the elevated tank, or the one immediately below it, must return to the first tank on the opposite side of the barge, as this latter is placed at the lowest point, the return being purely gravitational. It will also be seen that the water circulating between the tanks cannot escape. Glycerine is mixed with the water to prevent freezing in cold weather, so that the system can be used any time of the year irrespective of climatic conditions.

The scow shown in the accompanying illustrations is in daily service at Stockholm, and has proved eminently satisfactory to the engineers of the city. The results that have been obtained prove that this self-dumping barge is superior to the ordinary hopper type with false bottoms. It is cheaper in first cost and maintenance; can handle rock of practically any size and weight within its total capacity; and is a first-class craft for any harbor transport. If desired, the elevated cylinder can be unshipped in a couple of hours, and the barge used as an ordinary lighter. The system is applicable to any type of barge, whether of the blunt-ended type or one of fine lines. It is only necessary to insure a sufficient breadth to counteract the influence from high winds. The success of the flush-deck type has induced the inventor to extend the idea to craft with sunken holds for handling gravel, mud, and other semi-liquid or soft material, which cannot be accommodated on a flush deck.

HALLEY'S COMET AT ITS BRIGHTEST.

BY HENRY NORRIS RUSSELL, PH.D., PROFESSOR OF ASTRONOMY AT PRINCETON UNIVERSITY.

It may have seemed remarkable to many people that so long a time has elapsed since the first observation of Halley's comet at its present return, and yet it has not shown itself at all to ordinary eyes. The accompanying illustration (Fig. 1) will help to explain this. When first detected last September, with very powerful telescopic aid, it was far beyond the limits of our diagram, at twice the distance of Mars from the sun, and nearly as remote from the earth. At first the two

Fig. 4. Spectrum of Halley's comet.

Photographed at the Yerkes Observatory by Prof. Frost, January 14th, 1910. The spectrum of the comet is in the middle between the two brightest star-spectra. See description in text. The blue end of the spectrum is on the right; the ultra-violet on the left.

bodies approached each other rapidly; but before the end of the year our planet crossed the line joining the comet with the sun, and by January 1st, as the figure shows, we were moving almost straight away from it. During the early part of the year the earth and comet passed on opposite sides of the sun, so that it was lost to our view early in March.

About the time that this is printed it will come into sight again, on the other side of the sun, rising before daybreak. But now its path has curved so that it is coming toward us—almost directly, if we take our motion into account as well as its own. It therefore seems to stand almost still among the stars, while growing steadily larger and brighter, so that any one might tell by its mere changes in appearance that it was approaching us rapidly.

Finally, about the middle of May the comet will apparently approach the sun again, and on the 18th it will pass in front of him, literally between us and the sun, transiting the latter's disk. If at this time its tail is more than fifteen million miles in length we will pass through it, as the figure shows.*

The comet's closest approach to us comes two days later, on May 20th, when it is but fourteen million miles away. For a few days following this it will be splendidly visible in the evening sky, and then it will fade gradually as it recedes from us.

It is clear from the diagram that this apparition of the comet is an exceptionally favorable one, for it passes the earth almost at the point where their orbits come nearest to one another. If it had returned only three weeks earlier, it would have come as near as possible—only seven millions of miles—but at this time it would have been directly south of the earth, astro-

nomically speaking, almost over our south pole, and quite invisible from northern latitudes. It therefore appears that the present conditions are almost ideally favorable for observers placed, as we are, north of the equator.

The illustration on the first page shows better than any verbal description where to look for the comet in the morning sky in New York. The moon and Venus

Fig. 1.—RELATIVE POSITIONS OF HALLEY'S COMET, THE EARTH, AND THE SUN.

are shown in the positions which they will occupy about May 1st, when, on the whole, the comet can be seen to the best advantage. At an earlier date, Venus was higher in the sky, compared with the comet. There was less trouble then from moonlight, but the comet did not rise so early—about 4 A. M. on April 15th as against 3 A. M., on the later date.

The comet's brightness when it appears in the evening sky about May 20th will be sufficient to render any finding diagram unnecessary. It will only be needful to look toward the west half an hour or more before the comet sets, which it does at 8:20 P. M. on the 20th, 9:15 on the 21st, and 9:55 on the 22nd, after which it will be clearly visible until after 10 P. M.

Our other illustrations, which appear here through the courtesy of Profs. Frost and Barnard of the Yerkes Observatory, show the appearance and character of the comet earlier in its apparition. Fig. 2 illustrates its extreme faintness at the time of its rediscovery (which was announced by Prof. Wolf of Heidelberg less than a week before the earliest of the four photographs here shown was taken) while it was still 300 million miles distant, both from the earth and from the sun. On any one plate it is difficult, if not impossible, to distinguish the comet from the multitude of faint stars around it, but on comparing the four (which show exactly the same region of the sky) it is easy to see that the stars are the same in all, while the comet is "here to-day and gone to-morrow."

With the great Yerkes telescope (which gives far smaller and sharper images of the stars than can be reproduced on any known photographic plate) the comet was even at this time quite different from the stars in appearance; in Prof. Barnard's words, "a fleck of light surrounded by a faint nebulousity" with no

Fig. 2.—Halley's comet at its reappearance in 1909.

From photographs taken by Mr. Lee with the two-foot reflector of the Yerkes Observatory. These four photographs represent the same portion of the sky. The arrows point to the comet which appears like a faint star but moves from night to night.

definite boundary. His measures, made on several nights, show that its actual diameter was about 12,500 miles.

Our second illustration, from a photograph taken when the comet was 143 million miles from the sun, and 162 million from us, shows it already well advanced in the changes which invariably accompany the approach of any considerable comet to its perihelion. The head of the comet has become larger—not merely in apparent size, owing to its approach to us, but actually in miles, while a faint slender tail, pointed away from the sun, makes its appearance.

As Fig. 1 shows, the tail, which extends directly away from the sun, was at this time also nearly in line behind the head, as seen from the earth, so that its actual length must have been much greater than it appears to be—about five million miles, according to Prof. Barnard.

This considerable development of the tail, while the comet was still at two and one-half times its least distance from the sun, makes it probable that at and after the perihelion passage, on April 20th, it will be much longer, probably long enough to envelop the earth as it sweeps past.

Our third illustration shows the spectrum of the comet photographed on January 14th, when it was about 170 million miles from the sun.

In taking such a photograph, a prism is placed in front of the camera. The light of a star is thus drawn out into a line which, by letting it trail on the plate, is broadened into a band, crossed by the dark lines which tell us what absorbing gases exist in the star's atmosphere. Most of the objects on the plate are the spectra of stars near the comet obtained in this way. The comet's spectrum is near the middle, between the two very broad and conspicuous "comparison spectra," which were produced by supplementary exposures on some bright star, and serve as reference marks to find the position of the lines in the spectrum of the comet itself. The latter, unlike that of the stars, consists

Fig. 3.—Halley's comet on February 3rd, 1910.

From a photograph taken at the Yerkes Observatory by Prof. Barnard. As the instrument was kept pointed at the comet during the exposure the stars appear as short streaks. The actual length of the comet's tail is about five million miles.

mainly of bright bands or lines, three of which are conspicuous. The brightest of these, as is shown by comparison with the hydrogen lines of the comparison spectrum, is the so-called "cyanogen band" at the extreme violet end of the visual spectrum. The others are probably, as in the case of other comets, also due to gaseous compounds of carbon.

Between these bright bands can be seen a faint continuous spectrum, due to reflected sunlight.

When the comet first appeared, the photographs made at the Lick Observatory showed this continuous spectrum alone. At that time it must have been shining entirely by reflected light; but by the date of our illustration it had already begun to be self-luminous. This is corroborated by the fact that its brightness increased much more rapidly than could be explained by the mere increase in the amount of reflected light, due to its approach to the sun and to us.

This intrinsic light of the comet, as its spectrum shows, is given off by luminous gas; but we do not yet know what makes this gas shine. It can hardly be high temperature, for the comet had just come from the depths of interplanetary space, and did not yet receive nearly as much heat from the sun as the earth does. It must, however, be due to some kind of solar action, for it increases very rapidly as a comet approaches the sun. We can reproduce the same spectrum in the laboratory by passing an electrical discharge through a vacuum tube containing compounds of carbon and nitrogen at very low pressure.

It is of special interest that, even if the carbon compounds form but a small percentage of the gas in the tube, their spectrum becomes relatively prominent when the pressure is made very small, say 1/100,000 of that of ordinary air. It may be, therefore, that at the lowest pressures, carbon compounds have an exceptional capacity for shining; and it would be unsafe to conclude that they are the principal gaseous con-

* Prof. Barnard has informed us that the tail was 14,000,000 miles long on February 27th, from which it may well be inferred that it is much longer than 15,000,000 miles now.—ED.

stituents of the comet, because they give off almost all the light.

It may be added that the "cyanogen" bands in the spectrum are produced, not only by the poisonous gas of that name, but in all cases when carbon and nitrogen are together under electrical excitement. For example, they are very strong in the spectrum of an ordinary arc-light, where the nitrogen comes from the arc, and the carbon from the terminals. It would be about as reasonable to conclude that an arc-light was poisonous, after looking at it through a spectroscope from a distance, as to make the same deduction about a comet.

Whatever may be the origin of this intrinsic light of comets, it is responsible for most of the phenomena which make them of general interest, for almost all the light of the tail, as well as of the head of a bright comet is of this kind. If Halley's comet shone by reflected sunlight alone it would be barely visible to the naked eye, even under the most favorable circumstances.

Actually, owing to its intrinsic light, it has been a conspicuous object at every return for the last 2,000 years. The only gap in the record—in A. D. 912—has lately been filled by the discovery of unmistakable references in old Japanese chronicles.

The actual quantity of matter composing it must, however, be very small as compared with the more familiar heavenly bodies. It is possible to form a rough guess as to its amount by considering the amount of light which it reflects when it is not shining on its own account. From the estimates of magnitude made last September, it appears that a single body only a little over 30 miles in diameter at the distance of the comet would have sent us as much reflected light, provided that its reflecting power was equal to that of the moon, which is lower than that of most of the planets.

It is, therefore, clear that the comet must be composed of separate particles widely separated. The whole cross-section of the comet (12,500 miles in diameter) is about 120 million square miles; while the total area of all the reflecting particles, according to the above estimate, is about 1,000 square miles. A ray of sunlight falling on it has therefore less than one chance in 100,000 of being stopped, and all the rest of getting through some empty space. It is no wonder that comets are transparent, and that stars can be seen through them! If we only knew how big these particles were, we could now estimate their number and their total mass. But here we are quite in the dark. As the light of the comet seems uniformly diffused and it shows no signs of resolution into points of light, the number of particles composing it must at least be counted by thousands. Their average diameter must therefore be less than a mile, though they may vary enormously in size. If all gathered into one compact group, they could at most hardly exceed in bulk the satellites of Mars or the smallest of the asteroids.

But how much smaller than this limit their actual dimensions may be, we do not know. If, purely for illustration, we suppose that they average an inch across, there would be some five or six million millions of them. This sounds like an enormous number, but if we calculate the bulk of the comet, we find that there would be only five or six particles per cubic mile of space, on the average, inside it. Near the center they would doubtless be more closely packed, and more thinly toward the outer parts of the comet. The combined bulk of all these particles would be about 80 million cubic yards—a large amount from the engineering standpoint, but not equal to the quantity of water which falls within the limits of the smallest State in the Union during a heavy rainstorm.

This may serve to give us some idea of the extreme tenuity of the comet as a whole. If we took a space as big as the comet, that is, half as much again in diameter as the earth, and sowed ordinary golf balls through it at the rate of two or three per cubic mile, leaving the intervening space absolutely vacant, we would get something that would look quite as bright as Halley's comet—if put alongside it when it first appeared.

The gaseous matter, which gives most of the light at perihelion, probably oozes out of the solid particles as these grow warm under the sun's heat when they approach it. As the gas becomes luminous under solar action, the brightness of the comet increases, and its outer regions, originally invisible because the number of reflecting particles was too small to influence our eyes, gradually come into view.

Some of this is repelled from the head of the comet, by little-known forces, and driven away from the sun by the action of the sunlight, which, as is well known, exerts a force of repulsion which, if a particle is exceedingly small, as are the gaseous molecules, is stronger than the attraction of the sun.

Thus arises the long and magnificent tail, which, like the smoke-trail of a steamer at sea, is ever being renewed at one end and fading away at the other, even though it seems to accompany the comet in its journey.

As the comet recedes from the sun, much of this gaseous matter has thus been lost, never to be regained. Some of the remainder probably condenses round the solid particles when they become cold, and some escapes into space.

The comet is thus gradually losing its substance, and in the course of ages it may be deprived of all its tail-forming material, and lose its former glory. This seems to have actually happened to some of the short-period comets, one at least of which has disappeared altogether.

Halley's comet is perhaps preserved from such a fate by the longer interval between its returns to the region near the sun, where its activity takes place. It may be, too, that it has more of the right sort of material to spare for a tail. But the time may come when most of this is lost, and its successive appearances may gradually lose those impressive features which have so long inspired awe and wonder in the hearts of mankind, and dwindle at last into something which the professional astronomer alone will be interested in watching.

The Mercury Vapor Lamp and Its Effect on the Eye.

About a year ago we published a reference to a report of Prof. J. Norman Collie, F.R.S., stating in effect that a German medical journal had described certain cases of alleged injury inflicted upon the eyes by rays of mercury vapor lamps. These cases referred to all prove to have resulted not from the mercury vapor illuminating lamp, which is now so largely in use in this country and which is constructed with a tube or container of glass, but from a special lamp used in medical, sterilization, and chemical processes, having a quartz container. The medical or sterilizing lamp, to be sure, uses mercury vapor, but its container being of quartz, it is transparent to those rays which may be injurious to the eyes, while glass is opaque to such rays and does not permit their passage. The quartz lamps referred to by Prof. Collie are intentionally made to emit germ-destroying rays. Dr. Charles P. Steinmetz, who has made a careful study of mercury vapor lamps used for illuminating purposes, stated in an article in the *Electrical World and Engineer* of February 21st, 1903, as follows:

"The mercury arc, therefore, is the only known artificial illuminant which is perfectly harmless, and thus especially suited for use where accurate work has to be done by artificial illumination, as in drawing rooms, offices, factories, etc."

The same scientist in an article in the *Daily Union, Schenectady, N. Y.*, on January 17th, 1903, stated as follows:

"Therefore electric lights are less harmful than gas or oil lamps, being whiter, and the white daylight the least harmful, while the mercury arc light which is entirely devoid of red rays, is absolutely harmless, and a person can look straight into one of these mercury arcs of enormous brilliancy without being blinded by it."

In one of Dr. Steinmetz's books entitled "Radiation, Light, and Illumination," he makes the following statement:

"The harmful effect of working very much under artificial illumination is largely due to its energy effect, incident to a large amount of orange, red, and especially ultra-red in the radiation of incandescent bodies used for illuminants and thus does not exist with 'cold light,' as the light of the mercury lamp."

The Current Supplement.

Prof. R. F. Ruttan writes most interestingly in current SUPPLEMENT No. 1789 on the manufacture of alcohol from sawdust and other wood waste. A novel type of automatic stamp-vending machine is described and illustrated. Prof. Charles Edward Lucke writes on the development of power systems. Prof. Otto N. Witt's paper on fast and fugitive dyes is concluded. Harlan I. Smith presents some curious information on the wooden monuments of the Northwest Coast Indians. A biography of the famous Dmitri Ivanovitch Mendeléeff is published. A method of instantaneous microphotography is described.

Official Meteorological Summary, New York, N. Y., March, 1910.

Atmospheric pressure: Highest, 30.51; lowest, 29.47; mean, 30.8. Temperature: Highest, 78; date, 29th and 30th; lowest, 24; date, 18th; mean of warmest day, 64.5; date, 25th; coolest day, 32; date, 15th; mean of maximum for the month, 52.4; mean of minimum, 37.0; absolute mean, 44.7; normal, 37.5; daily excess compared with the mean of 40 years, 7.2. Warmest mean temperature of March, 48, in 1903; coldest mean, 29, in 1872. Absolute maximum and minimum of March for 40 years, 78 and 3. Average daily excess since January 1st, 3.5. Precipitation: 0.86; greatest in 24 hours, 0.26; date, 1st and 2nd; average for March for 40 years, 4.10. Deficiency of this month compared with normal, 3.24. Accumulated deficiency since January 1st, 1.09. Greatest precipitation, 7.90, in 1876; least, 0.86 in 1910. Wind: Prevailing direc-

tion, northwest; total movement, 7,983 miles; average hourly velocity, 10.7; maximum velocity, 44 miles per hour. Weather: Clear days, 13; partly cloudy, 13; cloudy, 5; on which 0.01 or more of precipitation occurred, 6. Snowfall, 0.4. Mean relative humidity, 68.3. Dense fog, 2nd, 3rd. Sunshine, 69.2.

The Highest Dam.

At the hour of two in the morning of Sunday, January 16th, the completion of the Shoshone dam in Wyoming was announced. This is the highest dam in the world, being 328.4 feet from the base to the parapet. It is located in the profound canyon of the Shoshone River, in one of the wildest and most picturesque regions of northern Wyoming. The walls of the gorge are nearly perpendicular, and rise nearly 2,000 feet above the stream. At its base the dam is 70 feet across; on top it is 175 feet in length, and at the base the dam is 108 feet wide.

The completion of this dam creates an enormous reservoir, having a surface area of ten square miles and an average depth of seventy feet. The capacity of this irrigation basin in gallons is something like 148,588,512,000. The construction of this great dam was attended with difficulty from the beginning, owing partly to the inaccessible section in which it stands.

The dam is to control for all time the great floods of the Shoshone River and to provide an ample water supply for the irrigation of more than 100,000 acres of exceptionally fertile land in the valley below, a portion of which is now available for settlers under the terms of the reclamation act.

The contract for the Shoshone dam was let September 18th, 1905, to a Chicago firm for \$515,730. This firm, however, defaulted, and the work was completed by another contractor.

Rail-Cleaning Car.

When streets are cleaned by sweepers, whose brushes push the dirt before them, the dirt is swept into the grooves of the street railroad rails and then compacted by the wheels of the running cars. The rails so coated with dirt offer a greater resistance to the electric current, thereby causing a greater amount of power to be used for the propelling of the cars. The rails must be constantly cleaned to avoid loss of current.

The Hanover Street Railway Company has built for this purpose a special rail-cleaning car. It is similar in construction to a regular two-axle car, and has two 25-horse-power motors. Between the front and rear wheels on both sides of the car are steel brushes, which loosen the dirt from the rails. This dirt is automatically removed by a vacuum pump, and deposited in a box built into the lower part of the car between the axles of the driving wheels. The vacuum pump is operated by an electric motor attached to the dirt box. To avoid the raising of dust in dry weather, a sprinkler and two tanks, holding about 925 gallons of water each, are provided.

As soon as the box is filled, an automatic alarm notifies the motorman, who shuts off the pump, raises the brushes, and takes the car to a place where it can be emptied and made ready for another trip.

This car can be run at any rate of speed allowable in street traffic up to 17½ miles per hour, and still will work with good results. It can be run by one man, and the amount of power used at a speed of 10 miles per hour is only about 3,000 volts per mile. The car can clean daily an average of 45 miles of track, using according to weather conditions, up to 132 gallons of water and taking up to one cubic yard of dirt per mile of track.

Death of Thomas A. Baxendale.

The founder of the box toe industry in this country, Mr. Thomas A. Baxendale, died at Brockton, Mass., on April 1st at the age of seventy. A native of England, Mr. Baxendale came to Brockton in 1867 a poor man. The shoe industry was then in its infancy. He entered one of the large factories and invented the box toe which is now used in nine-tenths of the shoes that are worn. Later, with John Simmons as a partner, he founded the firm of T. A. Baxendale & Company. He invented many machines for producing shoes, most of which are now in common use. He died a wealthy man.

Death of Thomas B. Jeffery.

Mr. Thomas B. Jeffery, who invented what is known as the clincher pneumatic tire, died on April 3rd, at Pompeii, Italy. He was for more than twenty-five years a partner of the firm of Gormully & Jeffery, makers of bicycles. English by birth, he came to this country at the age of eighteen, and settled in Chicago. He took an active interest not only in the development of the bicycle, but in the automobile as well.

Death of Paul Theodore Sievert.

Paul Theodore Sievert died January 11th, 1910, in Dresden. He was a well-known German manufacturer and inventor. He is best known for an invention in which he applied compressed air for blowing vessels of glass of any desired size.