electric Light

By T. O'Conor Sloane, Ph.D.

ABOUT 133 years ago Sir Humphrey Davy produced an electric arc between two pieces of charcoal and this may be taken as practically the birth of the electric light. Very little effect of illumination had been given so far by any heated conductor, but the electric arc was a true light. The mind of the experimenter seems to have been fixed on the idea that the arc, the little flame-like body, extending from pole to pole, was the light-giving element. Later on, carrying out this idea of the importance of the arc, Sir Humphrey Davy, using an immense battery, one of two thousand jars, produced an arc four inches long. This gives an interesting illustration, or example, of an early misconception of the electric arc lamp. The carbons are now operated quite close together, and what the arc does is not to give light in itself to any extent, but to supply a path of conduction of high resistance and of very small dimensions. This makes it a concentrated spot of heat, and as the current passes, the two carbons become intensely hot and the light is derived from them, the arc giving a very small proportion. The early investigators quite misunderstood the operation of the arc as an illuminating agent, but experimented vigorously and tried to reduce the high resistance of the charcoal electrodes by treating them with metallic mercury. They seemed to have no objection to the idea of disseminating mercury vapor through the air that they were breathing.

The great trouble in experimenting with any apparatus requiring a strong and continuous electric current was in the battery. The primary battery of those days was a very poor affair and to-day, it is fair to say that except for special uses, the modern primary electric battery is poor enough. We can imagine the labor of setting up Davy's two thousand cups of primary battery, filling each cup with the acid, making the four thousand connections to the plates and realizing that from the moment the battery was started by bringing the acid and plates together, it began to run down. Even if left on open circuit while theoretically idle the battery would lose strength rapidly, would polarize as it is called, and would exhaust the acid and dissolve the zinc. From the instant it was set up it would begin to destroy itself.

THE electric arc excited great attention in those days, people thought it was of a much higher illuminating power than it really was and this idea lasted for many years. They were warned not to look at it directly for fear of some injury.

Difficulties in the use of the primary battery were so great in the development of power that the electric arc remained a thing of spectacular and theoretical interest only. Up to within quite a recent period, the so-called calcium light was the principal source of illumination for the magic lanterns, the progenitor of the moving pictures of to-day, which are projected by the use of the modern electric light.

The great Faraday, Sir Humphrey Davy's assistant, and who, it is said, was treated sometimes with scant civility by the older scientist, had produced electric currents mechanically. These were very slight and trivial, but his laboratory apparatus was the progenitor of the gigantic dynamos of the present day. And when a self-contained mechanical generator of electricity, and that is what a dynamo is, came into being, the electric arc light became a possibility and the most diverse efforts were made to bring it into use. At first the construction of a feed mechanism for maintaining the carbons at the proper distance from each other, offered considerable difficulties, and various inventors worked upon the subject. The machinery for feeding the carbons was more or less complicated and accordingly efforts were made to produce an arc lamp which would burn for a reasonable period without any machinery. The great problem then was stated to be the development of a method of dividing the electric light—the arc light giving several hundred candle power was not what mankind wanted, what was wanted was to divide up this illumination into smaller units and the expression—"The Division of the Electric Light" became a sort of by-word among investigators in the last century.

It is astonishing how much has been forgotten of the early work in this direction. A division of the electric light, to a certain extent, and the dispensing with feeding mechanism for the carbon was brought out by the Jablokoff candle, which played a very big part in the discussions and work of the last century. This consisted of two carbon rods thinner than a lead pencil, and perhaps eight or ten inches long, enbedded in a plaster-like composition which held them parallel to each other and at a distance apart of a fraction of an inch, for by this time inventors realized that a long arc was not desirable. The Jablokoff candle was mounted in the position of the everyday candle, in a socket, the terminals of the circuit being connected to the lower ends of the two carbon rods. A little bit of carbon was laid across between the upper ends of the main carbons and when the current was turned on this rapidly became incandescent, burned out in a few seconds, and the arc started. The idea was that the arc would persist until the candle burned down to the socket just as an ordinary wax candle would do.

This instrumentality for illumination was tried on an extensive scale both indoors and outdoors and much to the terror of the gas manufacturers the division of the electric light seemed at last to be effected.

In the direct current arc light one carbon always burns much more rapidly than the other, so the Jablokoff candle had to be operated by an alternating current. Its life was rather short and when it died a natural death, it was pretty well forgotten and to-day, just as the wireless operator, in many cases, never knew what a coherer is, the modern electric lamp technician in most cases, could not tell you what a Jablokoff candle was.

THE power of the electric arc, when its mechanism was completed so that it could be used for a number of hours' work without any attention, was greatly exaggerated. It was always spoken of as of 2000 candlepower but it probably was of less than half that power.

The division of the electric light on the basis of the arc was found to be almost impossible. The experiment was tried of putting it on a very high pole, perhaps 100 feet in height, and depending upon it to illuminate a large area. It was so small that the shadows which it cast were very sharply defined. There was no penumbra, that is, no shading off of the edges of he shadows. We were told that people stooping down would try to pick up the shadow of a twig, cast by the arc light on the pole, as if it was a real one.

Edison, by this time had won his fame as the wizard of Menlo Park and he attacked the problem of the subdivision of the light. If a lamp could be devised which would operate by pure incandescence of a solid, without any arc and with a consecutive conductor, it would seem that the problem would be solved. Every one looked to him for the solution and his platinum wire lamp was described and illustrated in the press as important news.

In this lamp a little vertical coil of platinum wire in the general shape of an inch of lead pencil was ignited by the current and gave light. Through its center a metal bar passed and when the coil approached the danger point of fusion, the expanion of this bar, acting on a switch, opened the circuit and reduced or cut off the current. In practice, this was supposed to act almost like a variable resistance, the makes and breaks as far as they were produced, succeeding each other with a rapidity approaching continuity. It was not satisfactory, so going down the line the substance was sought which, unlike platinum, was virtually infusible. Chemistry had not advanced very far in those days, at least there was much ahead of it to be discovered, and for the electric lamp it appeared that the most obvious substance which would conduct electricity, which was practically infusible, so that it could be brought up to a white heat, was carbon, the very substance of the pencils or rods of the arc light. Edison tried a filament of carbon using any number of materials to get a good substance, sealed it in the bulb just as in the tungsten lamp of to-day, and pumped out all the air. To do this he used a mercurial pump of the Sprengel type and at one time he had 500 of them in his laboratory at Menlo Park.

The filament in the shape of the inverted letter "U" was contained in a bulb more or less pear-shaped, and from this form only slight departures have been made during the many intervening years. At "one fell swoop" a lamp was devised without any mechanism, one that would require no attention during its lifetime, and which would burn hour after hour without change. The thing that struck people who saw these lamps for the first time was that they were looking at gas flames and not at an electric light, so perfect was the invention.

FOR many years there has been a standard of light for gas on which contracts were often based. A burner, consuming five cubic feet an hour of standard gas, was supposed to give 16 candles of illumination, though it often gave much more. This was the light given by sixteen standard sperm candles. It became the goal of the everyday incandescent electric lamp.

All sorts of carbonaceous materials were used as the basis for the filament. Edison had the world combed over to get the best material. The filament was subjected to various treatments. It was ignited to a red heat in an atmosphere of hydrocarbon vapor. This gradually diminished its resistance so that by regulating the time of this preliminary ignition it could be brought to any desired number of ohms. The filament which may have started almost as charcoal by this and other subsequent treatments became hard and elastic, which greatly increased its strength under disturbance by shaking or otherwise. When cold the filament was extremely elastic. A long filament, started into vibration by shaking the bulb, would oscillate back and forth with such extreme rapidity as to produce a sort of spectral image. It was a very interesting illustration of the elasticity of a solid body.

The great feature of the incandescent lamp was that it gave even illumination when subjected to a standard potential. Thus two leads of wire could be carried any distance and could be maintained at a definite potential difference, one from the other, and incandescent lamps connected across them like the rungs of a ladder, would be steadily lighted by the current. As the difference of potential would be greater near the source of electricity than at a greater distance, lamps of different voltages could be used on different portions of the leads. Inside the lamp bulbs as high a vacuum as possible was produced, then they were hermetically sealed so that the vacuum within them was permanent. For many years the carbon filament in the incandescent lamp was used with great success for house illumination.

One of the early incandescent lamps deserves a special notice, it came so near to being the perfect solution of the problem. It depended on the ignition of a clay filament to a white heat. The filament was virtually infusible, was absolutely unaffected by the oxygen of the air, it seemed to do away with the difficulties inherent in the old-time incandescent lamp with its carbon filament. This is the Nernst lamp, pretty well forgotten now, but from some points of view the best of the incandescent lamps. But like many other seemingly good things, it did not reach a successful exploitation.

When Edison worked on the incandescent lamp, he had also to provide a system of conductors for it. It was simple enough to run two conductors in parallel with each other, wherever light was desired. In this way, the conductors would have to be thick enough, that is to say, of low enough resistance, to economically carry the current for a single lamp or for a whole group, perhaps a hundred or more. The lamps were made of about 110 ohms resistance, some were of higher resistance than the others, determined by the points of the conductors where they were to be used. The happy idea then occurred of using a central conductor to maintain a difference of the standard amount of about 110 volts, between the central conductor and the right-hand conductor on one side and another 110 volts between the central conductor and the left-hand lead. The lamps were then connected from center to one side or the other of the group of conductors. In a general way they were supposed to be connected symmetrically, so that the arrangement was like a "ladder," which not only had its two sides, but had a central bar to support the rungs. This of course is a mere comparison. The three-wire systems brought about a most interesting condition that double the voltage could be used on the circuit and for the same number of lamps on a two lead circuit 33 1/3% more copper would have to be used.

If one lamp was turned off the other one would receive the potential existing between its outside conductor and the central one. If both were turned on, each would receive its proper voltage giving an aggregate of double the amount for one lamp. Now comes the personality element as it may be called. If all the lamps on such a circuit were going at once, they would be supplied by the two outside leads only and the central lead might be cut off for any good it would do, but the moment one lamp was shut off, the equilibrium would be disturbed and the central lead would have to pass current for the odd lamp. Now if all the lamps on one side were turned off, then everything would be done by the central lead and one of the outside leads, leaving the third one idle. But in the course of human events, it was almost impossible that all the lamps on one side should be turned out. It was quite safe to assume an average dimension for the central lead based on how the customers would handle their lamps in the way of turning them off or turning them on. It, therefore, appeared to be quite safe to reduce the size of the central lead. As a popular way of putting it, it may be said that this relation of sizes of leads was based on how human nature would treat the lamps.

A five wire system was tried and worked well, but never reached any development.

We are all familiar with cellophane, the peculiarly indestructible organic compound used as a wrapper. The question used to be asked, "What becomes of all the pins?" When we find cellophane being wrapped around everything from cigars to candy, the question may be asked, "What becomes of all the cellophane?" If the carbon filament lamp was not extinct, cellophane would seem to be quite an ideal substance as the basis for the filament.

The standard carbon filament lamp, following the lead of the old standard gas burner, gave a light of about 16 candles and required for this the expenditure of nearly 4 watts to each candle power.

Naturally, there was a great desire to use a metallic filament. One of the metals, tantalum, presented possibilities, but the conclusion was reached, oddly enough, that there was not enough metallic tantalum to be obtained in the world to supply the lamps for a year.