THE FRENCH AT MUSCAT.

THE recent incident at Muscat is still fresh in the public mind. The English desired to be masters of the Persian Gulf, while the French wished to establish a coaling station near Muscat, a town admirably situated for that purpose, near the entrance to the gulf. The French obtained permission from the Sultan to establish their station at Bender-Sissek, whereupon the English proclaimed the conquest of Arabia by France. People almost feared at one time a second edition of Fashoda; but this time French honor is safe, and everything has been arranged.

The French were very conciliatory in the treaty signed March 21 relative to Africa; and so to recompense them the English tolerated this coaling station. Thus France has been successful in her operations in Asia, although those in Africa did not end happily.

Muscat, a city of about 30,000 inhabitants, is the capital of Oman, the seat of the Arabian empire, which was so powerful up to 1856, and which at that time comprised, besides its 1,863 miles of coast on the Arabian peninsula, the isles of the Persian Gulf, the ports of Baluchistan and Persia, and most of the old Portuguese settlements on the coast of Africa, including Mozambique and Zanzibar. In 1857 Zanzibar separated from the empire, and the authority of the sovereign of Muscat rapidly lessened. The fleet of Oman, once the most powerful of the Indian Ocean—it consisted of thirty-five frigates constructed after European models—is now only a recollection.

France has always been on excellent terms with the rulers of Oman, and has enjoyed all the privileges which were accorded to England.

One of these Franco-English arrangements, the secret of which the French diplomats still hold, caused France to abandon, in 1890, the rights which she had in Zanzibar, but she carefully guarded her liberty of action at Muscat. When the English obtained a coaling station and kept a warship there almost continually, for the purpose of prohibiting all foreign influence from restraining them, France thought that it was time to affirm her rights and to act, if she did not wish to see the Persian Gulf turned into an English lake. Thereupon she created a consulate at Muscat, and appointed as consul M. Ottavi, who had rendered her great services at Zanzibar as consul. Then French

The fort of Muscat is extensive, and its situation at the extreme end of Arabia, opposite India, and at the entrance to the Persian Gulf, has made it at all times a natural emporium between India, Arabia, and Persia.

It is an excellent advantage for the French nation to have a place in which to recoat at the very doors of Muscat. France was without a place of shelter on the Arabian Sea. In the whole Indian Ocean, from Ceylon to the Gulf of Aden, France had no port except Obock on the African coast and Mahé on the Asiatic coast.

In the upper Indian Ocean French vessels had no place to put into for refuge, but now a third point has been acquired. This is an advantage, but a small one, because of the power of the English in this part of the world.

The fact that a port is henceforth officially open to France in Oman should be of great interest to French sea captains and commercial men who have already turned their attention toward Africa and gone as far as Obock and Abyssinia. Parallel to the Red Sea, the Persian Gulf opens for them a district which should be looked into.

Oman is the country of importation and exportation in the great trade with Bombay, Calcutta, Zanzibar, etc. The English carry on a great deal of business there, and the Germans are beginning to enter it. From the point of view of colonial achievement, Oman is also a country of the future. Everything has yet to be organized and to be accomplished in this region, which was so flourishing and is yet to become so again. The country is, with its numerous oases, like a fairyland. At the end of the Gulf of Bassorah stands Muscat. You have entered well into the country of the "Arabian Nights." The bad genii have cast a spell over Oman, but a prince must come from over the sea "on a horse of bronze" to awaken the enchanted earth from the spell.

This at least is what the Sultan, who loves legends, told the English consul one day, and the latter replied that the horses of bronze to-day are the English armorclads and the expected prince is the Prince of Wales.—*L'Illustration*.

THE ELECTRIC LIGHT BATH.

DR. J. H. KELLOGG in a paper read at the last meeting of the American Medical Association, and just pub-

lished in the journal of that body, calls attention to the electric light bath as a means of applying heat to the body as a therapeutic agent. He refers to a previous paper read by him at a meeting of the American Electro-Therapeutic Association, in which experiments were mentioned and comparisons made of the effects obtained with those of the Turkish and Russian baths. The general conclusions were as follows: (1) The electric light bath stimulates the elimination of carbon dioxide in a very marked degree. In a bath lasting thirty minutes, the percentage of elimination of the dioxide during the last ten minutes was 5.13, as compared with 3.60, the average elimination before the bath. In a Russian bath the percentage of elimination was 3.96; in a Turkish bath of thirty minutes' duration, 4.01. (2) The elimination of nitrogenous wastes, represented by urea, and also the elimination of total solids, was greatest in the Russian bath and least in the electric light bath, doubtless the result of excessive skin activity. (3) The amount of perspiration produced by the electric light bath was fully double that induced by the Turkish bath in the same length of time. The time required for the first appearance of perspiration was in the electric light bath about one-half that in the Turkish and Russian baths. The reason for this was apparent from the fact observed by Bouchad, that perspiration begins when the temperature of the blood has risen 0.7° F. above the normal.

The author in again calling attention to the subject says that he does not consider that there is any specific effect obtainable from the electric light which would not be derived from any equally efficient source of radiant heat, and on this account he would prefer to use the term radiant heat bath rather than electric light bath, as the former term leaves room for the employment of any luminous source of heat which may possess properties identical with those of the electric light. A number of forms of apparatus are figured in the article, showing how the ordinary incandescent bulbs are arranged to produce the desired results. "In auto-intoxication," says the author, "the electric light bath is particularly helpful, as it not only stimulates elimination through the skin, but by penetrating the tissues, stimulates the process of oxidation, whereby toxins and waste matters are prepared for elimination."

"By accomplishing the results required of it in so

short a space of time, the electric light bath is comparatively free from the exhausting effects which often result from the Turkish bath, the hot immersion bath and other modes of inducing perspiration. In the treatment of rheumatic diathesis there is no agent which so promptly affords relief as the electric light bath, since it adds to the powerful eliminative effects of heat the soothing influence of light upon sore muscles and joints. In obesity, likewise, the electric light bath proves a sovereign aid through the penetrating power of its rays, which stimulate the processes of dissimilation, while at the same time aiding the elimination of debris. Nervous headache, or migraine, now pretty generally recognized as a toxemia, yields readily to the systematic employment of the electric light bath in connection with the proper regulation of diet.

"The electric light bath enjoys the great advantage over other methods of applying heat in that it produces strong atonic effects, at the same time that it encourages powerful elimination. As a prophylactic, the electric light bath possesses a high value, especially for persons who are compelled to lead a sedentary life, such as teachers, doctors, lawyers, preachers, judges, and professional men generally, and to a still greater degree by the majority of women, and which necessarily results sooner or later in disease and premature death from the accumulation within the body of those poisons which are destroyed or thrown off through active exercise in the open air. The electric light bath is the best of all substitutes for muscular activity; for persons whose business necessarily keeps them confined indoors, it is the most invaluable means of maintaining sound health. . . . In this country a vast number of people, especially dwellers in cities, are daily suffering from the deteriorating influence of a sedentary life, to whom the electric light bath, combined with a cold shower bath, would prove an inestimable boon."

In conclusion, he says: "After having employed this bath in several thousand cases, I feel justified in urgently inviting the attention of the profession to test its value, and I feel sure that a study of its merits will lead to its practical application in the treatment of a great variety of chronic ailments, many of which so obstinately resist therapeutic measures."

LIQUID AIR.*

By Dr. W. HAMPSON, M.A. Oxon.

A GOOD deal of interest has lately been taken in liquid air. Connected as it is on the one hand with the refined scientific study of the properties of matter under rare and only recently attainable conditions, and on the other hand with the processes of refrigeration, which are becoming every day more important in the commercial world, there is in its production and properties plenty to attract the attention both of the student and of the business man. Its remarkable properties have lost nothing and gained a good deal every time they have been recapitulated, and in order that practical men who are not specialists in the subject may be enabled to avoid believing too much, without on the other hand rejecting too much, it will be well to make a brief statement of the facts in connection with the subject.

Those who have to do with refrigerating plant working with ammonia and carbonic acid are aware that no pressure, however great, will reduce these gases to the liquid state unless they are cooled at the same time to certain definite temperatures, about 130° C. in the case of ammonia, and about 31° C. in that of carbonic acid.

These temperatures are called the critical temperatures. Air also has its critical temperature, above which no pressure can possibly liquefy it, but in the case of air the critical temperature is very low, about -140° C. At this temperature a pressure of 39 atmospheres is required to liquefy air, but as lower temperatures are reached smaller pressures are sufficient to produce condensation, and at -191° C. air liquefies and remains liquid under normal pressure, as water does at +100° C. This temperature is, therefore, called the boiling point of liquid air, and is commonly understood when the temperature of liquid air is referred to.

It corresponds to 344° of frost on the Fahrenheit scale, and is twice as far below ordinary temperatures as boiling water is above them. In the liquid state air occupies $\frac{1}{15}$ part of its ordinary volume, or $\frac{1}{15}$ part of its volume as a vapor at its boiling point. Or, putting it in another way, if liquid air be vaporized and warmed to ordinary temperature, it will expand 800 times. Water converted into steam at its boiling point expands more than 1,700 times. The liquid is nearly colorless, and looks like water with a very pale blue tint, due to the oxygen, which is distinctly, though not strongly, blue. Its latent heat of vaporization is from 55 to 80 heat units on the Centigrade scale. It exhibits the ordinary properties of liquids, including capillarity. Inclosed in a vessel connected with a vacuum pump, it is without much difficulty cooled and frozen by reduction of temperature. The remarkable properties of the liquid and of other bodies at the same temperature are well illustrated by a number of experiments, which, with slight variations, have become familiar of late years at scientific lectures and demonstrations.

The possession of a means of readily obtaining intensely low temperatures, besides making it possible to perform many striking experiments, has greatly facilitated a special branch of scientific research, and, in consequence, it has long been a most desirable thing to make the production of extreme cold reasonably easy and economical.

Until recent years the method of producing liquid air has been very cumbrous and expensive. Those who are familiar with refrigerating apparatus will easily understand that the low temperature produced by an ammonia machine might be used, in the same way as the cooling water of the ammonia condenser, to condense a more volatile vapor, such as ethylene, in the coils of a second machine. The lower temperature produced by letting this liquid ethylene vaporize, as the ammonia does in the first machine, can be applied to the condensing coils of a third machine, in which air, compressed, and cooled by the vaporizing ethylene at a temperature of about -140° C., is thereby condensed. Of this condensed air, when it is released, a portion vaporizes, the remainder being a liquid at at-

* British Refrigeration.

THE SULTAN AND HIS HEIRS.

warships appeared on the coast of Oman at regular intervals, to salute the Sultan and assure him of France's sympathies.

The efforts of the French terminated favorably, and at the end of last year the dispatch boat "Scorpion" left for Muscat with a commission which carried to the Sultan presents from the government, and examined the coast for a place to use as a coaling station.

Our front page illustration shows the reception of the commission by His Highness Seyyid Feysal ben Tourki, the ruling sovereign of Muscat. He gave the commission a cordial welcome, and appeared greatly pleased by the presents they brought, which consisted of silks, Sevres vases, Gobelins tapestries, and gold and silver ware. The Sultan afterward visited the French ships and was high in his praises of the officers and sailors.

His Highness has all the experience of a man forty years of age who has governed a long time. He did not make any allusion as to how England stood; but he accepted events which have taken place, with the philosophical indolence so characteristic of him as an Asiatic ruler and follower of Mahomet.

The power of the Sultan extends over a population of from 1,600,000 to 1,800,000 inhabitants, and his revenues, that is to say, the revenues of the state, for he is the state, reach and even surpass \$2,400,000. He lives with some degree of pomp, consoling himself for misfortunes and regret for the ancient splendor of his empire, among his numerous children and still more numerous wives. He presented a part of his family, consisting of his sole heirs, to the commission, and our photograph shows them with him, the boy on the right being his oldest son and successor, Seyyid Feizour ben Feysal.

Muscat is situated at the end of a circular bay whose entrance is closed by an island and is bordered by red-dish precipitous rocks. These formidable rocks are topped with towers and fortifications, which, although they date only from the time of the Portuguese, render the city impregnable. All this scenery is very picturesque.

The principal fortification is the Mirami Djibali fortress, which commands the roadstead on the northwest. In the interior of the fortress is an old chapel which is a very curious specimen of the Portuguese architecture of the sixteenth century.

mospheric pressure. This is called the "cascade method." It was practically invented by Pictet, and much improved in arrangement by Olszewski, while the knowledge obtained by Cailletet of the properties of volatile but condensable gases, notably ethylene, added to the facilities for working it. A large plant, with first-class machinery, was constructed on this method at the Royal Institution, and proved the means of making liquid air enough to provide many popular displays, and thereby spread more widely a knowledge of the subject. But it will be seen from the above description that the process was very costly, involving at least three sets of powerful compressors, the same number of condensers, and a very extensive system of connections, requiring a great deal of supervision. The complication depended largely on the necessity of creating artificial cold to extract the heat of compression at the lower temperatures. Early in 1894, the present writer devised a system of producing intense cold in which all the compression heat was extracted from the gas by water at normal temperatures, and the connection between that and the low temperatures was made by an interchanger, in which the gas passed through all intervening gradations of temperature. This made a single compressor suffice, and got rid of the necessity for intermediate refrigerating agents, such as nitrous oxide and ethylene. The apparatus, as illustrated in the diagrammatic section, is made by the Brin's Oxygen Company, of 69 Horseferry Road, Westminster, the well known compressors of oxygen and coal gas, and makers of compressed gas apparatus. The apparatus is compact and neatly finished. The same firm supply compressors suitable for working it, and cylinders of direct and purified air, oxygen, or carbonic acid, to be used in the alternative method referred to below.

In the illustration the compressed air enters by the small pipe, and the expanded air leaves by the large pipe at the top of the interchanger. The expansion valve is at the lower end of the coils in the vacuum vessel which acts as a receiver, and is furnished with a spiral tube, similar to that used by Prof. Dewar for the removal of the liquid. The valve is controlled by a hand wheel at the top of the apparatus, acting through a hollow steel spindle. The receiver may be removed with its contents by unscrewing the cap beneath the concentric glass cylinders, which, by inclosing layers of still air, give additional insulation. When the liquefier is worked with a cylinder instead of a compressor, the preliminary cooling by carbonic acid is done by passing in the cold vapor directly to those parts of the coils which have to reach the lowest temperature.

This apparatus depends upon a method by which a moderate amount of refrigeration, produced by the expansion of a gas, may be accumulated and intensified till it reaches the point at which the gas used becomes liquid under atmospheric pressure. The method consists in directing all the expanded gas, immediately after its expansion, over the coils which contain the compressed gas that is on its way to the expansion point. The cold developed by expansion in the first expanded gas is thus communicated to the on-coming compressed gas, which consequently expands from, and therefore to, a lower temperature than the preceding portion. It communicates in the same way its own intensified cold to the succeeding portion of compressed gas, which in its turn is made colder, both before and after expansion, than any that had gone before. This intensification of cooling goes on until the expansion temperature is far lower than it was at starting; and if the apparatus be well arranged, the effect is so powerful that even the small amount of cooling due to the free expansion of gas through a throttle valve may be made to liquefy air without using other refrigerants.

The amount of refrigeration due to free expansion was ascertained by Joule and Thomson, and is, in the first place, proportional to the fall of pressure. Air at 0° C. is cooled 0.29 of a degree C. for every atmosphere of pressure drop. This cooling, however, increases with the descent of the temperature from which expansion takes place, and the law within the limits of observation of these experimenters is that it is inversely proportional to the square of the absolute temperature. Thus, expansion of air from 4½ atmospheres to 1, and from a temperature of 0° C., i. e., 274° absolute, gives about 1° of cooling in the air itself. But when the air expands from two-thirds of that absolute temperature, i. e., from -91° C., the cooling for the same pressure drop would be nine-fourths of 1°, or 2¼°.

The efficiency of the method depends upon the arrangement and construction of the coils and chamber forming the interchanger, in which the expanded gas takes up heat from the compressed gas. To make this action as perfect as possible, the conditions required are: Having a large surface of exposure between the compressed and expanded gases; having little thickness of material between them, and that little of high conductivity; having both compressed and expanded gas in small masses in close contact with the conducting material; having the total volume of the interchanger small, so as to expose little surface for the entrance of external heat; and having the total mass of coils and interchanger, which have to be cooled down with the gas, small and of little specific heat. These are all thermal advantages, and the arrangement of parts in the interchanger of the present apparatus is the most efficient hitherto designed for gases.

It has been attempted to obtain thermo-dynamic advantages by combining with a large difference of pressures a small ratio of pressures. This is done by expanding from the higher to an intermediate pressure, so as to have three pressures altogether. The action takes place in an interchanger of concentric spiral tubes, but at the cost of the thermal advantages named above; since the considerable intermediate pressure of gas in a pipe which incloses and is concentric with that for the high-pressure gas, and is itself inclosed in a third pipe for the low-pressure gas, necessitates great thickness and large mass of pipes, and prevents close coiling, thus increasing the size and mass of the interchanger, and diminishing the conductivity of the pipes.

In practice the thermal advantages are found to be the most important, so that the apparatus which embodies them not only liquefies air most quickly, but produces a given quantity of liquid with the smallest expenditure of power.

The apparatus is capable of working continuously with a compressor able to deliver air at a pressure of 80 atmospheres or over. It will also produce liquid from a single cylinder of air or oxygen. In the latter case the coils are previously cooled by passing over them cold vapor from a cylinder of liquid carbonic acid. The conditions of working in each case are as follows:

(1.) With a compressor.—Compression, 80 atmospheres or over; time for liquefaction of air, with 130 atmospheres, 10 minutes; time for liquefaction of air, with 120 atmospheres, 16 minutes; 150 atmospheres, 4½ minutes; indicated horse power employed, 3½; liquid air produced, 1.2 liters per hour; no preliminary refrigeration.

(2.) From a cylinder.—Preliminary cooling, cylinder of liquid carbonic acid; cylinder, oxygen, or air, up to 150 atmospheres; liquid produced, up to 225 cubic centimeters.

In both cases only one valve and one gage, requiring very little attention. The whole apparatus, including purifying cylinder, stand and connections, easily portable, and occupying two square feet of floor.

In the illustration the compressed air enters by the small pipe and the expanded air leaves by the large pipe, at the top of the interchanger. The expansion valve is at the lower end of the coils, in the vacuum vessel, which acts as a receiver. The valve is controlled by a hand wheel at the top of the apparatus, acting through a hollow steel spindle. Liquid may be with-

SECTION OF AIR LIQUEFIER.

drawn by the tap seen below the apparatus in the middle; or the receiver may be removed with its contents by unscrewing the vulcanite cap beneath the concentric glass cylinders, which, by inclosing layers of still air, give additional insulation. In the cylinder at the side of the support the compressed air from the pump passes through caustic potash, which removes moisture and carbonic acid, and so enables the apparatus to produce a clear liquid. When the liquefier is worked with a cylinder instead of a compressor, the preliminary cooling by carbonic acid is done by passing in the cold vapor to the bottom of the interchanger, whence it passes directly to those parts of the coils which have to reach the lowest temperature.

It was with the liquid supplied by one of the above machines that Prof. Ramsay last year made his interesting discoveries of hitherto unknown gases in the atmosphere, belonging to the same series as the argon previously discovered by Lord Rayleigh and himself; and by the same means he was enabled to succeed in preparing a sample of argon, as well as of neon, in the pure state, and so obtaining definite information as to their physical properties. The same self-intensive method, when employed by Prof. Dewar, made it possible at last to liquefy both hydrogen and helium.

Now comes a very interesting development. A certain Mr. Charles E. Tripler, of New York, nearly two years after the detailed and illustrated publication of the self-intensive process, completed an apparatus which is a very close copy of my form of that process, but on a very much larger scale, using a compressor of fifty horse power.

With this he has naturally been able to produce large quantities of liquid air—though not at a cheaper rate than the inventors of the process in their smaller plants. In conversations reported by writers in McClure's Magazine, of recent date, and in the Strand Magazine for April last, and copied in a number of weekly and daily periodicals, Mr. Tripler has definitely committed himself to the belief that he can make his apparatus produce without cost unlimited quantities of liquid air, to be used as a source of power.

The foundation on which all this rests is a mistake made by Mr. Tripler in the interpretation of some of his experiments with the apparatus, which he constructed on the European model—a mistake as gross and as vital as that which he had made before in his patent of 1893. In that patent he had overlooked the sensible heat due to compression, and the necessity of providing for its removal. In his recent experiments he has overlooked the latent heat given out by condensation and the necessity of providing for the removal of that heat. "We have just begun discovering things about the world," says Mr. Tripler, in his modest way. It is indeed very likely that by this time he has just begun discovering some elementary truths.

Working without this magical application, by which the liquid air is supposed to produce itself, and in the same humdrum way as myself and Dr. Linde, Mr. Tripler is able, like us, to produce liquid air at a cost, as he himself estimates, of about 10d. a gallon, or 1d. per pound. This pound, or pennyworth, of liquid air, expanding to the volume of thirteen cubic feet of air vapor at atmospheric pressure, will do a certain amount of work in an engine. Half a pound of water will also expand to thirteen cubic feet of steam at atmospheric pressure, and expanding from a smaller volume, will do more work than one pound of liquid air. But half a pound of steam, made in a good steam-raising apparatus, only costs 1½ parts of a penny. For equal quantities of power, therefore, liquid air is mathematically more than two hundred and forty times as dear as steam, and practically the difficulties of handling it will make it compare more unfavorably still.

A few instances may be quoted of the wild statements with which Mr. Tripler's promises are bolstered up: "Liquid air, costing but a trifle, has an enormously greater expansive power than steam." Weight for weight, the trifle it costs is one hundred and twenty times the cost of steam, and its enormous expansive power is half that of steam. "Enough liquid air to run a steamer across the Atlantic could be made for £50," instead of using 2,500 tons of coal at a cost of £2,500; 2,500 tons of coal can be made to raise 25,000 tons of steam, and £50 would, at Mr. Tripler's own estimate of 10d. a gallon, provide less than six tons of air-vapor from liquid air, with an expansive force not so great as that of three tons of steam. "A quart of liquid air would blow up the rock of Gibraltar. The strongest and heaviest receptacle that could be made of steel would not hold a pint of this marvelous substance hermetically sealed." Ignorance and absurdity reach their limits in this statement. A steel tube of three inches diameter, and one and four-fifths inch bore, and fourteen inches long internally, if hermetically sealed at both ends, would hold a pint of liquid air within the limits of safety for compressed gases recommended by the Home Office Committee; and a similar tube of twice the length and open at the upper end would contain a quart, which with a suitable joint could be held down by the weight of less than eight cubic yards of the Rock of Gibraltar. In face of all this American newspapers have stated that companies were being formed for the manufacture and distribution of liquid air as an agent for producing power and refrigeration.

It may be roundly stated that liquid air will never be used commercially to produce either power or refrigeration, on account of its cost. That this is so is shown by the preceding comparison with the cost of steam for power and ice for cooling. The reason why it is so can be easily made clear by comparing the process of liquefying it with that of the most economical refrigerating agent known, namely, ammonia. Ammonia can be condensed at ordinary temperatures, and the latent heat given out in its liquefaction can, consequently, be removed by the cheapest and most convenient of all cooling agents—water. The critical temperature of air is as above stated -140° C. Consequently, if we compress it with the object of liquefying it, we must provide outside the condensing coils some cooling agent which is below the temperature of -140° C. There is no natural agent to take the place of water in acting as a cooler at that low temperature, and artificial cooling agents, such as ethylene at a low pressure, or methane, can only be provided at great cost. It is, therefore, hopeless, not merely on account of practical difficulties, but on account of natural impossibilities, to make cold by means of liquid air that would even approach the economy of that made through ammonia. And power from liquid air is under the same disadvantage as compared with power from liquid ammonia, which no one has been able, in spite of many attempts, to set up as a rival to steam.

The chief use for liquid air so far has been as an instrument of great power in scientific research. The chief possibilities before it in the commercial world are for processes in which something can be gained by passing a substance through very low temperatures as a temporary condition. Thus it has been shown above that when air is liquefied, the nitrogen tends to boil off first and leave fairly pure oxygen behind. This may be made a means of extracting oxygen from the air, if care be taken that both gases be removed from the apparatus in such a way as to avoid depriving the system of any considerable quantity of the cold produced in an expensive manner. As an explosive, liquid air, either confined in strong chambers, or, after losing much of its nitrogen, ignited in presence of a combustible, is not the absurd impossibility that it is as a source of commercial cold or power. But the difficulty of deciding the right moment to fire it, when exactly the right quantity of liquid has evaporated, the large proportion inevitably wasted, and the necessity for producing it by means of steam engines, compressors, water-coolers, and interchangers, involving much nicely adjusted and controlled apparatus, at or near the place and time of its employment, make it very unlikely to compete in quarrying and blasting, and still more in fighting, with explosives of greater power, which can be comfortably prepared at leisure long before-

hand, packed and stored without loss, and discharged with certainty and exactness at the moment required. The suggested employment of liquid air as a caustic in surgical operations is a good example of the absurdities proposed by dishonesty or ignorance in order to impress the public. Even such mild cooling agents as the ether spray have to be used with great care, since there is much danger of causing mortification beyond the tissues intended to be acted upon. The last proposal reported from Mr. Tripler is to set up a large institution for reducing the bodies of the dead to the extremely low temperature of liquid air. Perhaps this is one of the least foolish of the wild ideas suggested. As an insurance against fire, a prophylactic or precautionary measure for the benefit of those who, conscious that they have spent in deceiving the public the time allotted them in this world, entertain some not unreasonable apprehensions of finding an uncomfortably high temperature in the next, such a preparatory course of liquid air cooling might seem to have some advantages.

A FEW SPIDERS AND THEIR SPINNING WORK.*

ACCORDING to the Greek myth, Arachne was transformed into a spider by Pallas Minerva because she had boasted her superiority over that goddess in the use of the distaff: hence the Greek name for spider—Arachne.

FIG. 1.—THE SPINNERETS WELL OPENED AND NEARLY CLOSED.

The classification of the various groups is based upon the web-making characteristics, and is divided into two principal groups—the sedentary spiders and the wandering spiders. The former group includes those which remain, for the most part, upon or within their webs, and take their prey by means of snares. This is further subdivided into the orbweavers, lineweavers, tubeweavers, and tunnel-weavers. From the orbweavers I will take a few examples and try to show what appear to be some of the chief characteristics of their spinning work.

The external spinning organs or spinning fingers are located under the posterior extremity of the abdomen, in most species. In some, however, they are placed a little more underneath or near the middle point of the abdomen. In the orbweaving species they consist ordinarily of six spinnerets. (Fig. 1.)

The three pairs differ somewhat in size and appearance—the middle pair being shorter and near together.

FIG. 2.—A POSTERIOR SPINNING FINGER AND INDIVIDUAL TUBES.

The posterior and anterior spinnerets have two joints; the middle are unjointed. They are movable, particularly the posterior and anterior pairs, and can be closed in upon each other until the tips touch at the spinning field. (Fig. 2.)

The spinning field is that portion of the tips and

sides of the spinnerets on which are placed the tubes out of which the silk passes. In repose the spinnerets are generally closed, but in active operation they are thrown well open.

On each spinning field is placed a number of spools or tubes which are divided into two parts, of which the base is the thicker and sometimes the longer. They

FIG. 3.—ORB DIVISIONS.

CS, central space; FZ, free zone; NZ, notched zone; H, hub; SS, spiral space; FS, foundation space.

are hollow tubes through which the delicate ducts connected with the silk glands convey the liquid silk to the surface. These groups of spinning spools are surrounded by hairs and bristles, which appear to have some important part in spinning.

Orbwebs are divided into two great groups—vertical snares and horizontal snares—while vertical snares are arranged under four subdivisions—full orb, sectoral orb, ray orb, and orb sector. (Fig. 3.)

The orb itself is further divided into the central space, the spiral space and the foundation space. The central

FIG. 4.—MESHED HUB, SHEETED HUB, AND OPEN HUB

space has three distinct parts—the hub, the notched zone, and the free zone. The hub usually corresponds in size to the length, including legs, of the spider that has woven it. The spider when waiting for its prey upon the snare is frequently, and at night generally, stretched upon this hub, and a close observation of its feet will show that the claws grasp and even draw out somewhat the lines which represent the radii continued. Every motion of the net is thus communicated by the taut lines to the sensitive feet; while the delicate hairs which cover the feet, and which are in contact with the lines, must greatly increase the sensitivity of the creature to every movement. The spider is perhaps also aided in this natural telegraphy by the short line from the spinnerets to the hub. Yet the

chief design of this habit would seem to be to hold it to its snare when it rushed after its prey, or to give a point of attachment for dropping out of the web in case of assault, and an equal advantage when it wishes to return. (Fig. 4.)

The hub may be meshed, sheeted or open. The meshed hub is wholly or partly covered by a series of irregularly shaped meshes through which may be often traced the continuation of the radii as zigzag lines. The sheeted hub is covered by a closely woven sheet of white silk. The open hub is entirely free from any spinning work and prevails largely in horizontal orbs.

The notched zone is a short series of spiral lines, usually from four to ten, immediately surrounding the hub. These spirals do not cross the radii directly, but each overlaps the radius longitudinally for a minute space at the point of crossing.

The free zone is that portion of the central space which lies between the notched zone and the spirals, and consists simply of the radii.

The use of the central space is thought to be protective. No part of it has viscid beads, and this permits the spider freer motion around the center without danger of entanglement upon the snare, and also decreases the chances of an insect's being entrapped there. Of course the further from the center the insect is entangled, the least damage necessarily ensues to the web, the longer it remains serviceable and the more easily it is mended. For the same reason the free zone may

FIG. 5.—HUB OF SPIDER WEB.

be considered protective and gives the spider the further advantage of easy access to the under part of the snare, a convenience which is sometimes important. The purpose of the notched zone is to brace and hold in position the radii before the spirals are worked in and to strengthen the web. Certain genera further strengthen the notched zone by a plain band of white silk which extends between the two radii, along the perpendicular diameter upward from the hub to the spiral space. (Fig. 5.)

Sometimes the ribbon reaches both upward and downward from the hub as a zigzag cord. This peculiarity always prevails in the genus *Acrosoma* and in our familiar and beautiful representatives of the genus *Argiope*. Some species of *Uloborus* have a similar habit, but at times throw the cord entirely around the notched space, making a series of circles. These give a strikingly beautiful appearance to the web. The graceful lines and thick, white flossy texture of the bands showing in pretty contrast.

In the construction of the web the first line laid down by the spider is the frame or foundation line. This is accomplished by the spider crawling over and upon the objects upon which it purposes to spin the snare, drawing after it a line which in many places it fastens to the surface by pressing the spinnerets for an instant to the surface thereon. When these spin-

FIG. 6.—MULTIPLE THREADS OF ATTACHMENT; SPIDER LAYING SPIRALS; CLAWS GRASPING AND DRAWING OUT LINES OF THE HUB; VISCID BEADS OF SPIRAL LINE.

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