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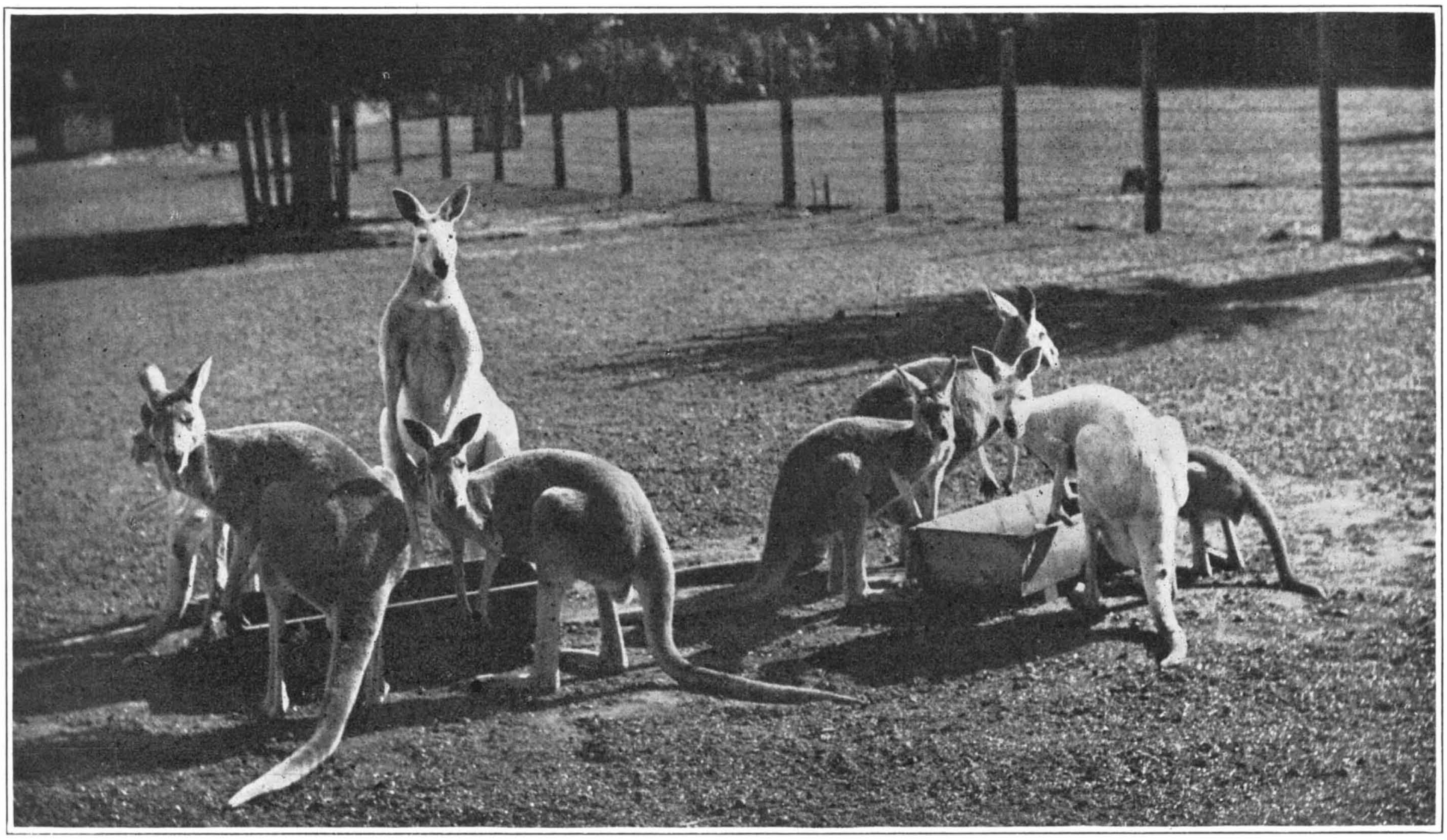
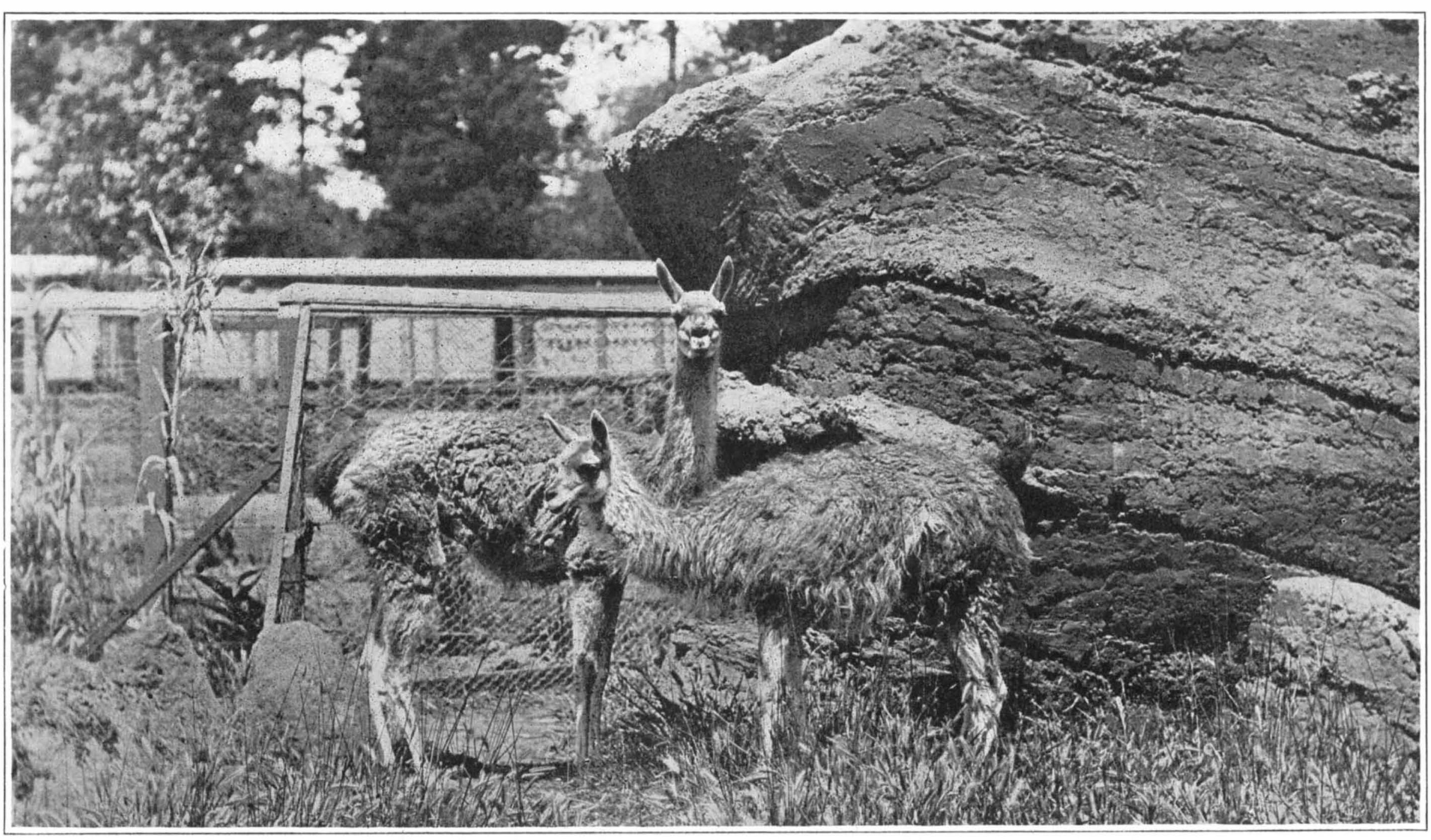


A group of red kangaroos in the Melbourne Zoo.



Picturesque Home of the Huancos.

SOME NOTED ZOOLOGICAL PARKS.—The Gardens of Melbourne.—[See page 136.]

Evolution in Shipbuilding—I*

The Wonderful Progress of the Past Century

By A. C. Holzapfel, M.I.N.A.

At the end of the Napoleonic wars, Europe was in a state of such complete exhaustion that her industries for some considerable time remained at a comparative standstill. The United States of America, which had escaped this conflagration owing to their geographical position, at that time commenced to develop a shipbuilding industry which forty or fifty years later culminated in the building of sailing vessels of a size and speed till then unprecedented. America's virgin forests readily gave the material for this industry, but the enterprise of her inhabitants, less fettered by tradition than that of Europeans, was the main cause of this rapid development.

During the same period the building of river steamers of enormous size and speed was also developed, and these were of a design hitherto unknown in Europe. With their enormous white-painted superstructures, they were the marvel of the European emigrants who entered New York Bay during the last century. Both as regards size and speed, these vessels have made little further progress. Among those I inspected on the Mississippi in 1869 were the "Robert E. Lee," then twenty years old, but still the fastest vessel on that river; and the "Great Republic," the largest. The levee at St. Louis at that time was a busy spot, covered with merchandise and workmen. When I saw it again, nearly six years ago, I was astonished to find it practically deserted, and in a state of great dilapidation, the navigation of that splendid waterway, the Mississippi, having been practically destroyed. I need hardly say that the destruction of the trade of such a magnificent waterway and the substitution of railroad transport is nothing short of a national crime.

Between 1840 and 1850 iron shipbuilding was started in England, the "John Bowes" being the first steamer of any size built of iron plates and frames. This vessel carried about 800 tons of coal, and was employed in the trade between Newcastle and London till the beginning of the present century. Other vessels rapidly followed, and England, having the most important steel and coal industry within her borders, gradually wrested the supremacy of shipbuilding and shipowning from the United States. Passenger steamers, of gradually increasing sizes, first with paddles, subsequently driven by propeller, were built, and after various disappointments the iron transatlantic steamer established herself and wrested the passenger-carrying trade from the sailers. As regards engines, appointments, and size, these vessels were extremely crude compared with those of the present day, but a great step in advance took place toward the end of the sixties, when the surface-condensing compound engine was adopted, and coal consumption reduced to about one half. In the early part of the eighties the first express steamers were built. It was the firm of John Elder & Co., Fairfield, who built the first of these vessels, and their speed went up from the former orthodox 13 knots at one bound to 17 knots. The Guion Line of Liverpool and the North German Lloyd were the first two companies to adopt this type of vessel, although the Inman Line of Liverpool had in a measure anticipated it in the "City of Rome," built at Barrow in 1879, and of a little over 15 knots speed. The North German Lloyd, however, combined in the internal fittings an amount of luxury and elegance of decoration which, from that time forward, has become practically inseparable from high-class passenger vessels.

In 1893-4 the first steel ships were also built, resulting in a considerable saving of weight. In the beginning the steel was sometimes of very unequal quality, till Lloyd's Register and other registration societies started to send their surveyors to the steel works, there to test the steel plates and bars before they were delivered to the shipbuilders. At this time also commenced a radical change in the attitude of Lloyd's Register toward the fundamental principles of construction of iron and steel ships. The original principle of construction of iron vessels was based on the practice for building wooden ships. Transverse frames were erected, and to these the plating of the ship was attached, the same as in wooden ships. Lloyd's Register depended largely on the thickness of the shell plating for the strength and rigidity of the whole structure, quite forgetting that in iron a new material had been obtained which lent itself to much greater variety in the principles of construction. During the sixties Scott Russell, an eminent engineer and naval architect, had realized this, and had proposed various methods of construction, among them that of longitudinal framing, which has now been largely put into practice under the Isherwood system. Nevertheless, Lloyd's Register insisted on an enormous weight of shell plating, and neglected to obtain rigidity from the internal frame and girder work, till in about 1883-4 it was realized, chiefly on the advocacy of many eminent shipbuilders, that the past system had involved a great waste of material and corresponding reduction in carrying capacity.

About this time it was discovered that great mistakes had also been made in the dimensions of steamers, particularly cargo or tramp steamers. The dimensions of the first cargo steamers were based on the practice of building sailing vessels. Soon after it was found that by increasing the length the speed was not materially affected, with the result that greater length was adopted, the belief being that beam reduced speed. Water ballast tanks were adopted, raising the center of gravity of a loaded vessel. Owing to the increased length superstructures were built forward, aft, and 'midship. All this added to the top weight, with the result that vessels, when laden with grain or coal cargoes, were exceedingly unstable or tender. For some time many of these ships were lost without any of the crew reaching land; then several capsized, and by the aid of other ships members of the crew were saved. At last it was realized by shipowners and shipbuilders that cargo ships, as then built, with water ballast and the usual superstructures of topgallant forecastle, bridge amidship, and poop aft, were far too narrow. At that time vessels of 33 feet beam and with the superstructures named had over 24 feet in depth of hold. At present ships of similar depths are built with 45 feet beam and upward.

About this time there was a good deal of trouble between British shipowners and the British Board of Trade about the freeboard to be allowed for various types of vessels. At that time Sir Digby Murray, a former captain of the White Star Line, was technical adviser of the British Board of Trade, and he had framed tables of freeboard to be used by the Board of Trade officers, which did not make the necessary allowances for such superstructures as raised quarter-decks, long bridges, poop, forecastle, etc. As a matter of fact, in a flush-deck vessel loaded according to his regulations, the spare buoyancy was often not over 20 per cent, while in vessels having considerable superstructures it might be more than 40 per cent. At that time, being engaged in shipowning, I was drawn into this controversy. I had ordered and built a number of steamers of identical dimensions, with raised quarter-decks, long inclosed bridge, topgallant forecastle, and hood aft, and when one of these, the "Mercia," was ready to leave the builders' hands, the Board of Trade surveyor notified my firm of the freeboard required, which exceeded that which I considered necessary by about eleven inches, and would have reduced the carrying capacity of the vessel by about 200 tons. I had based my calculations on some tables of freeboard elaborated by Mr. Benjamin Martell, then Chief Surveyor at Lloyd's, and I considered that these tables were based on better scientific principles than those used by the Board of Trade. Many shipowners at that time were in the habit of overloading their ships, from the Board of Trade point of view, and sending them out at night time when the Board of Trade surveyors were not about. Everyone protested against the requirements of the Board of Trade and many prosecutions took place. When I received notice from the builders that the Board of Trade surveyor required a freeboard 11 inches in excess of that which I had allotted, according to Martell's tables, I notified the Board of Trade of my intention to load her to the depth allowed by Martell's tables, with the result that a few days later Sir Digby Murray called at my office in Newcastle and complimented me on the frank manner in which I had approached his question, expressing the view that we should have no difficulty to come to a suitable understanding. He then proposed to make a personal inspection of the vessel, and I took him down to her loading berth, where I found all the principal Board of Trade surveyors from the different British ports—thirty-seven in number—on board. Among them I met several gentlemen I knew, and it was not long before a compromise was offered, which, however, I declined, refusing even to concede an inch or two—to which these gentlemen were at last reduced. The ship was finally loaded to the freeboard I had allotted and went to sea without being stopped. I then asked the Board of Trade why they had allowed her to go to sea, and received the reply that the vessel had loaded in brackish water, and would, on getting into salt water, rise several inches, whereupon the reduced freeboard that their advisers had agreed upon, after inspecting the vessel, would have been obtained.

In the meantime, a second vessel of the same size, the "Dalmatia," was ready, and I informed the Board of Trade that she was about to load in the lower regions of the river, where there was no brackish water, and challenged them to stop her, if so advised. She also went to sea laden down to my freeboard. Soon afterward a third vessel followed, and went to sea under similar circumstances. Immediately after she had sailed, Mr. Joseph Chamberlain, then president of the Board of Trade, issued a circular that the tables of freeboard till then used by the Board of Trade had been abolished, and that, pending the adoption of other tables, each surveyor would have to use his own discretion on the question of overloading. Soon afterward a government committee was appointed under the presidency of Sir Edward Reed, which finally adopted the Martell's Tables of Freeboard. These tables have since undergone two slight modifications, and are now in use practically throughout the world.

Into this period also falls the triple-expansion engine and the higher steam pressures. Dr. Kirk, of Glasgow, built the first triple-expansion engine for a cargo steamer of about 150 nominal horse-power. About the same time the steam yacht "Isa" was built for Mr. Hugh Andrews of Newcastle-on-Tyne, with triple-expansion engines, and in 1882 the firm of Fisher, Renwick & Co., of Newcastle, built the "Claremont," with triple-expansion engines. Mr. Alex. Taylor, their consulting engineer, published particulars showing the great economy of this type of engine, with the result that shipowners and engine builders soon afterward adopted it for all except the smallest vessels. Many compound vessels were also tripled by putting a high-pressure cylinder on top of one of the other cylinders, but this system did not give satisfaction, owing to the unequal balancing of power. Quadruple-expansion engines were also adopted soon afterward, but are now used only in vessels of considerable power. The twin-screw system also had its birth at this fruitful period of evolution, Mr. Hill, of the firm of Allan Brothers, having had the courage to build the first transatlantic steamers on this system, and he was soon followed by the Great Eastern Railway Company, which built their cross-Channel steamers on the same system. Lastly, the application of hydraulic, pneumatic and electric tools dates from this period. The pneumatics which are now almost universally adopted, and are the source of immense labor saving, emanated from the United States. The hydraulic consisted chiefly of hydraulic riveters, which were generally adopted for boiler construction. For shipbuilding, however, it proved unsuitable, as the transverse frames were in the way of a traveling hydraulic riveter. I may, perhaps, be allowed to refer here to an attempt made by myself to adopt traveling hydraulic punches and riveters for shell plating. This consisted of flanging the shell plates on all four sides, placing them into position, clamping them together, then punching the two flanges simultaneously by hydraulic punches traveling on overhead ways, and subsequently riveting the flanges together with a hydraulic riveter.

I established a small shipyard at Blackwall, near London, and fitted up a shipbuilding berth with the necessary machinery. In order to give transverse strength to the structure, I elongated the transverse flanges about 2 inches above the longitudinal flanges, and attached reverse bars to these. The plates were spaced end to middle, and being 10 feet long, I thus placed transverse bars at distances of 5 feet from one another, and attached to alternate plates. I built three barges in this manner, which gave entire satisfaction, and they were found very strong and rigid. Naturally, the cost of an experimental construction of this sort was somewhat excessive, but I am satisfied that for building barges and certain classes of vessels having very little variety in shape, this system can still be usefully applied. Unfortunately, I was unable to obtain further orders after I had built the three barges, the shipowners buying them stating that they wanted to see whether they would give satisfaction. I, therefore, decided to give up the shipyard and sell the machinery. I was associated in this business with Mr. George B. Hunter of Wallsend-on-Tyne. A year after I gave up the experiment a London firm offered me an order for thirty similar barges, but it was then too late.

* *The Shipping World.*

Into this period also falls the building of the first ocean-going tank steamers. The first tank steamers had been built in Sweden, for the firm of Noble Brothers, at Baku, and they had gone out *via* St. Petersburg, through the Neva Canal into the Volga. A considerable number of these had been trading on the Caspian Sea and the River Volga, when it was decided to also adopt this class of vessel for oversea transport of petroleum in bulk. At first several cargo tramps were converted on the Tyne, among them the "Petriana," converted by Messrs. Hawthorn, Leslie & Co. Messrs. Armstrong, Mitchell & Co. at the same time built the "Glukauf" for the German-American Petroleum Company, and the late Col. Swan took out patents in connection with this class of construction. Lloyd's Register at first refused to class this sort of vessel, but the Bureau Veritas accepted them, and after they proved a success Lloyd's also agreed to climb down and give them a class. A little later two whale-back steamers from the American Lakes crossed the Atlantic with grain cargoes to Liverpool, where they aroused considerable attention. From these the design of the turret ship was developed by Messrs. Doxford & Co., Sunderland. In this case also Lloyd's refused their class, and the Bureau Veritas stepped into the breach. Lloyd's accepted the same type a year or two afterward, although on the reading of a paper by Mr. Frank C. Goodall, describing this type, before the Institution of Naval Architects, Mr. Martell had remarked that he would humble himself before the Institution if such a vessel would ever be a success.

Other variations of type were patented, each entailing a saving in weight, and particularly a reduction in the thickness of shell plating. After the retirement of Mr. Martell the spirit of conservatism disappeared from Lloyd's Register, who are now prepared to accept any design on its merits.

With the introduction of steel ships, the question of protecting the ballast tanks under boilers impressed itself on the notice of shipowners. In iron ships the corrosion had not been very great; moreover, at the time when ships were built of iron, it was not customary to have ballast under the boiler, but simultaneously with the introduction of steel a new regulation for measuring vessels was put into force, according to which depth of hold was measured from the tank tops instead of from the floors for the purpose of ascertaining the ship's registry, provided that the vessel had a complete double bottom. In order to combine the maximum carrying capacity with the lowest possible registered tonnage, shipowners, therefore, adopted a continuous double-bottom for ballast tanks from stem to stern. It was then found that the portions under boilers very rapidly corroded, so that after three, four, or five years, most expensive repairs had to be incurred in order to make good the damage. This corrosion resulted partly from moisture and partly from the radiation of heat from the bottoms of the boilers to the tank tops and the tank itself, causing great variations of temperature. Naturally, repairs in such a cramped position were very expensive. In order to reduce this radiation, boilers were lifted considerably higher above the tank tops than before, and means of drying the space underneath by ventilation were also, in some cases, adopted. Fireproof non-conducting cement has of late been largely applied in Great Britain and Germany to these portions of the vessels under the name of heat-proof cement, and with excellent results.

It will also be of interest to refer to the substitutes for wooden sheathing on steel decks. For this, various materials were introduced about ten years ago, and I am aware that some of them have given very unsatisfactory results, as they contained corrosive substances in their compositions. I have seen decks of vessels which have been so covered, and which after a few years have been very severely pitted. Just recently Sir Archibald Denny, Bart., of Dumbarton, has, in conjunction with Mr. Anderson, a chemist, patented a material for this purpose which is alkaline and non-corrosive in character, and also possesses excellent adhesive properties, and I venture to think it will make an ideal substitute for wood sheathing on iron and steel decks.

The next important departure in connection with shipbuilding is the invention of the marine turbine by Sir Charles Parsons. This gentleman, in about 1884, built turbines for driving electric dynamos, and it was not until considerably later that the marine turbine was evolved. It must undoubtedly rank as an epoch-making invention, and has been adopted practically throughout the world for fast war and mercantile ships, but its adoption for slower vessels is only a matter of quite recent evolution. In this connection three systems were advocated: the first, mechanical gearing, perfected by Sir Charles Parsons, which is being widely used, and for which he stated some time ago that machinery representing 1,600,000 horse-power was under construction. The second method was the very clever hydraulic transformer invented by Prof. Foettinger of Danzig, Germany, which utilizes a high-speed turbine to drive a centrifugal pump, delivering water to a water turbine. By means of this apparatus, you can not only reduce and control to a nicety the revolutions of the propeller, but you can also very quickly reverse, and can, therefore, dispense with the reversing steam turbine. In June, 1914, there were transformers of about 200,000 horse-power building in Germany, chiefly for German war vessels. The loss of power of the mechanical gearing by Parsons amounts to 2 or 3 per cent, while that of the Foettinger transformer amounts to 10 to 12 per cent, according to size and speed. The greater loss of the latter instrument, however, is compensated for by the saving of the cost and weight of the reversing turbine, with the attendant drawback of having to suddenly admit steam to a cold turbine. The Foettinger transformer has also been used in connection with internal-combustion engines, and I had the privilege of ordering the first one for commercial purposes, that is, for a gas-driven vessel about which I will speak later. The third method of gearing is the electric, which has been tried on a large vessel by the United States Navy. A close competitor for the geared turbine which will undoubtedly be very popular is the heavy oil engine, with which a number of sea-going vessels, particularly tank ships, have been fitted during the last three years. The results have not, in all cases, been quite satisfactory, but sufficient experience has already been gained to enable me to say with the utmost confidence that, in some districts where heavy oil is obtainable at low prices, this type of engine is bound to displace the steam engine and steam turbine. Unfortunately for the promoters of this enterprise, the price of heavy oil rose very considerably almost immediately after public attention had been directed to this method of propulsion, and, as a consequence, many firms who would have otherwise interested themselves in it were deterred. It will no doubt take some time to again awaken their interest in this matter, and by that time probably all initial difficulties of this new type of machinery will have been overcome, and the cost of manufacture, which is at present very high, will have been reduced. The last new type of engine which has from time to time attracted attention is the marine gas engine. In the United States and Germany a number of small vessels trading on rivers and estuaries were fitted with marine gas engines and gas plants using hard coal. In Germany, Emil Capitaine advocated this method of propulsion seven or eight years ago, and installed gas engines and gas plants on a number of small vessels on the Rhine and other rivers. On the whole, his efforts were unsuccessful. An experiment on a larger scale made by Messrs. William Beardmore & Co., Dalmuir, Glasgow, was also a failure. The United States next constructed the "Carnegie," with auxiliary gas engines and gas plant. I heard of her some few months ago as being at Falmouth, England, where a friend of mine, who had some experience in gas engines, was requested to officially inspect the vessel. He told me that neither gas engine nor gas plant had been much in use, as many difficulties had manifested themselves in connection with the latter.

I also made an experiment by building a small sea-going cargo vessel of 370 tons, which I fitted with a six-cylinder gas engine of 180 horse-power and gas plant using hard coal, and instead of the usual clutch gear I used a Foettinger transformer. This vessel, called the "Holzapfel I," made twenty-two sea-going voyages with cargoes around the coast of Great Britain, Ireland, and France, but the arrangement of the gas plant on board was not suitable, so that I finally decided to take the gas engine and gas plant out, and to convert her into a steamer. A Dutch firm also built a twin-screw vessel of 600 tons, the "Seamew," with similar engines, but, so far as I can ascertain, she has not given the results which had been anticipated. Although there is a strong probability that this type of machinery may be perfected for sea-going vessels of moderate powers, there is at present, so far as I know, no one seriously occupied with the problem.

(To be concluded.)

Recent Studies of Pasteurized and Boiled Milk*

The relative resistance of raw pasteurized or boiled milk is a most important problem. The claim has been frequently made, and insisted upon, that sterilizing by boiling, or partial sterilization by pasteurization, renders milk perfectly safe. The opponents of these methods, or rather those who refuse to see any good in them, declare that while boiling and pasteurization of milk are indicated under certain circumstances, they are by no means ideal, and that while in some respects they safeguard the health of the young, in other respects they are somewhat of a delusion and a snare.

With regard to the relative resistance of raw, boiled, and pasteurized milk, Schorer has stated not long ago (*Journal of Infectious Diseases* 1912, Vol. II, p. 295) that pasteurized and inspected milk showed a greater increase in the bacterial content than certified milk. On the other hand, Ayres and Johnson, of the U. S. Department of Agriculture, Bureau of Animal Industry (*Bulletin 126*), found that the rapidity of multiplication was the same in pasteurized as in raw milk containing the same number of bacteria.

Careful experiments more recently undertaken in Cambridge University Pathological Laboratory by Lucy D. Cripps, M.B., and J. E. Purvis, and published in the *Journal of the Royal Sanitary Institute*, October, 1915, indicate that: 1. Heat renders milk a better breeding ground for such microbes as may get into it. 2. The effect of heat on the germicidal power seems to vary with the amount of heat, as indicated by the greater multiplication of bacteria in boiled than in pasteurized milk. At the same time, the decrease in the number of bacteria in the raw milk after 24 hours' incubation was remarkable, and the relative increase in the pasteurized and boiled milk was considerably less than at 2, 4 and 6 hours. Considering these results from a chemical point of view it has been definitely proved by Purvis, Brehant and McHattie that when milk is boiled, definite amounts of proteids, phosphates and fat are thrown out of solution, and it may be surmised that such changes indicate other definite chemical changes which make the constituents of milk more suitable for the growth of micro-organisms. Further, it is well known that the enzymes of milk undergo definite changes by heat, and, in fact, are destroyed when milk is boiled. It may be that these enzymes are responsible for the germicidal power of raw milk, whereas in boiled milk they are absent because they have been destroyed; or again, it has been suggested that the destruction of the lactic acid bacillus by pasteurization facilitates the growth of undesirable bacilli; finally, where there is a mixture of saphrophytic and pathogenic bacteria, the condition of raw milk favors the growth of the saprophytic type rather than of the pathogenic.

But whatever may be the cause of the relative resistance to infection of raw and boiled milk, the experiments clearly show that there is more danger of reinfecting boiled and pasteurized than raw milk, and that, therefore, milk should be used as soon as possible after it has been pasteurized or boiled. This conclusion is strengthened when the unsatisfactory condition of the great bulk of the milk supply is considered, and the great possibility of the contamination of the milk in the houses of consumers, especially where the housing conditions are bad, and where there is a lack of knowledge of the principles of hygiene.

As has been emphasized time and again in the editorial pages of this journal, pasteurization of milk is at best but an alternative, necessary no doubt under existing conditions, but, alas, all too often liable to abuse. By insisting for pasteurization that it adequately protects the milk so treated, too much is claimed. Indeed, it does not protect the milk from future contamination or infection at all, but rather renders it more liable to subsequent infection. Further, a feeling of confidence is created in the pasteurized product which is far from warranted, as has been demonstrated by the experiments of Cripps and Purvis. Such milk is too often a menace to the general public and especially a fruitful source of danger to infants.

Pasteurization to be effective must be performed properly and scientifically and the milk thereafter handled with the utmost care. Pasteurized milk carelessly handled in transportation or in the homes of the poor quickly collects bacteria and becomes highly dangerous to health. The problem of a fairly safe milk supply is still far from being successfully solved. The difficulties in the way of such a solution appear to be almost insurmountable, but much can be done in this direction by an energetic and efficient board of health. The Health Department of New York has accomplished more to ensure a safe milk supply than the health boards of any other city in the world, and its work should serve as an example for all health departments. It is not the intention of this article to decry pasteurization of milk, but simply to sound a note of warning. The method when correctly carried out is, under present conditions, extremely valuable, and in some instances, perhaps, absolutely essential, but at the same time it would be idle to pretend that it is a panacea and that by its employment the whole question of a safe milk supply is settled or that an ideal food for the young is provided. Pasteurization is effective in proportion to the manner in *which* it is done and *when* it is done, and even then it cannot be regarded as an entirely satisfactory substitute for mothers' milk.

* *American Medicine.*

Non-Porous Alloy Castings

When castings of bronze alloys, especially those made by pressure castings are required to be particularly "close," or dense, to reduce their porosity, it is customary to add lead to the mixture. Too much lead reduces the strength of the metal, but cases of valves are cited that have 3 per cent lead, with a tensile strength of 30,000 pounds.

Aerial Torpedoes*

Old Devices That Have Been Revived During the Present War

The name "aerial torpedo" is being applied more and more to the explosive shells thrown by the trench mortars, as distinguished from the shells fired by regular heavy artillery. The former are projected to a short distance by a special gun, and are furnished with devices that will ensure their fall point down, while the others maintain direction by their rapid rotation, due to the rifling of the cannon; but neither one nor the other resembles the submarine torpedo. There is between these classes a fundamental difference—the former are not self-propelling.

They are, it is true, so contrived that the point lies always in the trajectory. This direction is assured by fins, or wings or tails, an example being the grenade of Feuillette. This inventor, after having developed, by his ingenious machines, the linen industry of France, occupied himself with the war. He has been able to shoot from guns, and without injury to the projectiles, some very destructive grenades. But first, recognition is due to Gen. Dumézil for having so fortunately remodeled the old Moison form of mortar, having brought into use bombs with wings, and having really created trench cannon. First of all the cannon had no platforms and the recoil was a brutal one. This kind of gun has now a platform, and means of pointing. To-day its range is precise. Distances of 300, 600, 800 and even 1,600 meters have been attained with bombs weighing 16 to 45 kilogrammes, and charged with 7 to 23 kilogrammes of explosive. The guns of 58 millimeters have required reinforcement, however, to carry the larger projectiles.

Old pieces of artillery have been modified, such as howitzers of 15 centimeters, which will carry only up to 130 meters, and the old Moison gun, which will project its horned bombs (Fig. 4) of 16 kilogrammes to 400 meters. The most powerful of the existing guns is the

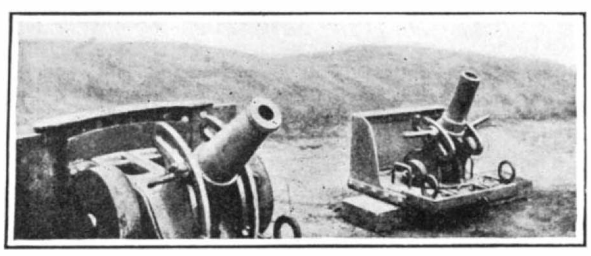


Fig. 2.—Trench mortar of 58 millimeters.

80-millimeter gun, which will project bombs of 58 to 78 kilogrammes, or even larger ones of 105 kilogrammes (Fig. 5). This branch of artillery is still being developed, and its accomplishments have been shown in surprises.

All these guns are muzzle-loaders. The direction of the projectile is assured by the stem, which enters into the bore of the cannon to receive the impulse of the explosion, and by tails, which in form are suggestive of those of Japanese firework bombs. Thanks to these tails the bombs fall vertically on the point of the fuse, which works instantly or with pre-determined delay, according to the nature of the obstacle or the work to be performed.

But once discharged from the gun, these projectiles obey gravity and submit to the resistance of the air without the power of self-propulsion, which marine torpedoes possess. Fulton is responsible for this term torpedo, and he applied it to mines to be driven against the hulls of ships, using in the first instance springs and clockwork. Everyone knows of the development of the marine torpedoes and of their destructive power. Very lately attempts have been made to direct them with Hertzian waves. Perhaps, in the future, it may be necessary merely to install a magnet or a solenoid which will steer the torpedo to the armored ship or submarine, as soon as it shall have entered within the field of attraction of the ship, no matter what might be its evolutions. All of this is testimony to the flexibility of self-moving torpedoes.

Originally the word torpedo was used to designate contact mines or other forms, in the discharge of which was to be found the fitness of the appellation, since the torpedo, flat on the bottom of the sea, secures its prey or defends itself by a sharp shock of electricity.

A number of times the idea has been conceived of a projectile which once discharged would propel itself after the manner of the firework rockets. But the only actual torpedo of the kind that ever existed was the "rocket-bullet," which was tried out at Vincennes in 1863. In this the projectile, of the usual Gothic lines of the common shell, carried within its base a cylinder filled with an inflammable mixture and carrying a fuse.

* From *La Nature*.

The shell was discharged in the usual way from a rifled gun, the fuse became ignited at the time of discharge, and when the shell began to flag through the influence of gravity and the resistance of the air new life was given to it by the burning mixture. This projectile gave rise to great hopes, for it was expected to add to the

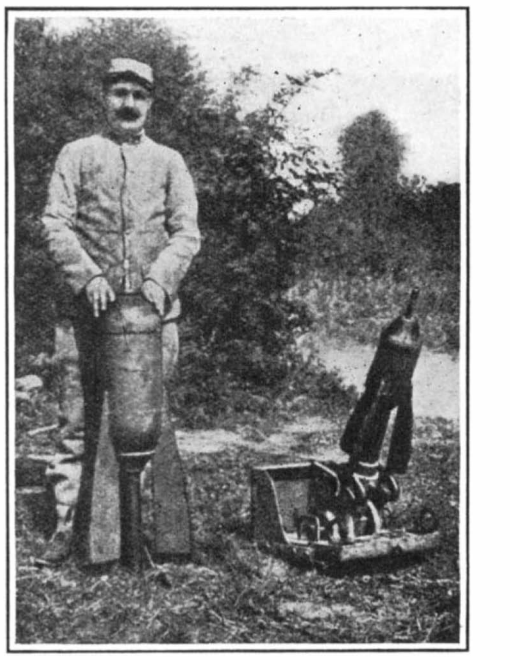


Fig. 1.—The two forms of bombs for 58-millimeter trench mortar.

advantages of rifling, those of maintaining speed, and the name given to it was "projectile de l'Empereur." Although these hopes were not fulfilled the gun did good work in the trenches, being light in form, and serviceable. But for great range of several kilometers, of which there had been dreams, it was unsuccessful, for with heavy charges the propelling mixture was ignited as the shell left the cannon instead of at a distance.

In actual practice at the present time, the only aerial torpedoes in use are the rockets. Several thousand of these, named after Nicolardot, an officer of artillery, who, in October last, developed them, and brought into use

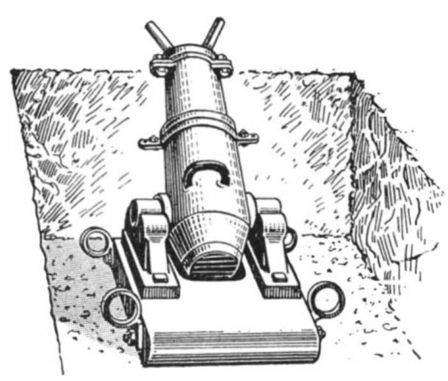


Fig. 4.—Moison mortar with horned bomb.

the first efficient weapon against the trenches, have already been discharged.

The rocket is an engine of war which had its days of glory before the cannon was used, inasmuch as the Greeks of the Byzantine Empire employed it. It is a self-moving projectile like the torpedo, but it differs in that it is its own projector and requires no mortar. Like a rocket it has body, head, and tail, or stick, and to fire it there is needed only a trough or tube or inclined table to give it direction.

The body of the rocket may be of paper or of thin sheet metal, and contains what may be termed a "fizzing"

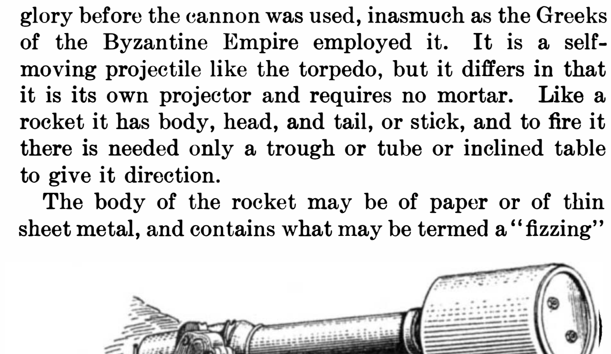


Fig. 5.—Eighty-millimeter mortar with bomb of 105 kilogrammes.

compound of the nature of black powder—nitrate of potash, sulphur and charcoal, in the proportions of six, one and one, an old formula of powder makers. The powder was used originally in a pulverized form, and experiments of the last century caused the manufacturers to grade it in larger or smaller grains according to the desired velocity. Fig. 9 shows the rocket to be similar in form to those used for firework displays. If very large rockets should be needed in the future, drawn-metal shells with no joints may be necessary.

On loading the rocket a spindle (Fig. 6) is first placed at the bottom of the body, its office being to control the vents through which the gases escape which propel the rocket.

For convenience, especially with paper bodies, these are held in a strong mold while charging. The operation is like that of the old-fashioned musket, the powder is poured in with a special form of scoop (Fig. 7), and is tamped with a special form of ramrod (Fig. 8). This is generally of bronze, has a cavity to correspond with the form of the spindle and carries in its head a wooden block to soften the shock when the ramming is done by blows of some instrument like a hammer. There is some real danger in thi old way of proceeding that may be avoided by the use of finer powder and hydraulic charging, which is more certain, quicker and more regular.

The charge in the body of the rocket is the propelling force, and when it has burned, the projectile moves through its inertia. As in sky-rockets, the fire is then continued to the head, the charge of which may be a

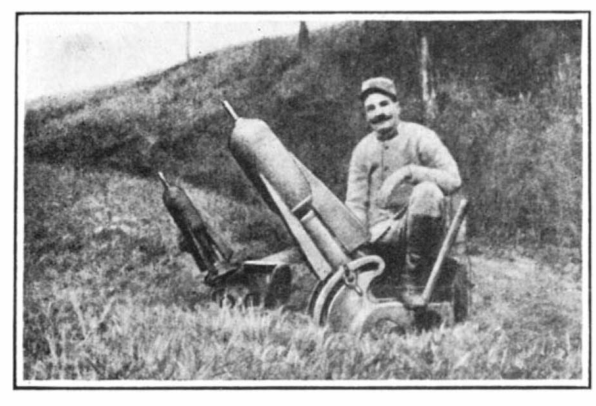


Fig. 3.—Trench cannon of 58 millimeters ready to project a 45-kilogramme Dumézil bomb.

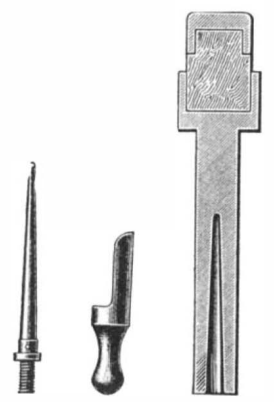
brilliant light suspended by a parachute which slowly lets it descend, an incendiary fire or an explosive mass. The fire is communicated by a fuse to a little charge of powder which disengages the parachute from the falling rocket or throws out the fire or the bombs.

The rocket having been finished by the insertion of proper wads above the powder, wicks of tow are led from all points to the bottom and tied together in a knot convenient for lighting.

To guide it through the air the rocket should have a proper stick, which must be light and yet present considerable surface. Fig. 9 shows the convenient arrangement. The rocket may be placed on some special kind of horse to discharge it. Capt. Rouge, who in the last century was studying rockets, devised a number of ways of launching them. If they are fired in volleys, an excellent method on account of the comparative lack of precision in aining, the box in which they came, and its cover, may be inclined and used, but when fired single, and precision is desired, a tube on a tripod (Fig. 10) is found convenient.

In warfare it is important that the source of the rockets be not actually disclosed, and that the horse or outfit for discharging and directing them be very portable and possible to carry to any of the trenches. The rocket presents a number of advantages, lightness of apparatus for quantity of explosive carried, this being even as much as several kilogrammes, facility of use and comparatively slight cost. It has the disadvantage of disclosing its source if fired in the daytime, especially in calm weather. For that reason it is better at night and in volleys, especially to surprise sentry posts or groups of workmen. It is possible even to the moment of firing to determine their purpose whether for signals or for illumination.

Rockets are subject to certain kinds of accidents, due to the pressure of gas, which may break them apart or explode them prematurely. In the former case, not infrequently, the body is thrown backward while the head is driven forward. Such an accident is due, perhaps, to irregular packing of the powder, cracking of the charge on account of some shock, either of which will give opportunity for irregular and sudden increase in pressure of the gas, or from obstruction of the vent-holes in the base



6 7 8

Fig. 6.—The spindle.

Fig. 7.—The scoop.

Fig. 8.—The ramrod.

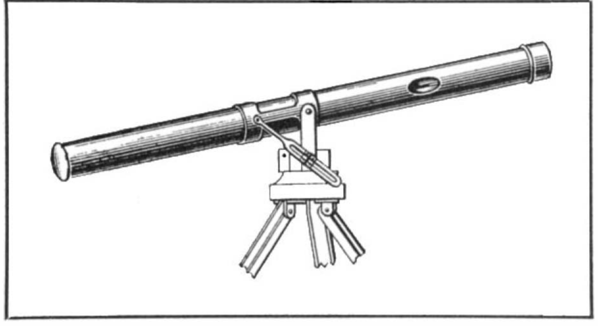


Fig. 10.—Tripod tube for firing rockets.

of the body or dampness and other causes. Such accidents in actual war are of no great moment. There is generally no real danger to the firers, because they are behind the trench walls, and such devices are of necessity fired from the first row of trenches. There is danger only if the range is such that the rocket can change its direction and return among its firers.

As soon as rifling of cannon was invented —and this dates from 1742—experimenters have sought to give a rotary movement to the rocket. The earlier efforts by modifying the shape of the stick resulted in what might have been predicted, unexpected antics of the firework in directions not prescribed. One of the succeeding efforts was to impart a motion of rotation to a rocket without stick by the Barker's mill principle, in which the gas was made to escape from the body through helicoidal vents, and, as in shells, the attempt has been made to give them rotation by outside mechanical means. But after all, for the short distances necessary and at night the present precision is sufficient and their effect much more than transitory. Fig. 11 presents the old form of rocket of 12 centimeters body carrying a bomb of 22 centimeters. Sir William Congreve invented a war rocket about 1805 which was successfully used for many years.

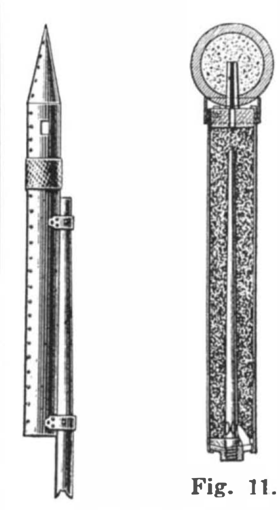


Fig. 11.

Fig. 11.—Rocket of 12 centimeters armed with bomb of 22 centimeters.

Fig. 9.—Rocket with stick.

Hints on Judging Diamonds

The quality of polished precious stones, especially of diamonds, is unfavorably affected by faults which in general lie within three categories. First, there are inclusions of foreign minerals, which in diamonds are usually coal or graphite, which were formed before or during crystallization and were enclosed with the stone. When they can be seen with the naked eye, these inclusions are designated "sand," but when discernible only through the microscope, they are termed "dust." Such "dust" forms "clouds," and these hurt the transparency and the color. If the microscopic inclusions appear in streaks or silky, shimmering layers, they are called "flags." A second fault lies in gas or moisture pores. These also cause clouding, or "flags," but they may have the further effect of giving to the interior of the stone a porous appearance that is very noticeable through the microscope on account of reflection or irradiation of light. Then, third, there are small fissures called "feathers," which cause an iridescence in the interior of the stone.

In purchasing diamonds one should always make use of the microscope, not the magnifying glass of the jeweler, but one of a power of ten to twenty, for then one can find faults in inclusions, polishing, etc., even with stones advertised as microscopically pure.

As is self-evident, the value of a diamond depends upon its weight. The determination of weight is difficult when it is in its setting. Prof. August Rosiwal[1] has made up from his own measurements a table of sizes for small stones which is given with this article. From the table it is possible to determine weight by measurement. Cut stones of the same form are similar solids, and their weights will therefore be as the cubes of their corresponding sides.

This simple proposition in geometry serves to establish relationships, the stone of twice the diameter having eight times the weight, and with a millimeter scale and a microscope it will be possible for the layman to determine the diameter of a stone to within a tenth of a millimeter. With the four-cornered stone, take the mean between the square side and the diagonal, which is approximately correct. The diameters of the Rosiwal table are intended for medium high crowns. Low crown stones, weights being equal, will be about 2 to 3 per cent greater than indicated in the table, while high crowns will be about the same amount less. With stones below one quarter carat this hardly comes into consideration.

The scond factor to value is quality, and is the result of purity or color. Diamonds as commercial products are divided into several grades in point of quality, and these grades are generally denominated first, second and third water.

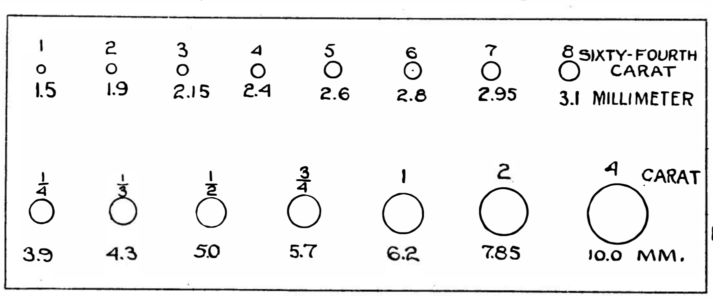
A diamond of the first water must be entirely colorless and transparent, without any inclusion or flaw; it is of the second water if it is colorless with small but unimportant faults, or if it is without faults but with some traces of color, and third water if it is colorless but with larger faults, or if it is distinctly colored. The correct valuation is therefore very difficult and often subject to the jeweler's judgment. For this reason Prof. Rosiwal gives to the layman the following hints: Stones of the first water are carried only by the highest class jewelers. The requisite is perfect lack of color, or what is more highly prized, a tinge of blue. In general, beautifully colored diamonds command fabulous prices and are to be found only in the treasure vaults of princes.

Stones of the second water are numerous. They are supposed to be microscopically pure, but almost always show some inclusions.

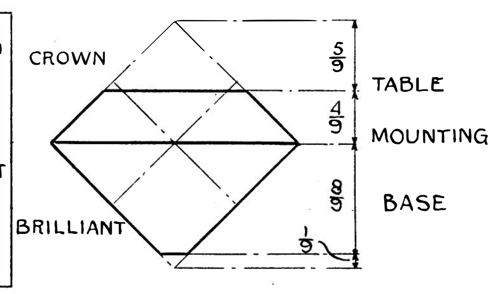
There are oftentimes traces of yellow color in this grade, and because this can be seen best in sunlight, one should never buy diamonds at night, for the prevailing lights cause stones that are even noticeably yellowish to appear clear. Most of the stones of the ordinary market are of the third quality, and the dealers try to cover up their faults by combining them into groups for border stones or for the popular pendants, diamond hearts, marquise rings, etc. While they may be colorless, they are often so full of flaws that they would be ranked as "bort," or diamonds good only for mechanical purposes, if there had not been such a demand for the gems as to increase the price.

An effort to standardize the value of diamonds was made thirty years ago, and for stones of the different waters up to three carats the proportions were set, first water, 100; second water, 83, and third water, 66. To-day, thanks to the demand for jewels by America, the first water has risen to some three times that ratio. The European prices for a one-carat stone are from \$400 to \$600 (\$110 in 1878) and \$250 and \$200 for inferior stones. Trimming stones that are quite small—under one eighth carat—bring from their commonness perhaps \$100 a carat.

In this country the prices are somewhat higher, diamonds of the first water going up to nearly \$800 a carat. In this country also for a year or more the weighing has been by "hundredths," one hundred hundredths being equivalent to a carat.



Small diamonds, four fifths actual size (after Prof. Rosiwal).



Section of brilliant cutting.

* From *Prometheus*.

[1] "Uber edler Steiner," vol. LIV. Schriften des Vereins zur Verbreitung Naturwissenschaflicher Kenntnisse in Wien.

The Spiders in Flowers

The Thomisidae or crab spiders have acquired the habit of frequenting flowers for the purpose of preying on the insect visitors. They usually lurk in thrysoid or dense clusters of small flowers like the inflorescences of sumac (*Rhus*), meadow sweet (*Spiraea salicifolia*), elderberry (*Sambucus*), *Viburnum*, *Cornus*, and the bristly sarsaparilla (*Aralia hispida*), though they are also found on large individual flowers as the rose. The commonest species of this family is *Misumena vitia*, a white spider with a crimson stripe on each side of the abdomen. It is quite common, but its color will often cause it to be overlooked until a dead insect is noticed lying upon the surface of the inflorescence. Mr. J. H. Emerton informs me that this species and also *M. aletaria* may be either white or yellow and the pink stripes on the sides of *M. vatia* may be either present or absent. Another species, he further states, has red markings and sometimes exactly resembles the sorrel (*Rumex acetosella*).

Misumena does not spin a web, but conceals itself among the flowers and pounces upon its unsuspecting prey while it is collecting pollen or nectar. On the 16th day of July I had the opportunity to observe the capture of a bumblebee which was gathering pollen on a wild rose (*Rosa lucida*). My attention was for a moment diverted, but was recalled by the loud buzzing of the bee. The spider had leaped upon its back and grasped it with its mandibles just behind the head. At first the bumblebee struggled violently, but so virulent was the poison that its movements speedily ceased entirely. The spider then dragged it over the edge of the flower to the leaves where it dined at leisure.

The temerity and success with which the Thomisidae attack large butterflies, dragonflies, and stinging insects, as wasps, bumblebees, and honeybees, is astonishing. Honeybees are often captured, and large flies belonging to the genera *Archytas* and *Therioplectes*, and rarely the wasp *Vespa Germanica*. In one case I observed that a small butterfly, *Melitaea tharos*, had been taken. From Framingham, Mass., I have received from Mr. C. A. Frost a number of very interesting specimens, together in each instance with the spider by which it was killed. The dragonfly (*Celithemis eponina*), the large butterfly, *Papilio asterias*, and the smaller species, *Colias philodice*, were captured by *Misumena vatia*, and the fly, *Desmometopa latipes*, the wasp, *Vespa Germanica*, and the copper butterfly, *Chrysophanus Americanus*, were captured by *M. aletaria*. It is difficult to understand why the spiders were not carried away by such strong-winged insects as the dragonfly and the large butterfly, which so greatly surpass them in size and strength.

The habit of resorting to flowers to capture anthophilous insects and the protective resemblance of coloration must have been acquired by the Thomisidae in comparatively recent times—that is, since the evolution of flowers and the development of anthophily among insects. The new habit would seem to be the result of observation and experience.—*John H. Lovell*, in the *Canadian Entomologist*.

A Chimney Periscope

The men in the fire room of a factory cannot always tell, without going outside to look, whether the chimney is smoking, and this is important, both as a matter of economy in burning the coal, and also to enable them to conform with smoke regulations. A writer in *Power* suggests placing a mirror outside the building and setting it at such an angle that the men, looking out of the window, can see the reflection of the top of the stack in the mirror. In some cases, where one mirror cannot be properly located, two might be used for the purpose.

School-Spread of Contagious Disease*

A Source of Epidemics That is Neglected by Officials and Physicians

By Myer Solis-Cohen, M.D.

The complacency with which physicians and public health officials regard the prevalence of the minor contagious diseases, and even sometimes of scarlet fever and diphtheria, is a matter for wonder if not for shame in this enlightened day of preventive medicine. So great is the helplessness and pessimism of most sanitarians as to our ability to limit the spread of the minor contagious diseases, that they make no serious attempt to study how to control it. At the same time they very properly regard as a disgrace the occurrence of a single case of typhoid fever, because they recognize that it can and should be prevented. If some of our statisticians would only show us the monetary loss caused by measles alone, as they have shown us in the case of tuberculosis, perhaps we might realize that it also is a disease whose prevention is worthy of consideration. The number of deaths from measles, or from its complication—pneumonia—is fairly well known. Some have even estimated the frequency of another of its complications—otitis media, which often goes on to mastoid disease, operation, and death. The cost in loss of services through death and disability and the actual expense of physicians, surgeon, nurse, hospital, undertaker, etc., can be calculated without difficulty. Another economic loss, which no one seems to realize, is the frequent failure of promotion owing to a five weeks' absence from school when a secondary case occurs in a house, especially should a second absence from a minor contagious disease occur during the same term. This loss of a year's schooling means that one begins one's life's work either a year later or with less education than would otherwise have been the case. The resultant loss in efficiency expressed in dollars would reach a very high figure.

It is, of course, true that by various restrictive public health measures and by medical inspection of public schools an attempt is made to limit the spread of the minor communicable diseases. But when all this fails to prevent widespread epidemics, no one seems very much disturbed or makes any serious effort to study why our present measures fail.

The school has always held an important place among the recognized sources of contagion, but I doubt if many realize how great a factor it really is in the spread of contagious disease. There can be little question that the vast majority of minor contagious diseases are contracted in school. A study of an epidemic in a classroom or in a school or in a city will show that the disease spreads from child to child in a room, from room to room in a school, from school to school in a city. And I am firmly convinced that an epidemic can be checked in a room, checked in a school, and checked in a city. In my papers on "Latent Diphtheria, a Public Health Problem,"[1] and "Diphtheria Carriers; Their Isolation and Control,"[2] I showed how diphtheria spreads in schools, institutions, and dwellings, and how it can be checked. In a more recent paper, "Reporting of Suspicious Cases by the Laity a Prerequisite to the Efficient Control of Communicable Disease,"[3] read before this section two years ago, I described several epidemics of scarlet fever, showing how they originated in unrecognized cases. Dr. Walter N. Roach of Philadelphia, in a paper on "The Rôle of the School in the Spread of Scarlet Fever," presented a diagram map tracing twenty-two cases of scarlet fever to one school of eighteen hundred pupils, although many of the infected children lived at some distance from this school and nearer four other schools with forty-five hundred pupils, not one of whom developed scarlet fever.[4]

Study of a Measles Epidemic.—To show how the minor disease spread, I have made a study of the epidemic of measles that occurred in Philadelphia during the fall of 1910, the winter of 1910-1911 and the spring of 1911. The records show that the epidemic began —not throughout the city with the opening of schools —but in the week ending October 15th, 1910, in one ward, spreading two weeks later to a contiguous ward, and three weeks later to another contiguous ward. During that week twenty-four cases were reported from three contiguous wards and only fifteen cases from the rest of the city. The next week this area extended, four contiguous wards having thirty-seven cases and the rest of the city having twenty-seven. The following week ninety-seven cases were reported from six contiguous wards; sixty-two from the ward where the epidemic started, while throughout the rest of the city there were forty-eight cases. Of the one hundred and fifty-six cases reported the next week, eighty-eight were from these same six wards, thirty from the original one and twenty-nine from one next to it. The epidemic was also beginning to spread to other parts of the city, two wards some distance away having eight and nine cases respectively, and one a little nearer having eight cases. The next week the six original wards and four other contiguous wards had a total of ninety-five cases. Included in the latter was one of the three wards to which the epidemic had spread the previous week. Another had a total of forty-nine cases, while from the third and from four wards adjacent to it thirty-two cases were reported. From the other thirty-one wards only forty-seven cases were reported. The original ward and six adjacent wards had one hundred and six cases the following week, and three wards in the second focus of infection had seventeen cases. There were seven cases this week, however, in a West Philadelphia ward, separated by the Schuylkill River from the original ward, and seven and nine cases, respectively, in two wards adjacent to it. The rest of the city had only forty-one cases. Two weeks later the original focus, now comprising nine wards, had one hundred and thirty-eight cases, the second focus of six wards had fifty-two cases, and the West Philadelphia focus of three wards directly west of the original ward had a total of fifty-three cases. A spread to the territory east of the original focus and north of the second focus was now beginning, thirty-two cases being reported from three wards in this section. There was a general increase also throughout the city, seventy-nine cases being reported from the remaining twenty-six wards. The spread then increased in the second focus of infection and in West Philadelphia and in the northeast section. At the end of four weeks there were one hundred and fifty-six new cases in the original area, now comprising ten contiguous wards, sixty-two cases in four contiguous wards at the second focus, which had spread to half the southern section of the city, seventy-two in the three West Philadelphia wards, and seventeen in two wards below them, and one hundred and nineteen new cases in eight wards east and northeast of the original focus. The epidemic had also spread to the northern section of the city, forty-four cases being reported from two wards. The other eighteen wards had a total of forty-two new cases. At the end of another four weeks only one case was reported from the original ward, although eighty-nine cases were reported from five contiguous wards above it. The second focus included nearly the whole southern section of the city, ninety-five cases being reported from nine wards. One hundred and sixteen cases were reported from six contiguous wards on the eastern boundary of the original area, eighty-five cases from the five West Philadelphia wards, and seventy from the two wards bounding the original area on the north. Sixty-two cases were reported from the other nineteen wards. Four weeks later the epidemic was diminishing in the original area, except at the northern end, where three wards had a total of ninety-three new cases. The second focus had spread in its southern section, five wards having a total of one hundred and three new cases. One hundred and forty-seven cases were reported this week from West Philadelphia, one hundred and fifty-two cases from seven northeastern wards, and one hundred and forty-four cases from four northern wards. One hundred and two cases were reported from the other twenty-three wards. At the end of another month the epidemic had partially left the section where it had begun. Four contiguous wards to the north and northeast of it had a total of one hundred and eighteen new cases. There was a decline in the wards on the eastern boundary of the primary district, but nine contiguous wards to the east and north of these had one hundred and fifty cases. The second focus now included nine contiguous wards in South Philadelphia, which had a total of one hundred and sixty cases. One hundred and sixty-nine cases were reported from West Philadelphia this week. The other twenty wards had a combined total of seventy cases. The epidemic then began to diminish, there being a drop of about a hundred and fifty cases during each of the next two weeks, of about a hundred cases the following week, and of about ninety the week after. During this week ending May 27th, 1911, four contiguous wards in South Philadelphia had a total of thirty cases, four of the West Philadelphia wards had sixty-nine cases, four contiguous wards in the northeast had a total of fifty-nine cases, one ward in the northwest had thirty-one cases, and the ward where the epidemic began had ten cases. The remaining thirty-three wards had in all but eighty-nine cases. Two weeks later only two wards had more than eight cases, one in the northwest with twenty-one and one in West Philadelphia with eleven. After another fourteen days but sixty-nine cases were reported from the entire city, and a week later, that ending July 1st, this had dropped to twenty-eight.

The Rôle of the School in an Epidemic.—The course of an epidemic in being confined at its inception to a small district and then spreading by contiguity is explained by the infection of a school and the transmission of the disease by infected scholars of this school to other members of their families or to playmates, who attend neighboring schools. But just as not all wards become infected in a city epidemic, all schools in a ward do not necessarily become infected. I prepared a chart of a small epidemic of measles occurring last year in a West Philadelphia ward showing the incidence in the different schools attended by the children of this ward. I also made a map showing the location of those schools. The epidemic began the week of January 14th and ended the week of April 29th. Of the sixteen schools there were no cases in four, one case each in two, three cases in one, seventeen cases in each of two, twenty cases in one, forty-five cases in one, and fifty-nine cases in one. This refers only to the reported cases, which represent possibly one fourth or less of all the cases that occur. What I have found practically is that one case appears in a class and at the end of the period of incubation several secondary cases occur, and at the end of another period of incubation another group of cases occur. To show this and also the interval between the date of onset and the date of report, as well as the relation between the date of onset and the last day in school, I tabulated the nine cases of measles reported from a small private school in which many more cases occurred. Although these case occurred fifteen days after the first case was in school the second day of the disease, six were in school on the date of onset, and two on the day before. One case occurred fifteen days after the first case was in school, one sixteen days later, and two eighteen days later, one nine days after the second case was in school and one fourteen days later. Of course the child may have been in the prodromal stage before the date of onset given by the parents.

When one studies the incidence of contagious disease in a school, one notices that epidemics are usually confined to certain rooms. In order to illustrate this I charted all the cases of minor contagious diseases that occurred during this school year in two public schools. One school had twenty-one classrooms—seven on a floor. Four cases were reported from the third floor, three from the second, and thirty-seven from the first. There was one case of measles in each of four rooms, two cases in each of two rooms, and four cases in one room. One case of German measles appeared in each of three rooms and two cases in one room. One room had three cases of mumps and one had one case. One case of chicken-pox occurred in each of two rooms, two cases in each of two rooms, and three cases in one room. Three rooms had one case of whooping-cough apiece, one had two cases, one three, and one six cases.

The second school had three floors of four rooms each, but the first floor children were on half time, there being different classes in the morning and afternoon. No cases of measles were reported from the third floor. There were three cases in one room on the second floor and one case in another room. On the first floor there were no cases in two classes, one case in one class, two cases in each of two classes, three cases in each of two classes, and fifteen cases in one class. German measles did not occur on the third floor; one case appeared in one room and two cases in another room on the second floor. Of the eight classes on the first floor there were no cases in three, one case in four, and two cases in one. One room on the third floor had one case of chicken-pox, one room on

* An abstract of a paper read before the Section on Public Health of the American Medical Association.

[1] *Jour. Am. Med. Assn.,* July 6th, 1907, vol. xlix, p. 30.

[2] *Journal Am. Med. Assn.,* January 9th, 1909, vol. lii, p. 111.

[3] *Journal Am. Med. Assn.,* September 28th, 1912, vol. lix, p. 1177.

[4] *Amer. Jour. of Public Health,* Boston, 1912, old series, vol. viii, p. 450.

the second floor had one case and another had three cases. Three classes on the first floor had no cases, four had one case each, and one had six cases. There was only one case of mumps on the first floor, one in one room and three in one room on the second floor, and two cases in one room and four cases in another room on the third floor. One case of whooping-cough occurred in one room on the third floor and two cases occurred in one room on the second floor. On the first floor there were no cases in three classes, two cases in each of two classes, two cases in one class, three cases in one and five cases in another.

Intensive Study of an Epidemic in a School.—I have made a still more thorough study of an epidemic of chickenpox in a parochial school, where every child who had been absent for any cause was examined by the medical inspector before re-entering the class room, and where all unexplained absences of over two days were investigated at the end of the week by the medical inspector. It is of course much easier to detect convalescent cases of chickenpox than those of measles or of German measles. This analysis gives some idea as to the number of unrecognized and unreported cases occurring in a class room during an epidemic. It also shows how the different groups of cases in a class are separated by the period of incubation. This school has over two thousand pupils in thirty classes, occupying three separate buildings. There were no cases in one building of four rooms and in another building of eleven rooms. The third building has three floors of five rooms each. On the third floor there were no cases in four rooms and one case in one room. On the second floor there were no cases in four rooms and one case in one room. Two rooms on the first floor had two cases each, one had four cases, one had six, and one had twenty-three. I shall here merely refer to the class that had twenty-three cases. Seven of these were discovered in the class room, seven were discovered on their return to school after being absent, six were found by the medical inspector at their homes, and only three were reported by the physician or family. Indeed, in many instances the parents were unaware that their children had chickenpox, believing the eruption a manifestation of disordered blood, etc. The great majority had no physician. The sequence of absence from school of these twenty-three cases is as follows: One each on the third, fourth and fifth of December, respectively, nine on the eighth, three on the ninth, two on the fifteenth and on the sixteenth, respectively, and three on the twenty-third.

Sufficient evidence has been presented, I believe, to bear out my contention that the unit in the spread of children's diseases is the class room; that an epidemic begins in one room of one school and thence spreads to neighboring class rooms and then to neighboring schools. Proper control will usually limit the epidemic to the original class room and will check the spread even here. The method of control is simple when one understands how the disease spreads in a class room.

The Prevention of School-Spread of Disease.—Infection occurs from a pupil in the class room who is in the prodromal or incipient stage of the disease, or who has had the disease some days, or who is convalescent from the disease. Nearly all of these can and should be discovered before they have had much or any opportunity to infect the other pupils in the class.

Of primary importance in the detection of such children in the class room is the teacher. It is she who sees every child at the beginning of and throughout the school session. If she is observant, she will know when a pupil seems sick or has an eruption, and if she is familiar with the outward symptoms of the common children's diseases she will be able often to recognize them in their incipiency, particularly during an epidemic and especially if at such times she is reminded to be on the watch and has recalled to her the symptoms she is to look out for. Medical inspection has failed to check the spread of disease partly because chief reliance has been placed on the medical inspector, who sees the children usually only at more or less infrequent intervals, and not on the teacher, who sees them every minute of every school day. There is no question but that the teacher is perfectly competent to recognize when a pupil is sick and she should be required to send to the medical inspector all pupils who seem ill. Should the medical inspector have gone for the day, the sick child should be seen by the nurse, when there is one, or be sent home by the principal. School laws which prohibit a principal from sending home a sick child are responsible for a considerable amount of the school-spread of disease. Another school rule that tends to keep sick children in a class where they infect others, is that requiring the dropping of a class that does not maintain a certain average attendance, irrespective of illness or epidemics. Many teachers refrain from sending sick children to the medical inspector for fear he may exclude them, and thus lower the attendance, with the possible consequent dropping of their class. And for similar reasons principals sometimes discourage their teachers from sending sick children to the medical inspector. If disease is to be checked in a school there must be a rule, which is enforced, that every teacher must send to the medical inspector, or to the principal, every pupil who appears ill, and that in the absence of the medical inspector the principal must send the child home. But the teacher and principal must be protected by a rule that absences on account of such exclusion shall not be the cause of dropping a class.

Medical inspection, properly conducted, is the second great bulwark against the spread of disease in a school. The medical inspector, if given the opportunity, can find the beginning cases and exclude them before they do much damage. He can also find the convalescent cases and prevent their re-entering the class room. But for the latter he must have the co-operation of the school authorities. Many of those who have been out of school two days to two weeks with measles, rubella, mumps, or chickenpox, bring notes from their parents stating that they have had a cold, or indigestion, or a stomach rash, or hives, or a tooth abscess, or have been sick, or had no shoes, or had to help at home, etc. In most schools such children immediately re-enter the class room and naturally transmit the disease to others, who wonder how they contracted it. A few schools send all absentees on their return to the medical inspector, but he seldom finds sufficient evidence to warrant excluding them. Besides, in many cities he is forbidden to undress or touch the child, and is thereby frequently prevented from detecting chickenpox, rubella, measles, and mumps. In order that the child convalescing from a contagious disease be kept out of school, there must be a rule, which is enforced, that all children who have been absent two days or more must wait in the doctor's office until permitted by the medical inspector to re-enter their class rooms. And the medical inspector must question the child closely as to the occurrence of eruption, sore throat, vomiting, etc., the presence of similar disease at home, etc. He often will have to frame his questions skillfully, as the child is sometimes instructed at home not to admit that she had a rash, etc. In addition to examining the tongue, throat, face, and hands, the medical inspector should be permitted to palpate for enlarged glands and when his suspicions warrant it, to examine the arms, chest, back, legs, and feet, of course in the presence of the teacher or principal. Any child who gives a history of having had a sore throat, should be cultured, as many mild cases of sore throat or tonsilitis are, as I have shown, in reality but cases of latent or mild diphtheria.

The beginning cases may be found as easily. All children sent to the medical inspector by the teacher should be examined carefully and their necks palpated when indicated. In the presence of an epidemic of measles all pupils in the infected room with coryza should be excluded; and in the presence of an epidemic of whooping cough, all children who cough should be excluded. Should the suspected disease not develop, the only harm done is the loss of a few days' schooling to one child. While waiting in the former instance for the eruption and in the latter for the whoop to develop, further subjects the class to contact with an infectious and hence dangerous person. When the medical inspector discovers a child with a contagious disease or has been notified of the recent presence of one in the class room, he should make a routine examination of the other pupils in the room for at least three days after the child has been in the room, to detect the first symptom of the disease in those who may have caught it from the same source that gave it to the absent pupils. He should examine more closely any pupil who had been absent recently, in order to discover the source of the contagion. In addition he should find out the last date the absent child was in school or the first day the child felt sick in school and from seven days later until fifteen days later examine the class every day, so as to discover at once any child who may have caught the disease from the one who is absent.

The school medical inspector of course should be competent and his action should stand unless questioned by the family physician, when a higher public health official should be called in. Some cities make a practice of having the contagious medical inspector pass upon all cases excluded by the school medical inspector. This sometimes prevents cases of adenitis being excluded for mumps, scabies, and pediculosis corporis for chickenpox, and urticaria and ivy poisoning for measles and rubella. But frequently the contagious medical inspector orders back to school a child convalescing from measles or rubella, in whom the eruption has disappeared, or one convalescing from mumps in whom the parotid swelling has subsided, leaving only enlarged cervical glands. The school should always be given the benefit of any doubt. It is impossible to keep disease out of a school if the health authorities insist upon returning to school infectious children who have been excluded on sufficient evidence by a competent school physician, merely because this evidence was insufficient or lacking by the time the contagious medical inspector arrived.

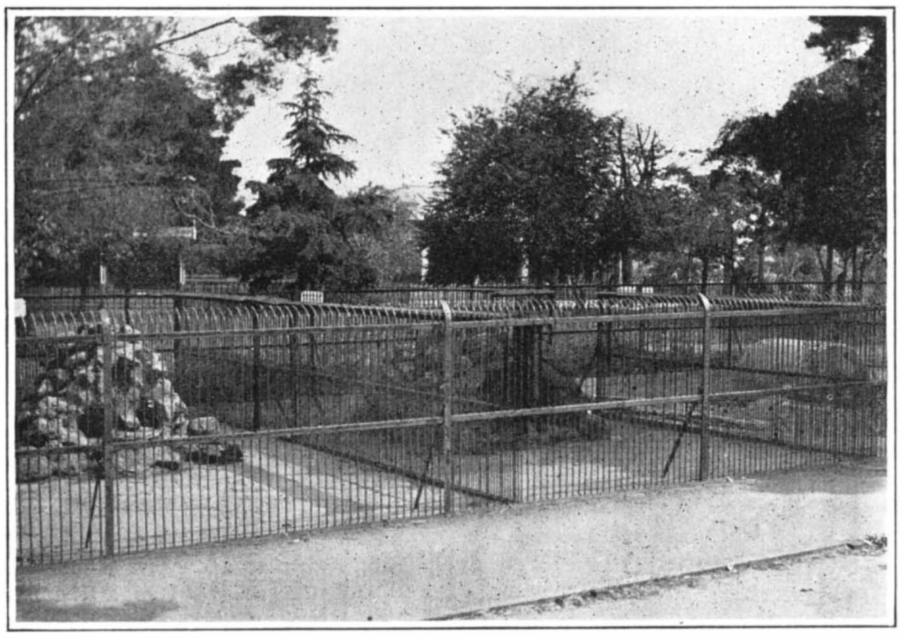
There is still left the pupil convalescent from a contagious disease who returns to school while still infectious, but in whom no evidence of disease can be seen and from whom no history of having had a contagious disease can be elicited. But even this case can be discovered if all concerned are willing to aid. The health authorities in the first place should insist on every physician reporting all cases of contagious disease he sees and should prosecute those who disobey the law. It will not be difficult to find them if the recommendations that follow are carried out. The parent or householder should likewise be compelled to report cases of contagious disease. There should be a rule, which should be strictly enforced, requiring teacher and principal to report to their medical inspector and to the health authorities all cases of known or suspected contagious disease among their pupils, of which they have knowledge. Parents frequently notify the teacher of the cause of the child's absence and other pupils are frequently cognizant of the cause. The attendance officer should report all cases of illness and all cases of suspicion to the medical inspector and should endeavor to learn the nature of the illness. All cases of illness that are not definitely known not to be contagious should then be investigated by the school physician or school nurse or by the health authorities. Some official should also similarly investigate the absences over two days among those who are under the compulsory school age. In addition the laity should be urged to report all cases of contagious or suspicious disease that come to their knowledge.

A practical point for the consideration of school and public health officials is that they must not attempt more than they have the means for carrying out. They must not demand of their subordinates more than they can properly do. Some heads, who realize the importance of all that should be done and yet are given insufficient men at insufficient salaries, try to make their few underpaid men do more than they are physically capable of or than can reasonably be demanded of them. The result usually is that the whole work is poorly and improperly done by discouraged, spiritless, uninterested men. Muncipalities must supply sufficient men and pay them adequately if contagious diseases are to be stamped out. And public health officials should be alive to the situation and should let the public know and understand their responsibility in the matter. Meanwhile they should do all that can properly be done with the assistance that has been afforded them. With teacher, attendance officer, and medical inspector, as we have them in most progressive towns, a great deal can be done to control the school spread of contagious disease, certainly much more than we are doing at the present day.

The Periscope of the Submarine

A SUBMARINE boat sight-tube was invented as far back as 1854, by Marie Davy, and 50 years later such tubes had begun to take practical shape. The periscope is the eye of the submarine, and in principle it is simple; in practice, it is a very complicated piece of apparatus. Its details are quite secret, and it is probable that each navy has its own particular type of instrument. Essentially, it consists of a tube having at its upper end, projecting through the surface, a right-angled reflecting prism, through which an image of a comparatively small portion of the sea is reflected through a similar prism at the lower end of the tube into an eyepiece, conveniently placed for the operator, who always stands facing forward. To obtain a view of any part of the horizon, the tube can be turned round in any direction in azimuth. The tube is moderately large, requiring an electric motor to turn it rapidly. With a periscope, such as described, if an image of a ship right forward is erect, that of a ship right aft will be inverted. This would be most confusing to the commander, and to obviate it, another prism is introduced to erect the image. This—the erecting prism—has to be rotated at twice the rate of the main tube, in order to obtain a constantly erect image. The eyepiece is arranged so that the operator gets a true perspective view of the field with slight magnification, and has an angle of vision of fifty degrees in a horizontal plane. An aeroplane directly overhead cannot be seen through the periscope. Considerable practice is required to enable the instrument to be used effectively.

The periscope is not required for navigating when submerged deeply; in fact, it would be useless, as it is impracticable to see half the length of the boat in ordinary sea water. Two periscopes are sometimes fitted in large craft, one for the use of the captain, and one for an observer, who is continually sweeping the horizon. The horizon, with the periscope four feet out of the water, is barely two and a half miles distant.—*The Marine Engineer and Naval Architect.*



Ornamental yards and houses for rodents.

Where the water fowl are made happy.

Some Noted Zoological Parks

The Zoological Gardens of Melbourne

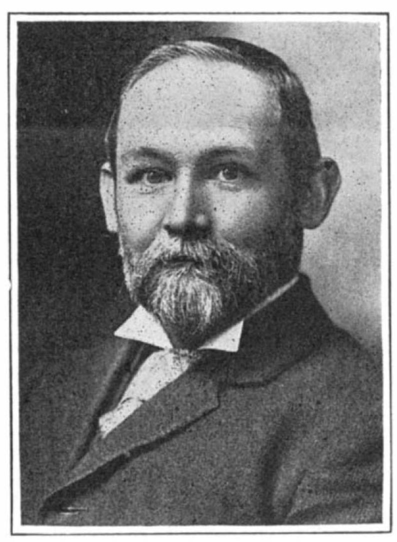
By R. W. Shufeldt

HAVING presented in this series of articles illustrated accounts of one of the oldest zoological gardens in the world, the London "Zoo," as well as a correspondingly ancient one in this country, the famous gardens of a similar character in Philadelphia,[1] I will now describe and illustrate the third park or garden of this kind that I have in my category, selecting one of the most noted ones of those occurring in other countries than our own. No one of these has a higher claim to general attractiveness, faultless management and important and extensive collections than the Zoological Gardens of Melbourne, Australia, which belong to and are under the control of the Royal Zoological and Acclimatisation Society of Victoria.

In assembling the material for my description of this most interesting and instructive garden or open-air menagerie, I am indebted to my friend, Mr. Dudley Le Souëf, C.M.Z.S., etc., its distinguished director, of whom a portrait is here shown. He is not only a most efficient superintendent for the position he occupies, but he has a very wide knowledge of the world's faunæ in general, and of the Australian continent in particular, and many of these have been described in various publications of which he is the author.

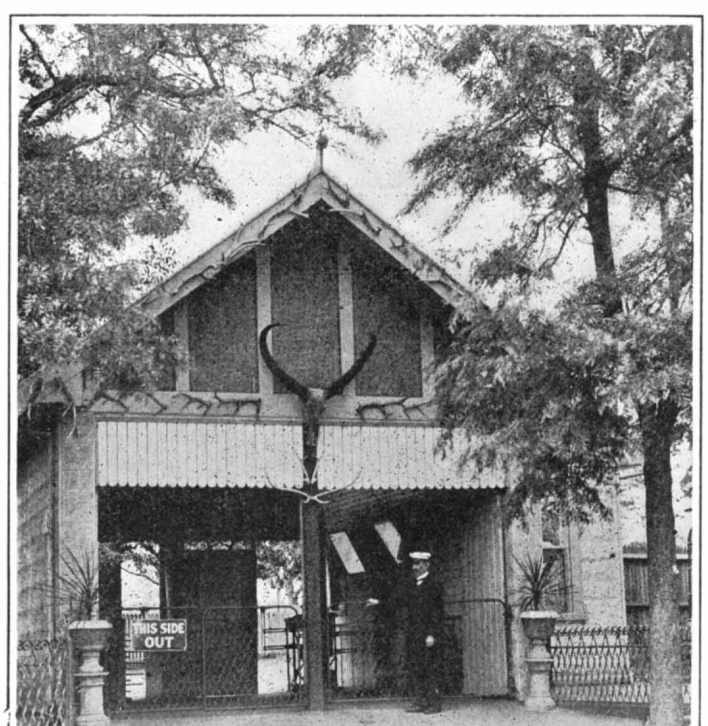
As will be observed by the accompanying plan of these gardens, the area is not only a comfortably large one, but it is compact in form and remarkably diversified in its general and special arrangement. There is not a turn in its paths or its roads that does not offer a vista of marked attractiveness and beauty. So numerous indeed are the various pens, paddocks, ponds and playgrounds for animals of all kinds, that it is quite out of the question to give a complete list of them here, as I did in the case of the London and Philadelphia gardens. There are two principal entrances, one of which is shown, and both are inviting and attractive, which decidedly is not the case with other gardens known to me.

As in the case of a great many other cities, the starting of the Zoological Gardens of Melbourne consisted in exhibiting a few of the indigenous mammals and birds—that is, native ones—in the Botanical Gardens; it took place at about the time the Civil War broke out in this country. This, however, did not last long, for, on the last day of June, 1862, various buildings were being erected in the Royal Park, the major portion of which had been set aside for the then recently acquired Zoological Gardens. Mr. Edward Wilson was elected president of the society, and Mr. George Sprigg its secretary; these two gentlemen were the first to hold these positions. Originally the society devoted itself entirely to the matter of acclimatization; it was not until about eight years had passed that it began to acquire animals from other countries outside of Australia, and the organization assumed the name

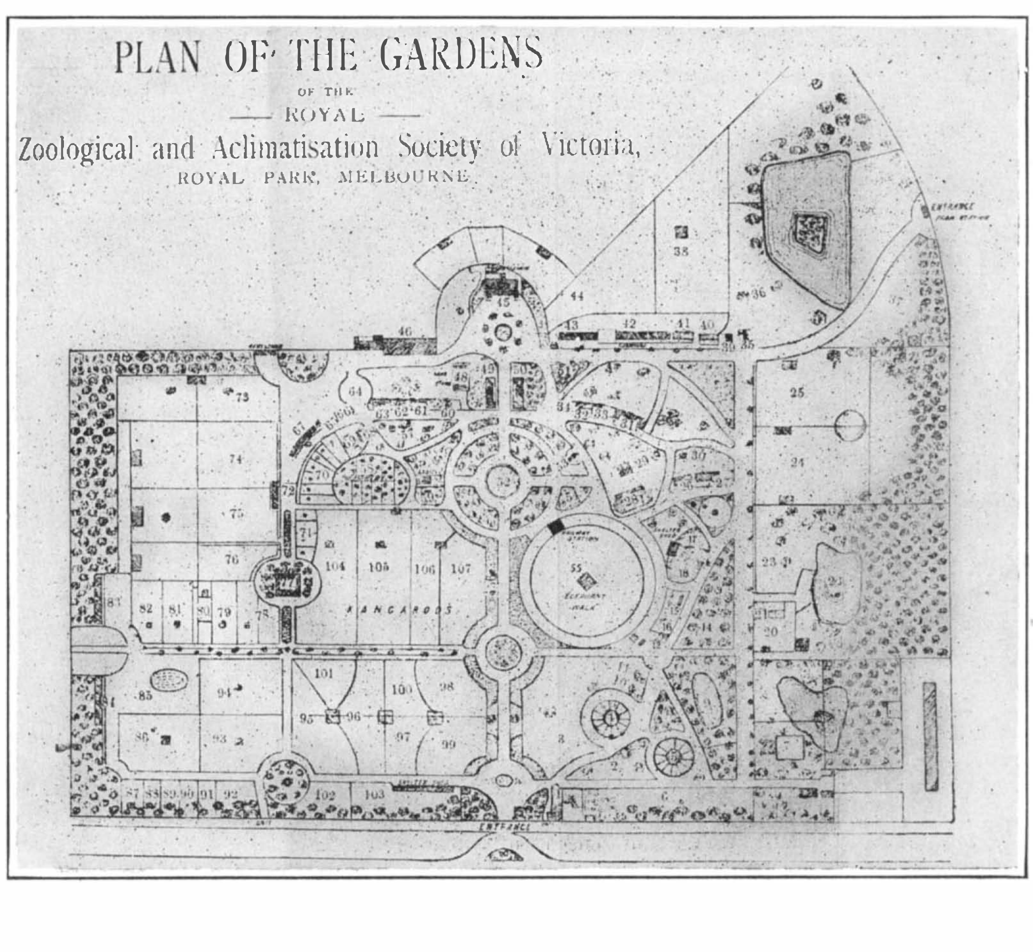


W. H. Dudley Le Souëf, C.M.Z.S., Director of the Melbourne Zoo.

[1] "Gardens of the Zoological Society of London," SCIENTIFIC AMERICAN SUPPLEMENT, March 20th, 1915. "Some Noted Zoological Parks: The Gardens of the Zoological Society of Philadelphia," SCIENTIFIC AMERICAN SUPPLEMENT, January 1st, 1916. A related subject was also dealt with in another contribution, namely, the "Collections of the New York Aquarium." SCIENTIFIC AMERICAN SUPPLEMENT, July 24th, 1915. All three of these articles are fully illustrated by reproductions of photographs of views, buildings, animals, etc., of the several institutions described.



One of the picturesque entrances to the Gardens of the Royal Society of Melbourne.



of the "Zoological and Acclimatisation Society of Victoria."

As in the case of all zoological gardens worthy of the name, the one in Melbourne issues a very attractive, not to say useful and instructive, guide-book; it contains a folding plan of the gardens, which is reproduced here. This guide-book is sold for sixpence, and about fifty dollars' worth of them are sold annually. Every fifty dollars is something when the expenses of a zoological garden are to be met; but, then, the authorities of such an institution as I am now describing understand how to collect extra means for its support, outside of sitting quietly in a chair, waiting for the general government to furnish the yearly appropriation. For example, they select an elephant, noted for its size and fine appearance instead of for its viciousness and unprepossessing appearance, and train it so that the animal is a perfectly safe one for children to ride; and in 1913 the elephant at the Melbourne "Zoo" became so popular in this way that the "rides" netted the gardens no less a sum than almost $900. Then, two years ago, the "donkey carriage rides"; the "motor railway rides"; sale of "bones and hides" ($600); "hire of go-carts"; "rent of refreshment room"; "gate money," etc., amounted to nearly $54,000. Now, when a garden is doing this much by its own efforts, it is natural to suppose that the general government would be far more inclined to help it financially. This would especially be the case in the United States, where the spirit of commercialism stands above everything else. Some will say: "Gate money! Why, who would visit a 'Zoo' if they had to pay *gate money*?" Well, all I can say to this is that in 1913—two years ago—390,000 people paid gate money to see these zoological gardens in Melbourne—that's all! Its revenue from this source alone is increasing annually at the rate of from six hundred to seven hundred dollars.

Not only are the Melbourne Gardens splendidly stocked with interesting and well-cared-for animals, but their botanical side is brought to a high degree of perfection. Rare plants and trees appear everywhere, forming attractive vistas at many places, and are a source of constant admiration on the part of all visitors. Mind you, the visitors at this garden do *not* constitute a rabble, for the gate-money proposition acts as a sieve and a safeguard in such a matter. Then, too, the population of the city is *white* and does not number thousands of high-tinted and ignorant half-bloods.

It is a treat of the highest order to stroll through this extensive and beautiful place in the company of its amiable director, Mr. Le Souëf, for he not only takes a personal interest in everything the institution stands for, but he is a thoroughly well-informed zoologist besides. There will be pointed out to you the wonderful and scientific improvements under way at the present time, or those which have been very recently finished; the large concrete house just erected for the two beautiful young giraffes—the only pair in all Australia. Instead of a cramped, wooden bathtub, scarcely large enough for the poor animal to turn around in, the pair of hippopotami here has an extensive yard, with a very capacious tank, the whole surrounded by fine trees and other verdure of a most attractive kind. The Polar bears—Polar bears in Australia!—have a similar comfortable home, and are doing beautifully. Indeed, all the structures in this garden are the finest of their kind, and the animals not only appreciate them, but look well and happy, with every evidence of being well cared for at all seasons of the year.

Mr. Le Souëf will impress the fact upon you that an entire building has been erected for the display of the fine snake collection and a few of the lizards. We come across, here and there, the most beautiful ponds and lakes, generously stocked with many species of wild fowl from all parts of the world.

Naturally—and properly so—much space is given to the exhibition of the animals found in Australia, and there is no country in the world where the ferine species are more interesting. In extensive and well-kept paddocks we see many species of wallabies or kangaroos, including the remarkable "tree kangaroo" (Bennet's) and the whip-tailed one; graceful flamingoes and other waders inhabit, as in nature, exquisite tropical pools and ponds, and, indeed, it would be quite impossible to enumerate here, even in a list, the living forms that are either presented to or purchased by this society in the course of a year. It amounts to several hundred animals; but, then, Australians do everything with a most liberal hand and very handsomely withal.

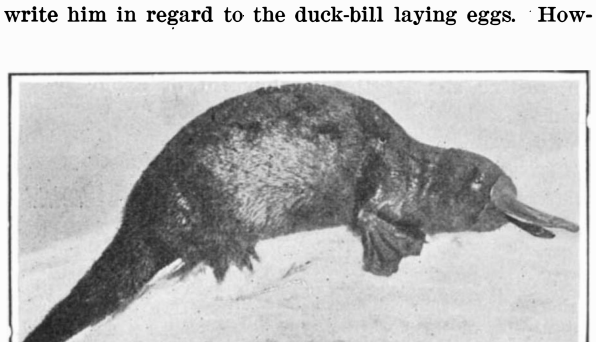
Australia's fauna is not only rich in marsupials, but it contains at least one very famous mammal known to lay *eggs*, from which its young come forth. This is the duck-bill platypus, or *Ornithorhynchus paradoxus* of science. Living examples of this creature are found here, in a home coequal in all particulars with the one they enjoyed in nature. The literature on this curious little fellow is most interesting, especially that part of it which refers to its egg-laying propensities. It is generally supposed that this was first described by Mr. W. H. Caldwell in 1884, who demonstrated that the animal laid two eggs, which, in the manner of their development, closely resembled the eggs of certain reptiles. I may state here—for the first time in print—that many years ago I bought in London the private

Fountain and pool of water plants.

copy of Sir Richard Owen's "Directions for Collecting and Preserving Animals," etc. (1835), which he used at the time he was curator in the Museum of the Royal College of Surgeons in London. This is a demiquarto volume of some fifty pages, interleaved with blank ones

The panda, or bear-cat.

for notes. It contained some original and remarkable letters, dating back to the early part of last century. A few years before his death, Sir Richard was a correspondent of mine, but I never had an opportunity to write him in regard to the duck-bill laying eggs. How-



The duck-bill platypus.

ever, among the letters I mention I found some notes in his own handwriting, and one dated February 13th, 1835, in which he refers to a Mr. Evans, who had returned a few days before from Hobart Town. Mr. Evans gave Dr. Owen an account of the mating of this *Ornithorhynchus* we see in the Melbourne "Zoo," and he said, among other things, that "the young is expelled fully formed, but with a covering like egg-shell, which sometimes adheres to the parent, and sometimes a portion sticks to the fœtus; size not mentioned. The shepherds laughed at the question respecting the milk-glands, having frequently expressed the milk in skinning specimens," etc. It is a most interesting and important fact that this discovery of Evans was given to Sir Richard Owen almost half a century *before* Caldwell announced his having ascertained that the platypus laid eggs. Mr. Le Souëf tells me that they do not live long in captivity, and as a consequence the animal is not always on the list of those to be found in these gardens. The picture I give here of the *Ornithorynchus* is from a photograph by W. Saville-Kent, F.Z.S., an eminent British authority on the natural history and photography of wild forms in nature.

An important adjunct to these gardens is its museum, a building divided into several compartments, in each of which are fine exhibits of many mammals and birds. Then there are extensive outdoor "flight aviaries," one each for parrots, doves, song birds, and so on. Sometimes there are as many as twenty-five flamingoes inhabiting the pond devoted to them, while specimens of the remarkable stone plover are also seen, as well as a collection of Australian owls, of which there are many species. They even have living specimens of our American buffalo there that are doing well. As there are upward of two hundred species of living birds in these gardens, with the rest of the vertebrata equally well represented, it will at once be appreciated how impossible it is for me to even refer to all that pertains to them within the prescribed limits of space, however briefly I might do so.

Among the "rules" of this garden may be noted that smoking on the grounds is prohibited; children under twelve years are not allowed to enter unless accompanied by adults; dogs are not allowed. There are numerous other prohibitions established and carried out with firmness, intended to protect the animals, plants and workmen; to preserve good order, and to prevent vandalism of any kind—all of which seem to be of a very necessary as well as excellent character.

In closing this account it is with the greatest regret that I find that the present fearful war in Europe has claimed among its victims not a few members of this society, some of which were numbered among the best men in Australian science.

The Chinese Calendar

Although the government of China has officially adopted the Western, or solar, calendar, and it is used in all official circles, the old calendar is still widely observed. It is a lunar calendar, and the words "first moon," "second moon," etc., are used in referring to months; for instance, "the first day of the first moon" means the first day of the year. The latter varies, with reference to the Western calendar, according to the moon's phases. In 1915 Chinese New Year began on February 14; during the year the first, fifth, seventh, ninth, and eleventh moons, or months, will have 29 days and the other seven months 30 days. In some years a readjustment is made in the calendar by having an extra, or thirteenth, month. In trade there are so-called "settling days," on which the Chinese dealers make a special effort to pay up all their obligations in order to "save face," or maintain their credit. The most important settling day is the last day of the year (February 3rd, 1916); others are the thirtieth day of the third month (May 13th, in 1915), the fifth day of the fifth month (June 17th, in 1915), the fifteenth day of the eighth month (September 23rd, in 1915), and the twenty-ninth day of the ninth month (November 6th, in 1915). The thirtieth day of the third month, the twenty-ninth day of the ninth month, and the thirtieth day of the twelfth month are settling days for the large dealers; the others, for the small merchants.—From Special Agents Series, No. 107, U. S. Department of Commerce.

Coke as a Boiler Fuel

Extended experiments made abroad continuing over a number of years, and with a number of different methods for utilizing the fuel, indicate that not more than 25 per cent of coke to 75 per cent of ordinary bituminous coal can be successfully used for steam purposes under a boiler. Even with this proportion it is desirable that the grates should be cooled by steam or water to prevent their burning, and to facilitate the removal of clinkers. On the ordinary grate, with hand firing, almost any mixture of coke and coal results in a falling off in the efficiency of the boiler. A mixture of 3.1 coal and coke produced a sheet of molten slag that stopped up the air passages between the grate bars and hindered the combustion of the remaining fuel. The character of the coal largely governs the proportion of coke that can be used, but satisfactory results can hardly be looked for with more than 25 per cent of coke.

Explosives*

Interesting Facts Relating to Their History and Nature

By Frank Bailey, M. Inst. C. E.

THE fact that we were not ready to meet on equal terms an enemy trained in war, and with enormous hordes of men, guns, ammunition, explosives and poisons, is no disgrace, but may be considered as evidence of our civilization. The fact that the progress of the enemy has been stubbornly resisted and checked is a monument to military skill and the bravery of men. The advantage obtained by this patient resistance has enabled this and other countries concerned to concentrate on the production of munitions.

In engineering work when a job has to be done well and quickly, it is better to leave it to the best man available, and to give him all necessary means to carry it out. As a nation, we have Ministers who can do their part to the satisfaction of the Empire.

The barbarous methods adopted by the enemy prove the futility of the Hague Convention when one of the parties repudiates word and bond. The use of poison gas, poison shells and bullets, treachery in surrender, cruelty to prisoners and non-combatants, and many other acts of barbarism, must be left for consideration by those most competent to deal with them when the time arrives.

In such a war of endurance, and possibly of exhaustion, the intermediate stages must depend on productive progress in military equipment, and we may therefore say that this is a war of machine tools, explosives, and gasoline. The history of the discovery, invention or development of munitions of war is now rendered available by the labors of numerous expert writers, and it may be interesting to refer to some explosives on which our safety as a nation now depends.

Explosives may be enumerated under three headings:

1. Detonators or exploders—fulminates.
2. Progressive or propelling—propellants.
3. Detonating or disruptive—fillers.

In the first division, although fulminates of gold and silver were known about the year 1660, nothing seems to have been done until 1800, when Edward Howard described fulminate of mercury in a paper read before the Royal Society. In carrying out his experiments, Howard had several explosions, and on one occasion he poured concentrated sulphuric acid on a quantity of fulminate, and was severely wounded, and most of his apparatus was destroyed by the violent explosion. He stated: "I must confess I feel more disposed to prosecute other chemical subjects." Even after this experience we find him striking fulminate on a cold anvil, and complaining of the "very stunning, disagreeable noise"; and yet he repeated this effect with an electric battery, and finally charged a gun, suitable for sixty-eight grains of gunpowder, with thirty-four grains of fulminate; but the breech was torn open, the touch-hole driven out, and the barrel split.

In 1824 the firm of Joyce & Co. were making a successful percussion cap, and from this date progress was made in the improvement of small arms, although it seems strange that our army had to wait until 1866, when the Snider rifle was adopted with a cartridge case of brass.

The history of propellants and fillers is practically confined to the last fifty years. Roger Bacon, who invented gunpowder in 1240, therefore, had no rival in history for more than 600 years, and his instructions have not been materially improved upon. These instructions were written in cypher, as he states that he considers this knowledge may be injurious.

The difficulty of constructing big guns retarded any improvements in gunpowder; and when it was shown that a stronger powder could be obtained by breaking the cakes into small grains, called "corned" powder, and not into fine "serpentine" powder, the guns, or "pieces of ordnance" as they were then called, soon fractured. When stronger guns were available, the powder makers increased the size of the grains, which developed into cubes, and finally into solid slabs perforated with holes—a number of these slabs forming one charge. Then came perforated prismatic, and perforated cylindrical cake powders, which enabled the quantity of gas evolved to suit the bore and length of the gun.

The disadvantages of gunpowder were the enormous clouds of smoke, and the fouling of the guns. In 1833 Prof. Braconnot, of Nancy, noticed that concentrated nitric acid changed several substances like starch, wood fiber, and some of the gums into a material which he called Xyloidine, now known as nitro-starch; and, finding it highly combustible, expressed a belief that it would be of some practical use in artillery. It was left, however, to Schönbein, Professor of Chemistry at Bale, to announce his discovery of guncotton, in December, 1845, and, owing to a charge that he had merely applied the work of Braconnot, we have full records of all his experiments, which appear to have led him from ozone to the oxides of nitrogen, and finally to the action of nitric acid on sugar and cotton. He was certainly a brave man, for, after trying guncotton in small arms, he fired the first cannon loaded with guncotton and with a charge of shot in the year 1846. Schönbein then wrote to Dumas: "In addition to the superior explosive force of this curious substance, it is in every respect superior to the best powder. Experiments which I have made in mines and with cannons and mortars have shown that 1 pound of this substance produces effect equal to from 2 pounds to 4 pounds of ordinary black powder. It should be added that cotton so treated does not leave any residues when exploded, and produces no smoke. The manufacture is not attended with the least danger, and does not require any costly installations." This statement does not appear to have been correct, for on July 14th, 1847, the first guncotton factory, which by arrangement with Messrs. John Hall and Sons was erected at Faversham, was destroyed by a disastrous explosion, with the loss of twenty lives.

This was followed by similar explosions in various works in France and Austria, and caused the manufacture of guncotton to be abandoned for about sixteen years. In the meantime Ascanio Sobrero, of Turin, discovered nitroglycerine in 1847, and found it had "a sharp, sweet, aromatic taste. A trace of nitroglycerine placed upon the tongue, but not swallowed, gives rise to a most violent pulsating headache, accompanied by great weakness of the limbs." It is now prescribed for angina pectoris, dyspepsia, asthma, sea-sickness, etc., and, like some other high explosives, it forms a medicine—internal for friend, and external for foe.

The dangerous nature of this liquid explosive was quickly recognized, for although a lighted match plunged into liquid nitroglycerine will be extinguished, without causing explosion, yet a drop of the liquid on a piece of blotting-paper will explode when struck with a hammer.

Alfred Nobel found that a small percussion cap of fulminate of mercury exploded it with great violence, and was apparently so fascinated with the dangerous liquid that he commenced to manufacture it at Helenborg, near Stockholm, in 1862. Two years later these works were destroyed by an explosion which killed several men, including Nobel's brother.

Undeterred by this accident, Nobel promptly erected another factory in Sweden and one in Germany, but was soon compelled to acknowledge that nitroglycerine in its liquid state was impracticable, and in endeavoring to overcome this defect he saturated various substances with the explosive, and finally adopted kieselguhr, a fine siliceous earth—then used in his factory for packing tins of nitroglycerine in wood boxes—which absorbed three times its own weight of nitroglycerine. This explosive, known as dynamite, though of no use for ordnance purposes, was placed on the market about 1870 as a blasting agent, and forms an interesting step in the development of explosives for mining and other purposes, for it soon led to the discovery of blasting gelatine, gelignite, and ballistite. No reference to the wonderful activities and genius of Nobel can be complete without giving him the credit of the fundamental idea of the detonation of explosives, now so important with high explosives.

We must now return to the unfortunate early history of guncotton, in order to find the road of progress to cordite. Sir Frederick Abel, by patient research and with all the facilities at Waltham Abbey, gradually improved the manufacture of guncotton until it became one of the safest explosives, and capable of being prepared in any desired form. His lectures and communications to the Royal Society in 1866 and 1867 have left a record of industry and genius the full value of which is being realized.

In 1889 the manufacture of cordite was commenced, and soon proved successful. Developed on much the same lines as Nobel's ballistite, there were important modifications, for a higher nitrate cellulose was incorporated with nitroglycerine by the aid of acetone. Petroleum jelly was added with the intention of providing a lubricant for the gun-barrel; but this idea was found to be a most fortunate error, for while it failed as a lubricant owing to the high temperature of explosion, it introduced unexpected technical results, which greatly improved the action of the cordite. The practical effect of the use of cordite as a propellant may be summarized as reducing the charge more than half as compared with prismatic powder, with a 50 per cent increase in muzzle velocity, and without black smoke.

It appears that some explosive, similar to cordite, is universally adopted in other countries. This is not surprising, as the insufficiency of oxygen in guncotton is provided by the excess oxygen in nitroglycerine; and by adopting correct proportions, smokeless results are obtained giving high muzzle velocities with low pressure. The temperature of explosion is very high, and to reduce erosion of the bore of the gun less nitroglycerine is used than formerly, the composition now being: Guncotton (acetone colloided), 65; nitroglycerine, 30; vaseline, 5.

It has been demonstrated that the velocity of the explosive wave is about 20,000 feet per second, and the explosive reaction progresses with incredible rapidity, transforming the solid material to the gaseous state, the gases being greatly increased in volume and pressure by the heat of combination attending the reaction. In the case of nitroglycerine, 1 volume yields 1,298 volumes of gas when cold, and this expands to 10,400 volumes at the moment of explosion.

We must now deal with modern high explosives which would burst guns if used as propellants, and are, therefore, only used to fill shells and bombs. The tar obtained from the distillation of coal provides the raw material for:

Picric acid, or trinitrophenol—phenol being carbolic acid.

Trinitrotoluol, or T. N. T. derived from toluene, which is contained in crude benzol.

Picric acid, so called from its bitter taste, was long known as a useful medicine and as a dye, but was not used as an explosive until 1886, when the French adopted it under the name of Melinite. In recent years it has been used under the name of Lyddite in England; Ecrasite in Austria; Shimose in Japan, and Sprengmunition or Granatfüllung in Germany.

A serious accident in 1887 at Manchester revealed the danger of some metals forming sensitive compounds or picrates when in contact with picric acid; and even red or white lead cannot be used to seal the screw threads of shell plugs. Picric acid is more powerful than guncotton, bulk for bulk, but has now been largely replaced by trinitrotoluol.

Toluol can be obtained from resins, such as tolu from a South American tree, the medicinal properties forming the basis of "Balsam of Tolu" and "Friars Balsam"; but the enormous quantities now required can only be provided by washing coal gas to strip it of benzol, and from the distillation of coal tar.

T. N. T. is easily prepared without danger—in fact, it is difficult to explode, and remains stable even when exposed to the air, and is not affected by contact with metals. A rifle bullet can be fired into it without causing it to explode.

There are many other explosives which we need not include in this brief summary, as they are used for mining and other blasting purposes. The number of permitted explosives is now about 260. The use of the chlorate explosives has been retarded by numerous accidental explosions. Potassium chlorate with castor oil thickened with nitro-hydrocarbon—such as nitrobenzene—provides a slow and mild explosive, called "Cheddite," useful for agricultural purposes, and for which there appears to be a promising future.

Having considered propellants and fillers, it is desirable to mention the function of detonation; described by one writer as "the result of heat or shock applied with great energy, whereby the oxygen escapes from the nitrogen and enters into combination with the combustible elements." This produces explosion owing to the sudden expansion of gases caused by decomposition or combustion.

The coal tar derivatives merit special attention, reminding us of the value of much that is lost by our present methods of burning coal. In Germany coke oven recovery plants are more largely used than in this country, and consequently their supplies of benzol

* From his presidential address before the Association of Engineers-in-Charge.

have for many years been far in excess of the production in this country, without detriment to any industry, and to the advantage of the users of coke. In 1913 Germany produced 160,000 tons of benzol, from which they could obtain about 50,000 tons of toluene. This quantity would be increased in 1914, and they are not likely to have exported such a valuable commodity, so that their supplies have been obtained through carbonizing, instead of destroying, their raw fuel. They also imported large quantities of tar products.

Some attempts have been made in this country to carry out low temperature carbonization, but the result has been unfortunate, without, however, proving that the proposal could not be successfully carried out on proper lines. Sufficient has been done by pioneers to show that the actual results justify commercial development, and there is no reason why all the requirements of this country for motor spirit, fuel oils, and other valuable distillates from coal tar, should not be provided, together with a supply of rich coke capable of supplying all our domestic needs without causing smoke.

The diarist, John Evelyn, wrote on July 11th, 1656: "Came home by Greenwich Ferry, where I saw Sir John Winter's new project of charring sea-coale, to burne out the sulphure and render it sweete. He did it by burning the coales in such earthen pots as the glasse-men mealt their mettal, so firing them without consuming them, using a barr of yron in crucible or pot, which barr has a hook at one end, that so the coales being mealted in a furnace with other crude sea-coales under them, may be drawn out of the potts sticking to the yron, whence they are beaten off in greate halfe-exhausted cinders, which being rekindl'd make a cleare pleasant chamber fire, depriv'd of their sulphure and arsenic malignity. What successe it may have, time will discover."

In a footnote, William Bray, the editor of this diary, writes in 1818: "Some years ago Lord Dundonald revived the project, but with the projected improvement of extracting and saving the tar. Unfortunately his Lordship did not profit by it. The Gas Light Company sell the coal thus charred by the name of coke for fuel for many purposes." At that time the temperature of distillation was sufficiently low to yield good tar and a smokeless fuel.

It is clear that the design of all implements of war must be governed by the explosive. The breech chamber of guns is modified to suit the amount of the charge, and the barrel is lengthened according to the strength of the propellant, its function being merely directive. Shells are primarily designed to suit the filler, and the fuse is constructed to make the best use of the detonating medium. In the days when cannon or "pieces of ordnance" were fed with black powder by a shovel thrust down the muzzle there must have been some excitement regarding ignition, especially when hot cannon balls were introduced as an improvement.

The earliest drawing of a gun shows it to be shaped like a bottle and discharging a dart. Round shot were not used until the idea that all projectiles must be shaped like an arrow had been overcome. In a similar manner our first motorcars resemble horseless carriages, and the first railway carriage was designed to imitate a stage-coach, while for forty years the dangerous practice was continued of placing luggage on the roof. Perhaps we are doing many similar foolish things to-day, and thus earning the ridicule of posterity.

Shells, fuses, cartridge-cases, primers, and guns all show evidence of their evolution through years of experience and the continual improvement of explosives. If we wish to appreciate the ingenuity and skill of the artillery expert, we have only to examine a shell with its fuse and realize that no drawing or description can adequately explain the necessity for absolute accuracy of all parts. The need for precision, the necessity for working strictly to gage, the selection and testing of metal—all become apparent when the functions of munitions are understood, and their assembly tests the interchangeability of all parts.

Many drawings have been published of universal shells and fuses, some with quadruple action fuse, the shrapnel body being distinct from the high explosive chamber, so that the shrapnel time fuse ignites the powder which ejects the bullets and bursts the shell, leaving the head and its high explosive to travel alone and to detonate by impact. If impact occurs before the time fuse acts, then the high explosive effectually disposes of the whole shell. In other designs the shrapnel fuse acts on impact with or without a time fuse for the high explosive. Knowing the velocity of the projectile, and the distance of the object, the time fuse can be trusted to obey the adjustment.

The development of the airplane and airship has introduced a new and important element in modern warfare. Man-kites and captive balloons provided an experience of aerial observation which can now be applied. As conveyances for a load of bombs, aircraft has proved its destructive utility, and owing to the high speed of the airplane the path of the bomb through space requires considerable skill in hitting the object. Assuming the height of flight to be 5,000 feet, and without making allowances for wind or air pressure, the bomb must be dropped about 500 yards before reaching the vertical line above the object. Assuming, however, that an airship remains stationary, a more accurate aim can be obtained by dropping the bombs through sighted tubes.

In the construction of these aerial bombs great ingenuity has been shown, and the incendiary bomb comprises all the latest diabolic inventions of the pyrotechnical chemist; resin, phosphorus and thermit are all used in this evil production.

The revival of trench warfare has also given inventors the opportunity of devising methods for projecting bombs for about 300 feet. Slings and catapults, going back in form to the ancient ballista, give the impression that we are reverting to savage methods; but for longer distances, trench mortars—operated by compressed air, gasoline, acetylene gas, or cordite propellants—have proved the ingenuity of expert engineers. John Evelyn remarked in his diary in July, 1678: "Now were brought into service a new sort of soldiers, call'd Grenadiers, who were dextrous in flinging hand grenades, every one having a pouch full; they had furr'd caps with coped crownes like Janizaries, which made them look very fierce, and some had long hoods hanging down behind, as we picture fools. Their clothing being likewise pybald yellow and red."

And again in March, 1687: "I saw a trial of those develish murdering mischief-doing engines called Bombs, shot out of the morter-piece on Black-heath. The distance that they are cast, the destruction they make where they fall, is prodigious."

We have said that this is a war of modern tools. The experience gained by repetition work, the use of high-speed tool steel, and the necessity for securing great accuracy, will result in a general improvement in the ordinary workshop methods. The design of modern machine tools with their stiffer construction, convenient change speed gear, and many improvements, will compel all users of workshop plant to seriously consider the economy of scrapping their old tools. Engineers-in-Charge will doubtless take a prominent part in such a change. Long after the present war the practical effect of the experience will be evident in industry; and, in view of the financial charges we shall have to bear, it is some consolation to know that there is not only room for improvement in many of our methods of manufacture, but that the means of securing this improvement are available.

We are all now working at high pressure, and it may usefully be pointed out that work prolonged beyond normal hours seldom proves efficient; nature insists on rest for recuperation, and the wise man finds relaxation in change of occupation; by this means a holiday can be obtained and yet useful work can be accomplished. The members of this association do not play at work, or work at play, and they have realized by hard experience that all the satisfaction of play can be obtained by the knowledge that their work has been efficiently accomplished.

The Early Days of the Railroad

In an address recently delivered at a meeting of the American Association of Traveling Passenger Agents, held at Boston, Howard Elliott, president of the New Haven and Hartford Railroad Company, related some amusing facts relating to travel in the early days of railroads in New England. He said:

One of the very early railroads was built in Quincy, nearby here, in 1824; it hauled the granite of which the Bunker Hill Monument was built.

Then the Boston & Lowell Road was chartered in 1830 for cars to be hauled by horse-power, and it was thought they would have at that time as much as eight tons of freight a day and 120 passengers a day!

After that came the Boston & Albany, and a very curious incident occurred in regard to that road. There was a great deal of opposition to building railroads at all in those early days. However, the Boston & Lowell, the Boston & Providence, and the Boston & Worcester were started, and these roads were built then as railroads are built now, by private capital. Private initiative started those railroads. When it came to the Boston & Albany it seemed to be a large problem, and the projectors asked for State aid and they had great difficulty getting it. Some idea of the difficulty of obtaining this assistance may be gathered from the resolutions adopted by the inhabitants of Dorchester, in town meeting assembled, one of which stated that the building of the railroad through that town would be of "incalculable evil to the town generally."

However, the projectors worked along and finally they got the Boston & Albany through, although one newspaper, the *Boston Courier*, in 1827 said editorially that a road from Boston to Albany would be as "useless as a railroad from Boston to the moon." You have just come over the Boston & Albany from the West, and you know what a great and fine property it is.

The travel, of course, in those days was very light. The Lowell people thought, as I told you, if they got 120 passengers a day they would be doing very well. Just to show you how travel has increased, here is a little quotation from the diary of President Quincy of Harvard College in 1771. He made the trip from Boston to New York about that year, by stage coach, and wrote of it as follows:

"The carriages were old, and the shackling and much of the harness made of ropes. One pair of horses carried us 18 miles. We generally reached our resting-place for the night, if no accident intervened, at ten o'clock, and after a frugal supper went to bed, with a notice that we should be called at three next morning, which generally proved to be half-past two, and then, whether it snowed or rained, the traveler must rise and make ready, by the help of a horn lantern and a farthing candle, and proceed on his way over bad roads, sometimes getting out to help the coachman lift the coach out of a quagmire or rut, and arriving at New York after a hard week's traveling, wondering at the ease, as well as the expedition, with which our journey was effected."

This in one whole week! By careful work in 1793 the time had been cut down to 4 days. Now, as you know, you can make it in a little over 5 hours. The fare was then fourpence a mile, or eight cents in our money. At that time passengers were allowed to carry 14 pounds of baggage, and you will be interested to learn that in those days, before the Cummins Amendment, all baggage was carried at the owner's risk.

There were very few conveniences in those days for travelers, and experiences were very trying. The roads had no signals. You will be interested to know that the first system of signals was originated by a conductor on the Erie road.

Time-tables did not come into use until 1847; brakes on the early locomotives were similar to those used on the old stage coaches; head-lights were unheard of and the cowcatcher was the device of a young machinist named Isaac Dripps, and was invented for the purpose its name implies. So effective was it, however, that the first time it was used a big bull was caught on the long iron prongs with which the first cowcatcher was equipped, and it required the use of ropes and considerable force to detach him. So that it was rightly named—not a cowcatcher, but in those days a bullcatcher. The first telegraph was used on a railroad in 1851. The first steam railroad trip in this part of the country was made on April 7th, 1834, between Boston and Newton. And that good newspaper, the Boston *Advertiser*, which was then, as it is now, one of the leading papers of Boston, had an account of the trip. It said:

"The party stopped several times for various purposes on the way out. They returned in 39 minutes, including a stop of about 6 minutes for the purpose of attaching five cars loaded with earth. The engine traveled with ease at the rate of 20 miles an hour."

The officials were so elated with the trip that they invited about a hundred and thirty persons to make the trip on the following day. The train on that occasion was apparently overloaded, as the iron bars used as couplers kept breaking, and the party did not get back to Boston until night.

The road to Worcester was opened July 3d, 1835, and in an account of the trip one writer said:

"Some of the passenger cars on this road are very elegant, and will hold from 20 to 30 persons. The motion of the cars upon the road is so easy that I saw a little child walking from seat to seat, as if in a parlor."

They must have had good rolling stock in those days and a good maintenance-of-way department, and the old dispute between the mechanical man and the track man was buried.

Protecting Motors Against Dust

A note in the *Engineer* states that in flour mills, stone mills and other plants where it is necessary to protect motors against dust, objection has been found to the solid wooden housings or coverings with which the motors are sometimes provided. As these inclosing structures must be built to be tight enough to prevent any entrance of dust, they also interfere with the egress of heat and may cause overheating in motors designed for free ventilation in the open air. A practical protective casing can be made, however, by erecting a framework about the motor and covering this over with cheese-cloth or other fabric. The open weave of the cloth permits the ready escape of heat, but prevents the entrance of dust to the motor.

Temperature Inversions in Relation to Frost*

Methods for Anticipating Critical Periods and Protecting Crops

By Alexander McAdie

Only in recent years have aerologists given much attention to the slow moving currents of the lower strata of the atmosphere. These differ greatly from the whirls and cataracts of both high and low levels which we familiarly know as the winds. The larger and more energetic air streams play a part in the formation of frost and their importance is not to be underestimated; but primarily it is a slow surface flow, almost a creeping, of the air near the ground which controls the temperature and is all important in frost formation. It is, therefore, of some importance to study the conditions which bring about this slow movement or displacement of air. It is true that there are times when, with thorough mixing and ventilation, and little opportunity for slow displacement, temperature will fall to low points and damage from frost result; but such conditions are more properly described as cold waves, though the term is somewhat misleading, or as freezes. In such cases there is an unusual loss of heat by direct convection and the translation of masses of cold air. Strictly speaking, frosts are connected with temperature inversions brought about by vertical movement of tne air, rather than horizontal; and are, therefore, essentially problems in *local air drainage.* The expression local air drainage requires some explanation. It was first used, so far as known, in explaining frost, by the writer, in his publication, *Frost Fighting, Bulletin 29,* U. S. Weather Bureau, 1900. It was there shown that in the valleys of California a slow but well-defined flow of the surface air can be traced and utilized in forecasting frosts. The condensed water vapor or fog can be seen drifting into the valleys or settling in the low places. There are well-marked stream lines and one is led to believe that a mixture of air and water vapor of a given temperature, say 278 deg. A., is cooled by contact with the hill-tops; and under the influence of gravity and other causes flows down the slopes.

It is well known that soon after sunset, valleys and low places serve as catchment basins for slow moving air that is denser and colder. The hill-tops, terraces and even mountain tops, if not too high, are in contact with air of higher temperature, which must be either an indraft from warm surrounding strata, or the displaced air from below. How the circulation begins and how it is maintained are not clearly understood; and, unfortunately, we have no instruments sufficiently sensitive for our needs. The cooling of the lower levels, the warming of the upper levels and the existence of an inversion, are evidently not the result of a single cause. But one fact stands out strongly in all of the investigations thus far made; and that is, that where the *air is in motion* there is less likelihood of frost than where the air is stagnant. This may be called the first law of frost formation.

One factor in establishing the circulation is that slopes, especially those facing west or southwest, have been heated by insolation during the day and therefore radiate more rapidly, since radiation is a function of the absolute temperature; but the energy thus radiated is not absorbed by any layer of vapor and dust particles, as generally is the case with the radiation from the lower levels. The valleys and low levels lose heat by radiation; but soon after sunset there is formed a thin blanket of condensed vapor, which interferes with free radiation and checks the rate of cooling. The air at the higher level is robbed of its vapor and dust nuclei, becoming more and more like a pure gas and permitting freer radiation. Mixed air and vapor is lighter than dry air per unit volume; and thus moist air would naturally tend to rise. The condensed vapor, however, must be regarded in a different light from the vapor before condensation. In condensing and also, but to less degree in congealing into frost flakes, heat is set free in the sense that molecular energy is decreased. This heat is not shown as a direct rise in temperature but does serve to prevent fall in temperature, such as expansion due to rising would produce. Thus, we have near the ground an increasing load of condensed vapor or vapor near the condensing point, which either crystallizes as frost with further cooling or is carried away by convective currents.

We see then that there are various conflicting processes; for there is gain and loss of heat by radiation (the upper slopes losing heat by radiation and the lower air masses gaining heat); retardation or acceleration of rate of temperature change by the change in state of the water vapor; direct gain or loss of heat by convection or the actual translation of cold and warm air masses; and, finally, we have a slight gain or loss by conductivity.

Unfortunately the term frost has been used as synonymous with lowest temperature, whereas it more properly is simply an indication of the existence of sufficient water vapor changed into ice in the form of spicular crystals. Such deposit does not necessarily indicate the place of lowest temperature, for with other than saturation conditions, lower temperatures may prevail without the crystals forming.

Some good illustrations of inversions of temperature are shown in the accompanying diagrams (Figs. 1, 2 and 3).

Fig. 1 illustrates a remarkable inversion which occurred January 5th, 1904, when the temperature at the valley station fell to 233 deg. A. There was also an inversion of similar character on the succeeding night. In Fig. 2 is shown an inversion occurring on February 25th, 1914, which is of special interest as the effective cause of cooling did not begin soon after sunset, as is the case with most inversions; and, in fact, did not manifest itself until *long after midnight.* Fig. 3 illustrates typical early fall and late spring inversions, of special interest to gardeners and truck farmers.

In all of these it will be noticed that there is a rapid rise in temperature at the lowest level, shortly after sunrise and a slow rise at the base, and still slower at the summit. The respective heights of the three stations are valley 18 meters, base of hill 66 meters, and summit 200 meters above sea level. This rapid rise at the valley level is significant for it indicates that with the formation of convective currents, due to insolation, there is air 0.98 degree for each hundred meter rise; but no such condition is found to occur at times of frost. On the contrary, as we have seen above, there is gain and loss of heat in various ways, and adiabatic equilibrium is out of the question. Neither the adiabatic rate for dry air nor for saturated air holds from the ground up to 200 meters. Instead of a fall there is a rise in temperature.

Nearly always as the temperature rises the humidity falls. Unfortunately our instruments for recording humidity are unsatisfactory. Relative humidity, standing by itself and as ordinarily expressed is very misleading; and, in fact, means a ratio in which one term is suppressed. No proper study of frost or temperature inversion can be made without a full and definite knowledge of the behavior of the water vapor and dust content. A form of instrument devised by the writer is a decided improvement over the usual form of hygrograph. It is known as a Saturation Deficit Recorder and gives a continuous record of the weight of the vapor in grammes per unit volume. The temperatures are given in degrees absolute, but the record sheet also is graduated to show the saturation weights for each degree. The thermograph portion of the instument, therefore, records the appropriate weight of the water vapor per cubic meter at saturation and the hygrograph portion gives the percentage existing. The difference between the two is the saturation deficit, a quantity that may be used to advantage in discussions of frost formation or in the more general problem of the changes in a given volume of moist air as it rises or falls or is transported from a region of high to a region of low pressure.

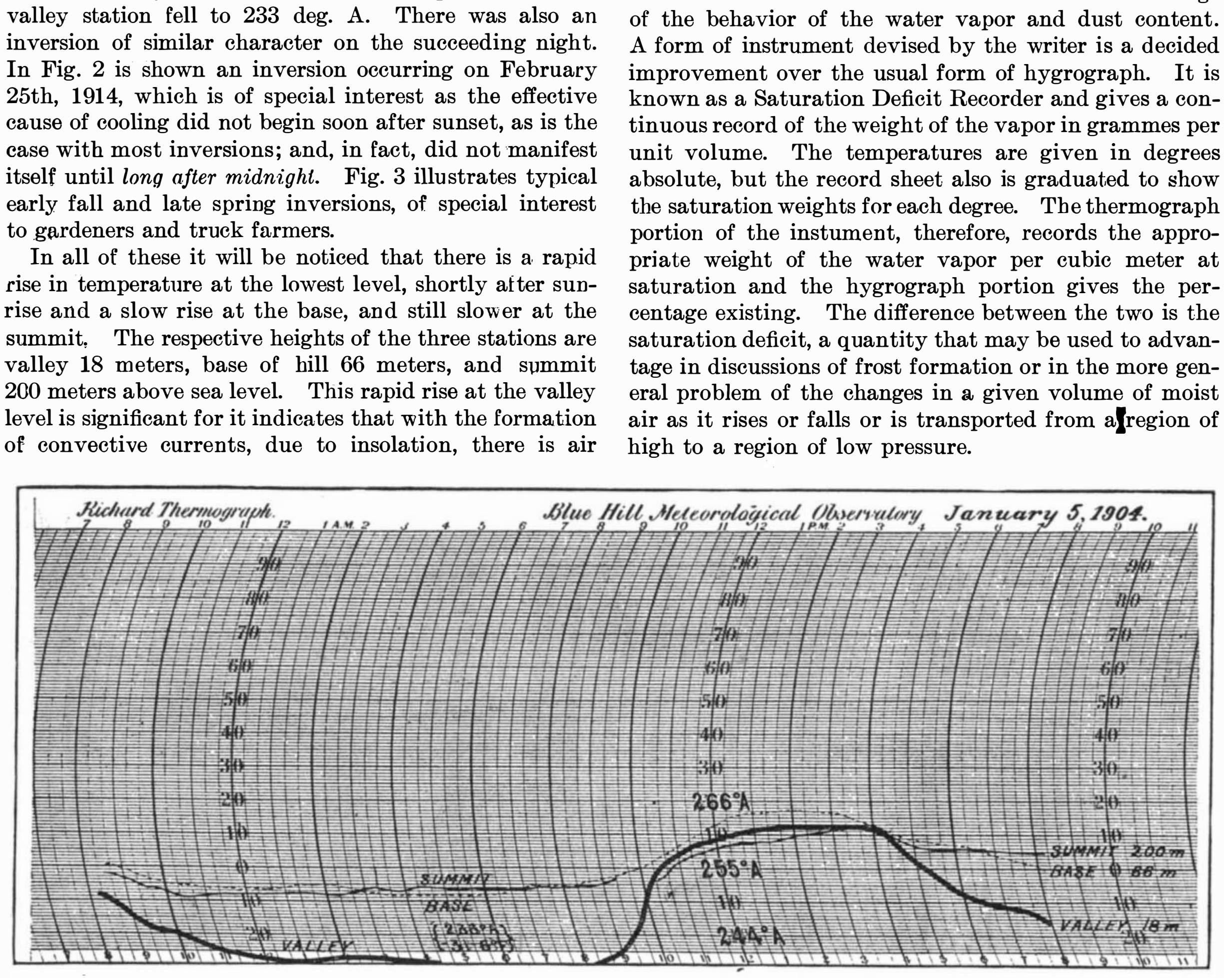


Fig. 1.—Winter type. Marked cooling 8 P. M. to 12 midnight, marked warming 8 A. M. to 11 A. M.

movement and effective heating. One might infer from this that the effective cause of cooling is not radiation but the rapid dying out of convectional currents near the ground after sunset, despite any acceleration due to displacement by the slow, down-moving air from the slopes. The mass of air surrounding the summit and hill-tops is in the main warmer, as we have seen; and remains relatively warm throughout the night, since radiation from air is less rapid than from the hillsides. Apparently, then, there is a slow flow of air down the sides into the valley; but no marked convectional interchange between the different levels. It should be noted that in the valley under discussion (the Neponset) the western slopes are far distant, so that in this case, the contour is not such as to confine the descending currents. It seems also plain from these inversions that the principal reason why the summit temperature remains high during the night is because of the existence of a moderate air movement and consequent mixing. Frequent eye observations of the rate of ascent of smoke from the valley on quiet, clear afternoons have enabled members of the Observatory staff to surmise the existence of inversion and to anticipate the frosts of the next morning, with a high accuracy. Any change in velocity or direction of air flow is accompanied with fluctuation in temperature. Discussion of the pressure distribution and general circulation must be restricted, for lack of space, and at present it will be enough to say that there are certain types of storm movement easily recognizable, which are followed by frosts. Gusty northwest winds, dying out at sunset, with unclouded skies and low and decreasing humidity above 100 meters but increasing in the lower levels, are significant local conditions preceding inversion and favoring frost.

Some writers have made use in their frost discussions of the adiabatic rate of fall of temperature, which is

It is to be regretted that we have no method of recording continuously what von Bezold has termed the *mixing ratio* or the mass of vapor mixed with a unit mass of dry air expressed as a fraction of this latter unit, nor that other term, which he calls the *specific humidity* or the quantity of vapor in a unit mass of moist air expressed in fractional parts of this unit. There is a difference, too, between vapor pressure and absolute humidity although the two are often considered as equivalent. The record of the mixing ratio would be important in frost work since for any given change of level, the change in the mixing ratio would give the quantity of ice deposited, not in this case due to ascent of the air, but by contact with the hillsides cooled by rapid radiation, or with the floor of the valley which also acts as a condensing surface. Moreover, the quantity of water (or frost crystals) thus separated from the air would give an indication of the intensity of the up-and-down movement of the air and vapor. We have, indeed, in frost conditions a problem somewhat similar to that in certain cloud formations, billow and bar, less pronounced but none the less phenomena of moving air strata of different temperatures and densities in close proximity. It may be pointed out, too, as Neuhoff has shown in his reconstruction of the Hertz diagram, that at 273 deg. A. altitude lines run parallel to pressure lines at equal distances from each other for equal pressure changes and, hence, the isothermal change of altitude at freezing temperature is proportional to the quantity of water present. Practically one gramme of freezing water is equivalent to a change of level of 27 meters.

A more direct form of instrument is that of the Foxboro type, the record of which is continuous not only for the temperature but also the temperature of evaporation. The pressure of the aqueous vapor can be readily determined from the formula as given by Ferrel (Report

*From *Annals* of the Astronomical Observatory of Harvard College, Vol. lxxiii, part 2.

C. S. O. 1886 App. 24) or directly from Table 150, Smithsonian Physical Tables 1914, p. 157. The dew-point, relative humidity, and humidity term 0.378 e which occurs in the formula for density of air containing aqueous vapor at pressure e can be easily obtained. This instrument gives more accurate readings if the two thermometers are placed near a small fan or other ventilating device. It is also preferable that this instrument be not inclosed in the usual louvered shelter, nor at the customary elevation of two meters above the ground; but as near the ground as possible.

Records of relative humidity as usually given are of doubtful value. As stated above, this term standing by itself means nothing.

It is also necessary to pay special attention to the purity of the water and the cleanness of the muslin used on the wet-bulb for evaporating the film of water. The pressure of saturated aqueous vapor varies somewhat at temperatures near 273 deg. A, depending upon whether the radiation is from a water or an ice surface. The following short table illustrates this difference:

	Temperature	Vapor pressure
Over water,	270° A	4.9 Kbs
	271°	5.3 "
	272°	5.7 "
	273°	6.1 "
Over ice,	270° A	4.7 Kb
	271°	5.2 "
	272°	5.6 "
	273°	6.1 "

It is important to obtain reliable records of the amount of water vapor present; and, if possible, the changes which this quantity undergoes. We believe that one source of cooling is the abstraction of considerable moisture from the air; and consequent increase in radiation. A copious deposit of frost, however, does not necessarily indicate the region of lowest temperature.

We have seen that the motion of the air is complicated at times of frost, and so, too, the motions and changes of form of the vapor. In a sense they are independent variables. A cubic meter of pure, dry air at 283 degrees weighs 1,247 grammes; but if cooled to 273 degrees weighs 46 grammes more. A cubic meter of mixed air and saturated vapor at 283 degrees weighs 1,242 grammes or 5 grammes less; and if this were cooled 10 degrees the mixture would weigh three grammes less than the same volume of pure dry air. In each case the mixture of air and water vapor weighs less than the air by itself. One would think that adding water vapor, which while light still has weight, would make the total weight the sum of both. It really is so, notwithstanding the above figures; and the explanation of the puzzle is found in an increase in pressure and consequent expansion, so that the volume of the air and saturated vapor is greater than one cubic meter. Since then a cubic meter of air and saturated vapor weighs less than a cubic meter of dry air at freezing temperature, we may expect moist air to rise and dry air to fall. Consequently, if, in addition to falling temperature, there is also a drying of the upper air, we shall have an accelerated settling or descent of cold dry air to the ground which, of course, favors the formation of frost. The water vapor plays also another role besides that of varying the weight per unit volume. The heat received by the ground consists of waves of a certain wave-length; but the heat re-radiated by the ground consists of waves of longer wave-length, and these so-called waves (twelve thousandths of a millimeter) are readily absorbed by water vapor. Thus, water vapor acts like a blanket and holds the heat, preventing loss of heat by radiation to space. Further on we shall speak of the high specific heat of both water vapor and ice as compared with air and show the bearing of this in frost fighting; but at present we may, from what precedes, formulate the second law of frost formation as follows: "Frost is more likely to occur when the upper air is dry than when it is moist." It is also true that a dusty atmosphere is less favorable for frost than a dust free atmosphere. Thus, we may generalize and say that whatever favors clear, still, dry air, favors frost. The theory of successful frost fighting then is to interfere with or prevent these processes which, as we have seen, facilitate cooling close to the ground. In what way can this best be done?

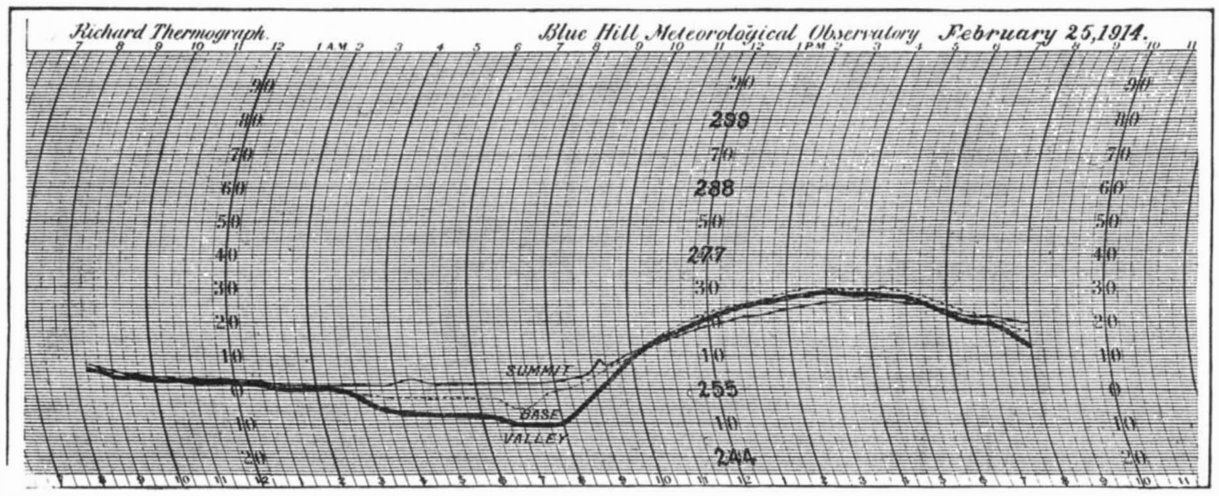


Fig. 2.—Unusual type. Marked cooling began 2:20 A. M.

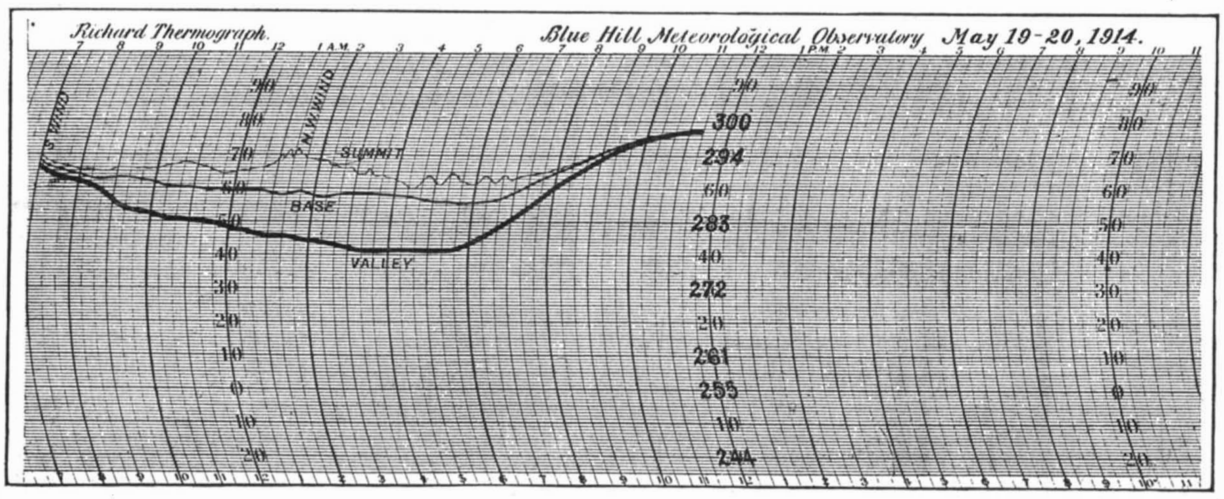


Fig. 3.—Typical late spring frost.

PROTECTION FROM INJURY BY FROST.

The most natural way would be to conserve the earth's heat, which could be accomplished by covering plants with cloth, straw, newspaper, or perhaps better still, modern weather-proof sheeting, or in still another way, by a cover of dense smoke, generally called a smudge. A second method would be by means of direct application of heat; and this is accomplished in orange groves by means of improved orchard heaters. Large fires waste heat and are neither economical nor effective. A third method would be based upon some method of mixing the air strata and getting the benefit of the warmer higher levels. Fourth. advantage might be taken of some agency, such as water or water vapor, having a high specific heat. Finally, if the crop is of a certain character, such as the cranberry, it will be found advisable to use sand, and to drain and clean, here again making use of the specific heat of some intermediary. And, furthermore, any one of these methods may be combined with some other method.

Regarding the first method, that of covers, it may be said that the practice goes back to the early husbandmen; but only in the last few years has the true function of the cover been properly interpreted and we are still far from obtaining maximum efficiency, nor is there yet a suitable, scientific cover available. Any medium that interferes with loss of heat through free radiation before and after sunset is a cover. The best type of cover is a cloud; and clouds whether high or low are good frost protectors. On cloudy nights there is little likelihood of frost; nor do inversions occur. We have mentioned above the fact that the earth radiates the heat it has received not in the same but in longer wave-lengths. These are easily trapped and held by the vapor of water. Furthermore, the rate of radiation is a function of the absolute temperature and so the rapidity of loss depends somewhat upon the heat received. Therefore, the cover should be used as early in the day as possible, that is, just before sunset. Aside from the water cover or vapor cover there are cheap cloth screens, fiber screens and also lath screens.

The second method, that of direct heating, has met with much success in the orange groves of California and elsewhere. Modern heating methods date from experiments begun in 1895. A number of basic patents granted to the writer in this connection have been dedicated to the public. At the present time there are on the market some twenty forms of heaters, which have been described with more or less detail in farm journals and official publications. It is not necessary to refer to them further here. The fuel originally used was wood, straw and coal, but these are now supplanted by crude oil or distillate. It has also been seriously proposed to use electric heaters, also to use gas. Properly installed and handled, there is no difficulty in raising the temperature of even comparatively large tracts five degrees and maintaining a temperature above freezing, thus preventing refrigeration of plant tissue.

The third method, that of utilizing the heat of higher levels by mixing, has not yet been commercially developed; while the methods of applying water, either in the spraying of trees or the running of ditches or the flooding of bogs, together with methods of sanding, cleaning and draining, have all been proven helpful. Methods available and most effective in one section may not necessarily be effective in another section or with different crop requirements. Certain devices most effective in the groves of California may not answer in Florida or Louisiana because of entirely different weather conditions. Along the Gulf coast, where water is available, it may be advantageously used to hold back ripening and retard development until after the cold waves of middle and late February have passed, whereas, on the west coast, conditions are very different, water having a definite value and the critical periods coming in late December or early January.

In what precedes, stress has been laid chiefly upon the fall of temperature and the congelation of the water vapor. There is, however, another important matter connected with injury to plant tissue and that is the rise in temperature after the frost. A too rapid defrosting may do considerable damage where no damage was originally done by the low temperature. It is in this connection that water may be used to great advantage. Water, water-vapor and ice, compared with other substances, have remarkably high specific heats. If the specific heat under constant pressure of water be taken as unity, that of ice is 0.49; of water vapor 0.45 and of air 0.24. Or in a general way, we may say that water has four times the capacity for heat that air has. Therefore, it is apparent that water will serve excellently to prevent rapid change in temperature. This is important at sunrise and shortly after when some portion of the chilled plant tissue may be exposed to a warming sufficient to raise the temperature of the exposed portion 10 degrees in an hour.

The latent heat of fusion of ice is 79.6 calories, and the latent heat of vaporization of water is nearly 600 small calories, or therms per gramme. Therefore, in the process of changing from solid to liquid to vapor, as from ice to water to vapor, a large amount of heat is liberated. This does not mean as is generally assumed that the air will be warmed, but it does mean a retardation of temperature change. And it is essential that the restoration of the tissues and juices to their normal state be accomplished gradually, neither too rapidly nor yet too slowly. There is probably an optimum temperature for thawing or defrosting frozen fruits and flowers.

Finally, the temperature records as ordinarily obtained need careful interpretation. It may be that the freezing point of liquids under pressure in the plant cells or exposed to the air through the stomata is not the same as in the free air. It is unfortunate, too, that in most places data showing temperatures of soil, plant and air are of doubtful character. A word of warning may be given against the too ready acceptance of Weather Bureau records made in cities and on the roofs of buildings. Garden and field conditions vary greatly from these. It is further advisable to obtain a continuous record of the temperature of evaporation, such as is shown by the records herewith. The two temperature curves made simultaneously and easily read at any moment enable the gardener or orchardist to forecast the probable minimum temperature of the ensuing ten or twelve hours. But not always, and some study is necessary. A slight increase in cloudiness or a slight shift in wind direction will prevent the fall in temperature, which otherwise seemed probable. With a persistent inversion of temperature there is sometimes an increasing absolute hu-

midity. In fact, the problem is many sided and we must consider the motion of the air vertically as well as horizontally. Air gains and loses heat chiefly by convection, and any gain or loss by conduction may be neglected. The plant gains heat by convection, radiation and perhaps by conduction of an internal rather than surface character. The ground gains and loses heat chiefly by radiation. But the whole process is complicated, nor are the rates of change uniform. Frosts generally are preceded by a loss of heat from the lower air strata, due to convection and a horizontal translation of the air. Then follows an equally rapid and great loss of heat by free radiation. There are minor changes, such as the setting free of heat in condensation and its utilization in evaporation, but these latent heats are of less importance than the actual transference of the air and vapor and the removal of the latter as an absorber and retainer of heat.

Frosts are recurrent phenomena reasonably certain to occur within given dates; and, as pointed out above, the cumulative losses are considerable. Methods of protection to be serviceable must be available for more than one occasion, for there is no profit in saving a crop on one night and losing it on the succeeding night. But the effort is worth while. Consider that the horticulturist regularly risks the labor of many months on the temperatures of a few hours. An efficient frost-fighting device is, in a way, the entering wedge for solving problems of climate control. One may not take a crop indoors, it is true, but there is no valid reason, in the light of what has been already accomplished, why at critical periods which may be anticipated, the needed volume of surface air may not be sufficiently warmed; and the losses which have heretofore been considered inevitable, be prevented.

Metallographic Description of Ancient Peruvian Bronzes*

Studies That Throw Light on Methods of Manufacture

By C. H. Mathewson

I AM indebted to Prof. Hiram Bingham for an opportunity to examine the ancient Peruvian bronzes collected at Machu Picchu by the National Geographic Society, Yale University Peruvian Expedition of 1912. The structures exhibited by objects of this character are of interest not only to metallographists, but also in archæological circles, inasmuch as certain definite facts concerning the methods used in shaping the objects can be learned from the structural examination. Such work, however, necessitates some mutilation of the specimens, which doubtless accounts for the scarcity of metallographic work devoted to rare objects. Collectors frequently submit their specimens for chemical analysis, since this merely involves the preparation of a small sample by drillling, while the scope of the forthcoming information is known in advance and the undertaking can be intelligently provided for. Metallographic examination, on the other hand, may yield much or little information and generally necessitates subsequent restoration of the object.

As to the character of the information likely to be obtained by the use of metallographic methods, the following general statements may be of service to those who are unfamiliar with this class of work:

1. An unaltered cast structure can be recognized at once and a qualitative distinction between rapidly cooled metal, e. g., metal cast in a small unit, and slowly cooled metal, e. g., metal from a casting of considerable size, can be made.

2. An annealed casting can be distinguished from an unannealed casting, but such annealing would serve no useful purpose in small bronzes of low tin-content and, in any case, would hardly be undertaken except as a preliminary to other operations resulting in more or less complete obliteration of the casting structure.

3. Mechanical alteration of a cast piece, or of a piece with more extended but not necessarily known past history, by rolling, hammering, etc., can be detected with certainty provided the piece has been worked with considerable intensity. A few gentle blows with the hammer, a bend, or a twist, would not alter the visible structure of the metal, but mechanical treatment resulting in pronounced change of form gives rise to characteristic structural changes as well. These effects do not, however, serve to differentiate at all sharply between different forms of mechanical treatment, whether by rolling, hammering, etc. It seems necessary to rely mainly upon surface observations for evidence of this character. Under the influence of mechanical treatment, the metal stiffens and gradually loses its ductility until, eventually, further change of form cannot be brought about without fracture. The precise nature of these changes cannot be detected by observations under the microscope. Certain coincident effects, such as elongation and etching peculiarities of the crystalline grains, serve, together with physical tests, to establish the worked condition of the metal.

4. Annealing restores the ductility by producing an entirely new growth of grain in which certain unfailing characteristics may be recognized. Thus, a recrystallized bronze can be recognized at once and the evidence of previous mechanical treatment, with following anneal, is thereupon complete. The nature of the recrystallization, whether fine- or coarse-grained, localized or evenly distributed, incipient or sufficiently developed to entirely obliterate the pre-existing structure, depends upon the composition of the metal, the nature, intensity and distribution of the mechanical treatment, as well as the temperature and duration of the anneal.

Fortunately, careful study of the recrystallization phenomena in a particular group of alloys leads to certain associations and generalizations, so that the treatment resulting in a given structure may frequently be specified without the too free admission of bewildering assumptions and conditional premises. Certain shortcomings must, however, be admitted. For example, a ductile object may be lengthened at will by intensive rolling, drawing, or hammering, if an adequate number of intermediate softening, or annealing, operations are conducted. The final structure and physical properties are determined by the last co-ordinated draft and anneal unless unusually light mechanical or annealing treatment has prevailed. No knowledge of preceding operations can ordinarily be derived from the structural characteristics at this point. If the duration of the last anneal is approximately known the temperature region of annealing may be estimated from the mean grain size. Some distinctions can be made without regarding the time factor, e. g., an anneal at bright red heat can be distinguished from one at nascent red, since the coarse grain produced in a very few minutes at the higher temperatures is not much affected by longer exposure and cannot be duplicated by even a very prolonged anneal at the lower temperature. It has thus been possible to fairly estimate the temperature which must have been reached in the finishing anneal of some of these old bronzes.

While, in completely recrystallized structures, the grain characteristics give no indication of the total extension of the piece or the number of stages in the process, partially recrystallized structures, in which traces of the cast condition are apparent, indicate that the finished piece corresponds closely in form to the original castings. Thus, a number of the bronzes examined were obviously cast in the rough and wrought into shape, the process requiring a moderate amount of work and a limited number of annealing operations; perhaps only one.

5. Drastic treatment whereby the object, by successive drafts and anneals, suffers manifold extension in one direction or another may sometimes be recognized by characteristic migrations of insoluble impurities which have remained sensibly unaffected during the heat treatment. Such evidence is purely qualitative, since the extension of individual units within the moving mass is not proportional to the extension of the piece as a whole. Most of the bronzes contain sulphur in small amounts which, from the chemical relationships involved, must occur in the form of cuprous sulphide. In the thin, flat bronze knives of the collection, the particles of cuprous sulphide are elongated to a degree attainable only through several successive drawing and annealing operations. A copper knife of similar form contains in the neighborhood of one per cent of cuprous oxide which, in the broader and thicker parts of the specimen, occurs in normal eutectic form as small globules characteristically grouped throughout the copper matrix. In the intensively worked parts of the specimen, notably the blade, each group of oxide particles has been dragged out into a continuous train which gives the appearance of a dotted line in the photo-micrograph.

6. Positive identification of hot-worked metal is not always possible, since, in hot-working at effective temperatures, the deformation is followed by recrystallization as in the anneal of cold-worked metal. Variables of the same character affect the result. In hot-working, however, recrystallization always takes place at temperatures[1] which would produce relatively coarse grain if time enough were allowed. Thus, the grain size is determined mainly by the time available for recrystallization between the blows, or after working has ceased. With small specimens, this is almost invariably brief, since the small mass of metal cools rapidly. Upon reheating, a coarser grain will develop. Since, with primitive facilities, it is impossible to work the whole mass of metal simultaneously, attention will first be directed to some particular portion which will later develop a relatively coarse grain while other portions are being worked. This results in a highly non-uniform conglomerate. Hot-working is, therefore, indicated where coarse and fine grains are found closely associated and where neighboring parts of the specimen exhibit wide variation in grain size.

The foregoing statement will indicate in a general way what manner of conclusions may be drawn from metallographic examination as applied to metal of sensibly uniform composition throughout, viz., in the case of pure metals or solid solutions. Some of these statements will be elaborated further on and the specific application of the principles involved will be given in individual descriptions of the several objects.

Additional characteristics are encountered when constitutional changes occur during thermal treatment of the metal, i. e., when the alloy is made up of two or more distinct structure elements differing in composition and subject to influences affecting their composition, distribution, or even identity. These characteristics may be used, in conjunction with the others already mentioned, to supply some knowledge of the past history of the object. To further the immediate appreciation of prevailing conditions, it may be observed at this point that, while all of the bronzes examined are normally composed of a single structure element, the alpha solution of tin in copper, certain secondary constituents of a transitory nature occur in the cast metal.

Aside from the purely micrographic aspects of the work, some facts of interest may be learned from first-hand observation. Thus, certain of the objects, notably the long cloak pins, show surfaces which may be closely simulated in wood by whittling; the separate surface elements are approximately flat and long enough in some cases to indicate the use of a very broad-faced hammer or even a rolling face in shaping the metal. One large pin has a flattened head bearing a single perforation, which, from its eccentricity and decreased diameter on one face, must have existed before the head was flattened. (A cylindrical hole starts to close on the hammered face.) Duplex objects, in which different parts are joined mechanically, by welding, or by duplex casting, may sometimes be recognized by superficial examination. A case of the last-named variety was found in the present collection. Where surface indications are not adequate, examination of a properly selected section will serve to settle the question.

The archæologist will doubtless be inclined to look through these pages for some expression as to the probable age of the bronzes. Unfortunately, no inferences of this sort can be drawn from examinations of this character, or from any other form of examination, as far as I am aware. The rate of oxidation, or patina formation, depends upon the purity and structural condition of the metal, but no laws governing the process have been formulated. Cast structures are more porous and structurally less homogeneous than worked structures and oxidize more rapidly. Certain structure elements are attacked selectively on long exposure to atmospheric influences.

Garland concludes from examination of some ancient Egyptian bronzes that some recrystallization of worked portions has very likely been effected by ageing; Rose, to possible recrystallization of an old trial plate of gold used as an assay standard in the Royal (British) Mint. Such conclusions are interesting, but they are based wholly upon circumstantial evidence. I have observed cases of incipient recrystallization of vigorous worked metal in the present collection of bronzes, but precisely the same effect may be produced by a form of annealing which is clearly indicated from other considerations. In other cases, the very fine recrystallized grains show deformational characteristics which proves that they were produced by the original craftsmen. Numerous mechanically hardened and subsequently unaltered (by perceptible recrystallization) structures were observed. In no case does it seem necessary to resort to ageing for an explanation of the structures observed in these bronzes. Whatever the actual facts involved, any eventual reversion of unstable, mechanically hardened, structures to more stable (recrystallized) form cannot be defined as a determi-

* Extracts from a contribution from the Hammond Laboratory of the Sheffield Scientific School, Yale University, published in the *American Journal of Science.*

[1] Where both hot-working and cold-working are permissible, as in the case of these alpha bronzes, the former is undertaken in order to avoid the necessity of annealing between stages of intensive working, i. e., the metal stays soft, owing to rapid recrystallization and relief of strain, if the temperature is high enough. A full red-heat is required for continued softness under a rapid succession of blows.

nate function of the time involved in the transformation.

It must likewise be conceded that metallographic examination of the finished object cannot be expected to furnish any clue to the smelting process used in preparing the metal or, indeed, to indicate whether the alloy was produced directly by smelting a mixed ore, or by alloying tin and copper.

SUMMARY OF ANALYSES AND STRUCTURAL EXAMINATION.

The present collection embraces about one hundred articles which may be classes as tools, including axes, hatchets, knives, chisels, bars and pointed instruments; domestic implements, including mirrors, tweezers, small knives, pins or needles, spatulas or spoons and various small articles ornamentally cast; articles of adornment, such as rings, bracelets, spangles, bells, etc.; and crude, or irregular pieces. A number of specimens (thirty-three in all) intended to approximately represent the diversity of the collection were analyzed. Twenty-one of these were cut into appropriate sections and examined structurally. A general summary of analytical data is given in the table.

No.	Character and Weight of Object.	Cu	Sn	Ag	Fe	S	
1	Knife, T-form. Weight, 26g.	94.26	4.82	-----	0.32	0.23	------
2	Spatula-shaped object. Ornam. head, bird-form	86.03	13.45	-----	---	---	Zn–0.32
3	Cloak-pin, star head. 37g.	95.99	3.60	-----	---	tr.	------
4	Ball. 35g.	96.90	2.11	0.81	---	---	------
5	Ornam. knife. Fisher-boy. 41g.	88.08	9.39	-----	---	---	Zn–0.17
6	Chisel. 224g.	96.20	3.71	-----	---	---	------
7	Knife, T-form. Llama head, 20g.	96.79	3.00	tr.	---	tr.	------
8	Axe, broken short below head. 242g.	93.70	5.01	-----	0.87	0.44	------
9	Thin, flat copper knife, T-form. 22g.	99.73	----	-----	---	tr.	------
10	Axe, broken short 1" above edge. 62g.	94.41	5.12	-----	---	0.29	------
11	Cloak pin, pierced flat head. 37g.	96.38	3.92	-----	---	---	------
12	Hand mirror. 72g.	94.35	5.34	-----	---	---	------
13	Tweezers, in process of manufacture. 9g.	90.05	9.72	-----	---	---	------
14	Thin, flat knife, T-form. 21g.	96.26	3.67	tr.	--	0.18	------
15	Axe with double-branched head. 414g.	95.63	3.99	0.37	---	0.40	------
16	Chisel, twisted and broken short. 100g.	93.90	5.53	-----	0.06	0.15	------
17	Irregular mass. 286g.	95.68	4.20	-----	---	---	------
18	Large, crude needle. 61g.	94.69	5.16	-----	---	---	------
19	Tweezers. 3g.	94.69	5.53	-----	---	---	------
20	Large bar. 1070g.	94.52	5.45	-----	---	tr.	------
21	Light rectangular piece. 20g.	94.42	5.96	-----	---	---	------
22	Thin, flat knife, T-form. 9g.	95.35	4.22	-----	---	0.20	------
23	" " " " 32g.	94.70	6.60	-----	---	tr.	------
24	" " " " 10g.	90.09	8.99	0.68	---	0.13	------
25	" " " " 49g.	92.55	7.14	tr.	---	0.20	------
26	" " " " 46g.	94.52	5.12	tr.	tr.	0.29	------
27	" " " " 18g.	95.03	5.12	tr.	---	tr.	------
28	Small bar. 32g.	92 06	7.30	0.31	---	---	------
29	Small rod. 8g.	93.21	6.90	-----	---	---	------
30	Irregular wrinkled sheet. 160g.	----	99.79	-----	---	---	Sb–0.08
31	Thin knife blade. 6g.	91.24	8.89	tr.	tr.	0.37	------
32	Small silver disc (spangle). 0.77g.	----	----	100.	---	---	------
33	" " " " 0.96g.	----	----	99.5	---	---	Pb–tr.

Some of the bronzes are remarkably pure, aside from small quantities of sulphur in the form of cuprous sulphide. This constituent was identified metallographically (cf. observations on cuprous sulphide in copper by Heyn and Bauer in every bronze examined, although sulphur was not reported in a number of the analyses.[2] One specimen, No. 8, contains nearly a per cent of iron, and another, No. 4, contains about the same quantity of silver. Others contain smaller percentages of these elements, while small amounts of zinc were found in two specimens. The rest of the bronzes contain practically no metallic impurities. Two silver disks are also very pure, one containing a trace of lead.

Perhaps the most noteworthy specimen is No. 30, which consists of very nearly pure tin. Other specimens were found in which strips of the metal were rolled into the form of a ball, presumably intended for convenience in cutting small pieces to alloy with copper. This metal was not analyzed, but it is unquestionably tin of good quality. Probably the discovery of these specimens constitutes the first direct proof that Inca metallurgists were acquainted with tin in elementary form. It is fair to infer that they used it in preparing their bronzes.

On the other hand, it is certainly true that the proportion of tin present in any given case has not been chosen with particular regard to the use for which the object must have been intended. The largest percentage of tin was found in a small spatula- or spoon-shaped object (No. 2) which is particularly distinguished by a perfectly executed cast figure of a humming bird at the extremity of the handle. This specimen contains 13.45 per cent tin. Next in order, we have another artistic casting representing a prostrate fisher-boy with line and fish which, although worked (mildly) into a blade below the figure, could never have been intended for severe use. This object contains 9.39 per cent tin. The ordinary axes and knives, which would seem to require high percentages of tin to give them maximum hardness and strength, carry from 3 to 9 per cent of this element, most of them in the neighborhood of 5 per cent. One knife, No. 9, is composed of very nearly pure copper. Boman points out similar anomalous relationships in discussing a table of some 65 analyses representing the compositions of various objects found in Argentina, Bolivia, Peru and Ecuador.

[2] When we consider that one part by weight of sulphur yields about five parts of cuprous sulphide, the constituent which appears under the microscope as a distinct structure element, it is apparent that the micrographic method may well be superior to methods of chemical analysis in detecting small quantities of sulphur in bronze.

At first sight these facts seem to indicate that the Inca bronzes were produced by smelting mixtures of tin and copper ores, since, by such a process, it would be difficult to control the composition of resulting alloy. According to Joyce, "it seems also certain that the presence of tin is accidental, since it is found in greatest quantity in those implements which require it least."

I have already remarked that metallographic testing methods cannot be expected to furnish any clue to the manner in which tin and copper were brought into association. Without additional facts of more direct application, it does not appear possible to prove the genesis of these bronzes. I wish, however, to draw attention to a few general considerations which have strengthened my belief that the present objects were produced by alloying the metals, tin and copper, after obtaining them in comparatively pure form.

In the first place, both tin and copper were known in elementary form, and the former metal must have led a transitory existence (as raw material for use in bronze making), since no finished objects of tin have been found in Inca ruins or burial places. From a metallurgical standpoint, while it is true that tin and copper occur closely associated in some Peruvian ores, I find it difficult to believe that these primitive people could have smelted mixed ores which would almost certainly contain other metals (lead, zinc, silver), and very likely arsenic and antimony, as well as sulphur, so as to produce the remarkably pure copper-tin alloys in question. A private communication from Mr. D. C. Babbitt, of the Cerro de Pasco Mining Company, contributes analyses of table concentrates from Peruvian sources showing copper and tin in association, together with silver, gold, tungsten, zinc, antimony, arsenic, sulphur and earthy material. These complex concentrates are handled with reluctance by the highly equipped smelters of Swansea (Wales), on account of smelting difficulties. Mr. Edmond A. Guggenheim, who has taken considerable pains to gather metallurgical opinions from his associates in South America, calls attention in a recent letter to the frequent occurrence of tin and copper in chemical or mineralogical combination; but, on the other hand, to the frequent occurrence of lodes carrying copper ores in association with tin ores. This is true of the Bolivian tin-fields, in which tin predominates over the copper. He also refers to the difficulty of smelting the associated ores, stating that in Cornwall, even in very remote times, the two classes of ores were separated before smelting.

It is far easier to believe that the Incas learned to recognize certain characteristic copper and tin minerals which were carefully hand-picked and smelted independently, or perhaps in association. Native copper, which occurs in small quantities throughout the Cordilleras, was probably known to them, while stream tin (cassiterite), also of likely occurrence in a limited sense, would furnish a very pure source of tin. The idea that native copper may itself contain percentages of the equivalent to those encountered in these bronzes cannot be entertained.

The fact that the percentage of tin contained in the Inca bronzes is not governed by the use for which they were intended raises the question as to what has governed the percentage of tin in case this was subject to some controlling influence. Joyce's observation that tin is found in greatest quantity in those objects which require it least is particularly interesting, since it suggests that the objects which require the least tin for proper service may require the most tin for some other reason. While I have not found time to search carefully through South American archæological literature for analyses pertaining especially to objects of known character, the present collection offers certain evidence bearing upon this question.

This evidence deals with the casting properties of bronze. As far as the present collection goes, those objects which would require the least tin in service are the more delicate or ornamental pieces. As already pointed out, the two finest castings, Nos. 2 and 5, contain maximum percentages of tin (13.45 and 9.39, resp.). A few rough experiments indicated that these high percentages of tin yield the best impressions in casting. Bronzes of this character expand in solidifying, whereby the finer details of the mold are registered in the metal, even though subsequent contraction, on cooling to ordinary temperature, determines a total shrinkage effect. Wust determined the value of this expansion (also the total shrinkage) in alloys containing approximately 5, 10, and 20 per cent tin. The percentage expansion was found to be 0.085, 0.122, and 0.01, respectively. Later, Haughton and Turner investigated the same property, using a somewhat different method, and located the maximum expansion at 10 per cent tin. Thus, we see the advantage of choosing alloys containing in the neighborhood of 10 per cent tin for casting purposes. It is also worthy of note that the 10 per cent alloy begins to freeze at a temperature some 50 degrees lower than the 5 per cent alloy, or some 80 degrees lower than pure copper. This means that, as the tin content increases, alloys from the same initial heat will remain longer in the fluid condition, whereby the casting operation is facilitated, particularly in the case of small objects which tend to chill rapidly.

Modern bronze compositions used in casting objects of art (statuary, etc.) usually contain fair percentages of zinc. This lowers the freezing point, increases fluidity, soundness and adaptability to hammering, chipping, etc. (lead is also an important addition agent where the latter property is particularly important), decreases cost and produces a pleasing color effect. Thurston specifies several suitable compositions, as follows: (1) Copper—92, Tin—2, Zinc—6; (2) Copper—85, Tin—5, Zinc—11; (3) Copper—65, Tin—3, Zinc—32. The expansion during the solidification and total shrinkage are generally favorable in well-chosen ternary alloys of this type. Cf. Miller.

Zinc occurs only as an incidental impurity in these bronzes and the Inca metallurgists were unable to avail themselves of its useful properties in this connection. Nor were they acquainted with other addition agents (e. g., phosphorus) which, by reducing the heavy, mechanically entangled tin oxide, itself formed during alloying by the reducing action of tin on the copper oxide commonly present in molten copper, slags out the oxide and cleans up the metal. Thus, their castings leave much to be desired by way of soundness and strength.

Having accounted for the high percentage of tin in ornamental cast objects, some attention will now be devoted to the objects which require strength and hardness for general industrial uses. No unusual characteristics were observed in any of these bronzes. They are simply alloys of tin and copper in which the physical properties were modified by the ordinary operations of forging, annealing, and cold-working. There is no evidence that any special heat treatment was adopted in order to facilitate the working of alloys high in tin. The metallographic tests indicate that cast pieces were usually hammered in their original condition and annealed as occasion demanded. Only moderate percentages of tin, preferably below 7 or 8, are safe when free working of the cast metal is a primary consideration. Foote and Buell, in a recent examination of three Peruvian bronze axes of uncertain origin, found 12.03, 5.58, and 3.36 per cent tin, respectively. They were unable to cold-work cast metal similar in composition to the first of these axes without first applying a special form of heat treatment, the significance of which will be pointed out later on. The four axes and chisels of the present collection (Nos. 6, 8, 15, and 16) contain from 3.71 to 5.53 per cent tin. Shepherd and Upton have shown that the ductility of cast specimens decreases rapidly beyond 5 per cent tin. The latter alloy gave an ultimate elongation of about 20 per cent, scarcely inferior to that obtained from pure copper, while, at 10 per cent tin, the elongation dropped to half this value. In the words of the author, "by suitable heat treatment, it is possible to vary the ultimate elongation of a bronze containing 90 per cent copper from 10 per cent to 37 per cent without affecting the tensile strength materially."

It is probable that the early Incas, at least, were unfamiliar with refined methods of heat treatment and were compelled to sacrifice the extra hardness and strength obtainable by increasing the tin content in favor of very free working properties. We would hardly expect the many different objects to show the same composition within narrow limits, since, aside from certain marked variations quite likely to arise in foundry practice which is not subject to analytical control, a greater or lesser degree of softness (measured by the tin content) would be desired to favor particular requirements in shaping the object. We may add that cold-working was invariably depended upon to produce the final stiffness and hardness of an object.

Rapid Production of Working Drawings

An ingenious method of getting out a set of blue prints quickly has recently been proposed, which appears decidedly useful where the scale of the drawings is large enough and where too much detail is not required. A sheet of carbon paper is laid face up on the drawing table, and over it is placed a sheet of tough tissue paper, upon which the drawing is made in pencil. It will be seen that the carbon backing of the drawing makes it strong enough to enable a blue print to be made at once, without the delay of having to trace the drawing over with ink. Even when the carbon paper cannot be applied when the original drawing is made, it can be used subsequently with advantage, if the drawing is made on the tissue paper, as it requires less time to go over the lines with a pencil than with ink.

The Relative Stimulating Efficiency of Spectral Colors for the Lower Organisms*

By S. O. Mast

THE relation between color and reactions in organisms has for many years been a prominent problem in the study of behavior. The earlier investigators (Bert, Lubbock, Romanes, Graber and others) were interested in this problem largely from the point of view of comparative psychology. Their aim was to ascertain the relation between color-vision in man and in the various animals with the hope of thus elucidating the evolution of psychic phenomena.

Loeb studied the reaction to colors in plants and in animals for the purpose of showing that they are the same in both, hoping thus to demonstrate that there is nothing in the nature of psychic phenomena in animals. Other investigators, e. g., Englemann, Wiesner, Strasburger, Verworn, Parker and Blaauw, were interested in the problem more from the point of view of comparative physiology.

I have for some time held the opinion that, aside from the importance of this problem in comparative psychology and physiology, it ought to yield results which would throw light on the nature of the chemical changes in the organisms associated with the reactions to light, especially those associated with changes in the sense of the reactions.

The chief difficulty encountered in the work has been connected with obtaining monochromatic light and measuring it in terms suited for comparison. Thus while a considerable number of organisms, both plants and animals, have been investigated in regard to the relation between wave-length and stimulation, only in a few are the results of such a nature that they can be compared with sufficient accuracy to warrant more than very tentative conclusions. Moreover, in a number of cases, otherwise excellent, only the region in the spectrum of maximum stimulation has been ascertained. In the following observations, to be published in full elsewhere, these difficulties and defects have been to a large extent eliminated.

It is well known that many of the simplest organisms respond very definitely to light. Some orient and travel fairly directly toward the light, others away from the light, while still others go toward it under some conditions and away from it under others.

In a field consisting of two horizontal beams crossing at right angles these organisms proceed toward or from a point situated between the two beams. The location of this point depends upon the relative effective illumination received by the organisms from these beams. If it is the same in quality and quantity, so that the stimulation is the same, the point lies approximately half way between them. (Details as to the process of orientation in these organisms may be found in my book *Light and the Behavior of Organisms*, John Wiley & Sons, New York, 1911.) Consequently, whenever the organisms proceed toward or from a point thus located, it may be concluded that the stimulating effect of the light in the beams is equal, no matter how the light may differ, either in quantity or in quality. (This is literally true for only a few organisms, but the principle as applied holds for all, as will be demonstrated in the extended paper to follow.) It is, therefore, obvious that if the light in one beam is kept constant in quality, white for example, while that in the other is changed in color, the relative stimulating efficiency of the different colors can be ascertained. To do this all that is necessary is to vary the luminous intensity of the white light for each change in the colored light until, in each case, the organisms proceed on the same path. The stimulating effect of the different colors will then be directly proportional to the various luminous intensities of the white light required to make the organisms under each of the different conditions proceed in the same direction, e. g., if for green it required twice as much light from the white source to make the creatures take a given course as it does for yellow, then the stimulating effect of the green is twice as great as that of the yellow. To ascertain the relative efficiency in terms of wave-lengths and energy it is only necessary to use a spectrum having a known distribution of energy, and to make corresponding corrections in accord with this distribution.

In the experiments referred to below, two gas-filled street-series tungsten lamps with coiled filaments were used in series to produce two beams of light. One of these beams passed through a Hilger constant deviation spectrometer and the other through a Lummer-Brodhun rotating sector. The whole apparatus was so arranged that the two beams of light crossed at right angles in the field of observation. For every color tested the intensity of the illumination in the beam of white light was adjusted by varying the opening in the sector, until the course of the organisms bisected the angle between the two beams of light. In nearly all cases the successive regions selected in the spectrum differed by 10 μμ. In this way the relative stimulating effect for the different regions of the spectrum was ascertained in fifteen different species as follows: Chlamydomonas, Trachelomonas and Phacus, each one species; Euglena five species; Panderina, Eudorina, Gonium and Spondylomorum, each one species; earthworms, Arenicola (larvæ) and blowfly (larvæ) each one species. All but the last three are green, microscopic organisms, relatively very simple in structure.

The results obtained will be stated in terms of relative stimulative effects of the different regions of the spectrum tested without corrections for the difference in the energy of these regions. They are, however, of such a nature that the corrections mentioned will not result in marked alterations. These corrections will appear in the final paper.

For all but one of the microscopic organisms the results fall into two groups. In one group the region of stimulation begins in the blue near the violet, between 430 and 440 μμ. From here toward the red end of the spectrum the stimulating efficiency rises, at first slowly and then rapidly, to a maximum in the green near the yellow, between 530 and 540 μμ; then it falls, at first rapidly and later more and more slowly, ending in the red at about 640μμ. In the other group the region of stimulation begins in the violet between 420 and 430 μμ, only a short distance from the place where it begins in the first group. From here the efficiency rises very rapidly, reaching a maximum in the blue between 480 and 490 μμ. It then falls rapidly and ends in the green in the neighborhood of 520 μμ. Three of the microscopic forms, Pandorina, Eudorina and Spondylomorum, belong to the first group, the rest to the second. To this group belong also Arenicola larvæ and the earthworms. For the remaining microscopic form (Chlamydomonas) the maximum is in the green very near 510 μμ; and for the blowfly larvæ it is approximately at 520 μμ. The distribution in the spectrum of stimulating efficiency is, for this creature, essentially the same as the distribution of brightness for totally color-blind persons. No difference in the relative effect of the different wave-lengths was discovered in any given species under different conditions. It was the same for organisms collected in different regions at different periods of the day and tested under various conditions of illumination and temperature, and it was the same for negative and positive individuals.

The results show that stimulation in all of the organisms studied depends upon the wave-length of the light; that the stimulating efficiency is very much higher in certain regions of the spectrum than in others; but that the distribution of this in the spectrum differs greatly in certain organisms that are closely related in structure, e. g., Pandorina and Gonium, while it is essentially the same in others that are very different in structure, e. g., Euglena and earthworms. They show, moreover, that if the absorption throughout the spectrum is the same in the different organisms the chemical or physical changes associated with the reactions differ in some species which are closely related. And that the changes in the organisms, whatever they may be, which cause changes in the sense of the reactions are not reversible; for if they were reversible one would expect the distribution of stimulating efficiency in the spectrum to differ in positive and negative specimens of the same species.

* *Proceedings* of the National Academy of Sciences.

The Gulf Oil Field

THIS field includes the pools of Southern Texas and Southern Louisiana, because these oils are much alike in their composition and in the products which they yield. In fact, these oils, though occurring over a long stretch of territory, are more uniform in composition than those of the Mid-Continental field. The oil is an asphaltic oil, with some of the characteristics of the oil from Baku, Russia. The similarity of the oil in all the pools of the Gulf field is doubtless due to the fact that it all occurs under practically the same conditions in connection with salt domes, which are thus far peculiar to the Gulf region. This mode of accumulation is somewhat analogous to that of the pools associated with igneous masses near the Gulf coast in Mexico. This Gulf oil has been of great value from the time of its first discovery, serving first an important purpose in developing a cheap and very satisfactory fuel for railroads. It also developed manufacturing enterprises very rapidly in the Gulf region. Later it was found practicable to refine it, and also within recent years the asphalt itself has become valuable for roofing and street paving and the asphaltic oil as a binder in macadam roads. The heavier naphtha serves unusually well as a solvent, and the lubricants have obtained an enviable reputation for their excellence.—From *Mineral Resources of the United States, 1913, Part II.*

Concrete Disease

AMONG professional maladies we mention a special form of skin eruption due to handling of cement, which is becoming prevalent since the extensive use of reinforced concrete. This eruption is commonly produced on the hands, fore-arm or breast when the workmen have these parts uncovered; also sometimes on the face, and the malady resembles the itch from the sensation which it produces. The effect comes from the alkaline contents of the material, and where the skin is already softened by contact with water, such substances have a marked effect. But such lesions of the skin are not serious, and a few days' rest with the use of a soothing liniment or a zinc ointment will cause the trouble to disappear. Covering the skin with a fatty substance and the use of suitable cloth gloves is a prevention, and it is recommended to give the exposed parts a good cleaning at the end of the day.

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