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THE FRANKFORT AND OFFENBACH ELECTRIC RAILWAY.

The electric railway recently set in operation between Frankfort and Offenbach furnishes an occasion for studying the question of such roads anew and from a practical standpoint. For elevated railways Messrs. Siemens and Halske a long time ago chose rails as current conductors. The electric railway from Berlin to Lichterfelde and the one at Vienna are in reality only elevated roads established upon the surface.

Although it is possible to insulate the rails in a satisfactory manner in the case of an elevated road, the conditions of insulation are not very favorable where the railway is to be constructed on a level with the surface. In this case it becomes necessary to dispense with the simple and cheap arrangement of rails as conductors, and to set up, instead, a number of poles to support the electric conductors. It is from these latter that certain devices of peculiar construction take up the current. The simplest arrangement to be adopted under these circumstances would evidently be to stretch a wire upon which a traveler would slide—this last named piece being connected with the locomotive by means of a flexible cord. This general idea, moreover, has been put in practice by several constructors.

In the Messrs. Siemens Bros.' electric railway that figured at Paris in 1881 the arrangement adopted for taking up the current consisted of two split tubes from which were suspended two small contact carriages that communicated with the electric car through the intermedium of flexible cables. This is the mode of construction that Messrs. Siemens and Halske have adopted in the railway from Frankfort to Offenbach. While the Paris road was of an entirely temporary character, that of Frankfort has been built according to extremely well studied plans, and after much light having been thrown upon the question of electric traction by three years of new experiments.

Fig. 1 shows the electric car at the moment of its start from Frankfort, Fig. 2 shows the arrangement of a turnout, and Fig. 3 gives a general plan of the electric works.

[Illustration: *Fig*. 1.—*The electric railway*, *Frankfort*, *Germany*.]

The two grooved tubes are suspended from insulators fixed upon external cast iron supports. As for the conductors, which have their resting points upon ordinary insulators mounted at the top of the same supports, these are cables composed of copper and steel. They serve both for leading the current and carrying the tubes. The same arrangement was used by Messrs. Siemens and Halske at Vienna in 1883.

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The motors, which are of 240 H.P., consist of two coupled steam engines of the Collmann system. The one shaft in common runs with a velocity of 60 revolutions per minute. Its motion is transmitted by means of ten hempen cables, 3.5 cm. in diameter. The flywheel, which is 4 m. in diameter, serves at the same time as a driving pulley. As the pulley mounted upon the transmitting shaft is only one meter in diameter, it follows that the shafting has a velocity of 240 revolutions per minute. The steam generators are of the Ten Brink type, and are seven in number. The normal pressure in them is four atmospheres. There are at present four dynamo-electric machines, but sufficient room was provided for four more. The shafts of the dynamos have a velocity of 600 revolutions per minute. The pulleys are 60 cm. in diameter, and the width of the driving belts is 18 cm. The dynamos are mounted upon rails so as to permit the tension of the belting to be regulated when necessity requires it. This arrangement, which possesses great advantages, had already been adopted in many other installations.

The electric machines are 2 meters in height. The diameter of the rings is about 45 cm. and their length is 70 cm. The electric tension of the dynamos measures 600 volts.

[Illustration: *Fig*. 2.—*Turnout track of the electric railway*, *Frankfort*, *Germany*.]

The duty varies between 80 and 50 per cent., according to the arrangement of the cars. The total length of the road is 6,655 meters. Usually, there are four cars *en route*, and two dynamos serve to create the current. When the cars are coupled in pairs, three dynamos are used—one of the machines being always held in reserve. All the dynamos are grouped for quantity.

[Illustration: *Fig*. 3.—*General plan of the electric works*.]

The company at present owns six closed and five open cars. In the former there is room for twenty-two persons. The weight of these cars varies between 3,500 and 4,000 kilos.—*La Lumiere Electrique.*

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By the addition of ten parts of collodion to fifteen of creasote (says the *Revue de Therap.*) a sort of jelly is obtained which is more convenient to apply to decayed teeth than is creasote in its liquid form.

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POSSIBILITIES OF THE TELEPHONE.

The meeting of the American Association was one of unusual interest and importance to the members of Section B. This is to be attributed not only to the unusually large attendance of American physicists, but also to the presence of a number of distinguished members of the British Association, who have contributed to the success of the meetings not only by presenting papers, but by entering freely into the discussions. In particular the section was fortunate in having the presence of Sir William Thomson, to whom more than to any one else we owe the successful operation of the great ocean cables, and who stands with Helmholtz first among living physicists. Whenever he entered any of the discussions, all were benefited by the clearness and suggestiveness of his remarks.

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Professor A. Graham Bell, the inventor of the telephone, read a paper giving a possible method of communication between ships at sea. The simple experiment that illustrates the method which he proposed is as follows: Take a basin of water, introduce into it, at two widely separated points, the two terminals of a battery circuit which contains an interrupter, making and breaking the circuit very rapidly. Now at two other points touch the water with the terminals of a circuit containing a telephone. A sound will be heard, except when the two telephone terminals touch the water at points where the potential is the same. In this way the equipotential lines can easily be picked out. Now to apply this to the case of a ship at sea: Suppose one ship to be provided with a dynamo machine generating a powerful current, and let one terminal enter the water at the prow of the ship, and the other to be carefully insulated, except at its end, and be trailed behind the ship, making connection with the sea at a considerable distance from the vessel; and suppose the current be rapidly made and broken by an interrupter; then the observer on a second vessel provided with similar terminal conductors to the first, but having a telephone instead of a dynamo, will be able to detect the presence of the other vessel even at a considerable distance; and by suitable modifications the direction of the other vessel may be found. This conception Professor Bell has actually tried on the Potomac River with two small boats, and found that at a mile and a quarter, the furthest distance experimented upon, the sound due to the action of the interrupter in one boat was distinctly audible in the other. The experiment did not succeed quite so well in salt water. Professor Trowbridge then mentioned a method which he had suggested some years ago for telegraphing across the ocean without a cable, the method having been suggested more for its interest than with any idea of its ever being put in practice. A conductor is supposed to be laid from Labrador to Patagonia, ending in the ocean at those points, and passing through New York, where a dynamo machine is supposed to be included in the circuit. In Europe a line is to extend from the north of Scotland to the south of Spain, making connections with the ocean at those points, and in this circuit is to be included a telephone. Then any change in the strength of the current in the American line would produce a corresponding change in current in the European line; and thus signals could be transmitted. Mr. Preece, of the English postal telegraph, then gave an account of how such a system had actually been put into practice in telegraphing between the Isle of Wight and Southampton during a suspension in the action of the regular cable communication. The instruments used were a telephone in one circuit, and in the other about twenty-five Leclanche cells and an interrupter. The sound could then be heard distinctly; and so communication

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was kept up until the cable was again in working order. Of the two lines used in this case, one extended from the sea at the end of the island near Hurst Castle, through the length of the island, and entered the sea again at Rye; while the line on the mainland ran from Hurst Castle, where it was connected with the sea, through Southampton to Portsmouth, where it again entered the sea. The distance between the two terminals at Hurst Castle was about one mile, while that between the terminals at Portsmouth and Rye amounted to six miles.—*Science.*

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PYROMETERS.

The accurate measurement of very high temperatures is a matter of great importance, especially with regard to metallurgical operations; but it is also one of great difficulty. Until recent years the only methods suggested were to measure the expansion of a given fluid or gas, as in the air pyrometer; or to measure the contraction of a cone of hard, burnt clay, as in the Wedgwood pyrometer. Neither of these systems was at all reliable or satisfactory. Lately, however, other principles have been introduced with considerable success, and the matter is of so much interest, not only to the practical manufacturer but also to the physicist, that a sketch of the chief systems now in use will probably be acceptable. He will thus be enabled to select the instrument best suited for the particular purpose he may have in view.

The first real improvement in this direction, as in so many others, is due to the genius of Sir William Siemens. His first attempt was a calorimetric pyrometer, in which a mass of copper at the temperature required to be known is thrown into the water of a calorimeter, and the heat it has absorbed thus determined. This method, however, is not very reliable, and was superseded by his well-known electric pyrometer. This rests on the principle that the electric resistance of metal conductors increases with the temperature. In the case of platinum, the metal chosen for the purpose, this increase up to 1,500 deg.C. is very nearly in the exact proportion of the rise of temperature. The principle is applied in the following manner: A cylinder of fireclay slides in a metal tube, and has two platinum wires one one-hundredth of an inch in diameter wound round it in separate grooves. Their ends are connected at the top to two conductors, which pass down inside the tube and end in a fireclay plug at the bottom. The other ends of the wires are connected with a small platinum coil, which is kept at a constant resistance. A third conductor starting from the top of the tube passes down through it, and comes out at the face of the metal plug. The tube is inserted in the medium whose temperature is to be found, and the electric resistance of the coil is measured by a differential voltameter. From this it is easy to deduce the temperature to which the platinum has been raised. This pyrometer is probably the most widely used at the present time.

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Tremeschini's pyrometer is based on a different principle, *viz*., on the expansion of a thin plate of platinum, which is heated by a mass of metal previously raised to the temperature of the medium. The exact arrangements are difficult to describe without the aid of drawings, but the result is to measure the difference of temperature between the medium to be tested and the atmosphere at the position of the instrument. The whole apparatus is simple, compact, and easy to manage, and its indications appear to be correct at least up to 800 deg.C.

The Trampler pyrometer is based upon the difference in the coefficients of dilatation for iron and graphite, that of the latter being about two-thirds that of the former. There is an iron tube containing a stick of hard graphite. This is placed in the medium to be examined, and both lengthen under the heat, but the iron the most of the two. At the top of the stick of graphite is a metal cap carrying a knife-edge, on which rests a bent lever pressed down upon it by a light spring. A fine chain attached to the long arm of this lever is wound upon a small pulley; a larger pulley on the same axis has wound upon it a second chain, which actuates a third pulley on the axis of the indicating needle. In this way the relative dilatation of the graphite is sufficiently magnified to be easily visible.

A somewhat similar instrument is the Gauntlett pyrometer, which is largely used in the north of England. Here the instrument is partly of iron, partly of fireclay, and the difference in the expansion of the two materials is caused to act by a system of springs upon a needle revolving upon a dial.

The Ducomet pyrometer is on a very different principle, and only applicable to rough determinations. It consists of a series of rings made of alloys which have slightly different melting-points. These are strung upon a rod, which is pushed into the medium to be measured, and are pressed together by a spiral spring. As soon as any one of the rings begins to soften under the heat, it is squeezed together by the pressure, and, as it melts, it is completely squeezed out and disappears. The rod is then made to rise by the thickness of the melted ring, and a simple apparatus shows at any moment the number of rings which have melted, and therefore the temperature which has been attained. This instrument cannot be used to follow variations of temperature, but indicates clearly the moment when a particular temperature is attained. It is of course entirely dependent on the accuracy with which the melting-points of the various alloys have been fixed.

Yet another principle is involved in the instrument called the thalpotasimeter, which may be used either with ether, water, or mercury. It is based on the principle that the pressure of any saturated vapor corresponds to its temperature. The instrument consists of a tube of metal partly filled with liquid, which is exposed to the medium which is to be measured. A metallic pressure gauge is connected with the tube, and indicates the pressure existing within it at any moment. By graduating the face of the gauge when the instrument is at known temperatures, the temperature can be read off directly from the position of the needle. From 100 deg. to 220 deg.F. ether is the liquid used, from thence to 680 deg. it is water, and above the latter temperature mercury is employed.

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Another class of pyrometers having great promise in the future is based on what may be called the “water-current” principle. Here the temperature is determined by noting the amount of heat communicated to a known current of water circulating in the medium to be observed. The idea, which was due to M. De Saintignon, has been carried out in its most improved form by M. Boulier. Here the pyrometer itself consists of a set of tubes one inside the other, and all inclosed for safety in a large tube of fireclay. The central tube or pipe brings in the water from a tank above, where it is maintained at a constant level. The water descends to the bottom of the instrument, and opens into the end of another small tube called the explorer (*explorateur*). This tube projects from the fireclay casing into the medium to be examined, and can be pushed in or out as required. After circulating through this tube the water rises again in the annular space between the central pipe and the second pipe. The similar space between the second pipe and the third pipe is always filled by another and much larger current of water, which keeps the interior cool. The result is that no loss of heat is possible in the instrument, and the water in the central tube merely takes up just so much heat as is conducted into it through the metal of the explorer. This heat it brings back through a short India-rubber pipe to a casing containing a thermometer. This thermometer is immersed in the returning current of water, and records its temperature. It is graduated by immersing the instrument in known and constant temperatures, and thus the graduations on the thermometer give at once the temperature, not of the current of water, but of the medium from which it has received its heat. In order to render the instrument perfectly reliable, all that is necessary is that the current of water should be always perfectly uniform, and this is easily attained by fixing the size of the outlet once for all, and also the level of water in the tank. So arranged, the pyrometer works with great regularity, indicating the least variations of temperature, requiring no sort of attention, and never suffering injury under the most intense heat; in fact the tube, when withdrawn from the furnace, is found to be merely warm. If there is any risk of the instrument getting broken from fall of materials or other causes, it may be fitted with an ingenious self-acting apparatus shutting off the supply. For this purpose the water which has passed the thermometer is made to fall into a funnel hung on the longer arm of a balanced lever. With an ordinary flow the water stands at a certain height in the funnel, and, while this is so, the lever remains balanced; but if from any accident the flow is diminished, the level of the water in the funnel descends, the other arm of the lever falls, and in doing so releases two springs, one of which in flying up rings a bell, and the other by detaching a counterweight closes a cock and stops the supply of water altogether.

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It will be seen that these instruments are not adapted for shifting about from place to place in order to observe different temperatures, but rather for following the variations of temperature at one and the same place. For many purposes this is of great importance. They have been used with great success in porcelain furnaces, both at the famous manufactories at Sevres and at another porcelain works in Limoges. From both these establishments very favorable reports as to their working have been received.—-*W.R. Browne, in Nature*.

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[*Nature*.]

THE TEMPERATURE OF THE SOLAR SURFACE.

I have, during the summer solstice of 1884, carried out an experimental investigation for the purpose of demonstrating the temperature of the solar surface corresponding with the temperature transmitted to the sun motor. Referring to the illustrations previously published, it will be seen that the cylindrical heater of the sun motor, constructed solely for the purpose of generating steam or expanding air, is not well adapted for an exact determination of the amount of surface exposed to the action of the reflected solar rays. It will be perceived on inspection that only part of the bottom of the cylindrical heater of the motor is acted upon by the reflected rays, and that their density diminishes *gradually* toward the sides of the vessel; also that owing to the imperfections of the surface of the reflecting plates the exact course of the terminal rays cannot be defined. Consequently, the most important point in the investigation, namely, the area acted upon by the reflected radiant heat, cannot be accurately determined. I have accordingly constructed an instrument of large dimensions, a polygonal reflector (see Fig. 1), composed of a series of inclined mirrors, and provided with a central heater of conical form, acted upon by the reflected radiation in such a manner that each point of its surface receives an equal amount of radiant heat in a given time. The said reflector is contained within two regular polygonal planes twelve inches apart, each having ninety-six sides, the perimeter of the upper plane corresponding with a circle of eight feet diameter, that of the lower plane being six feet. The corresponding sides of these planes are connected by flat taper mirrors composed of thin glass silvered on the outside. When the reflector faces the sun at right angles, each mirror intercepts a pencil of rays of 32.61 square inches section, hence the entire reflecting surface receives the radiant heat of an annular sunbeam of 32.61 x 96 = 3,130 square inches section. It should be observed that the area thus stated is 0.011 less than the total foreshortened superficies of the ninety-six mirrors if sufficiently wide to come in perfect contact at the vertices. Fig. 2 represents a transverse section of the instrument as it appears when facing the sun; the direct and

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reflected rays being indicated by dotted lines. The reflector and conical heater are sustained by a flat hub and eight radial spokes bent upward toward the ends at an angle of 45 deg.. The hub and spokes are supported by a vertical pivot, by means of which the operator is enabled to follow the diurnal motion of the sun, while a horizontal axle, secured to the upper end of the pivot, and held by appropriate bearings under the hub, enables him to regulate the inclination to correspond with the altitude of the luminary. The heater is composed of rolled plate iron 0.017 inch thick, and provided with bead and bottom formed of non-conducting materials. By means of a screw-plug passing through the bottom and entering the face of the hub the heater may be applied and removed in the course of five minutes, an important fact, as will be seen hereafter. It is scarcely necessary to state that the proportion of the ends of the conical heater should correspond with the perimeters of the reflector, hence the diameter of the upper end, at the intersection of the polygonal plane, should be to that of the lower end as 8 to 6, in order that every part may be acted upon by reflected rays of equal density. This condition being fulfilled, the temperature communicated will be perfectly uniform. A short tube passes through the upper head of the heater, through which a thermometer is inserted for measuring the internal temperature. The stem being somewhat less than the bore of the tube, a small opening is formed by which the necessary equilibrium of pressure will be established with the external atmosphere. It should be mentioned that the indications of the thermometer during the experiment have been remarkably prompt, the bulb being subjected to the joint influence of radiation and convection.

The foregoing particulars, it will be found, furnish all necessary data for determining with absolute precision the *diffusion* of rays acting on the central vessel of the solar pyrometer. But the determination of temperature which uninterrupted solar radiation is capable of transmitting to the polygonal reflector calls for a correct knowledge of atmospheric absorption. Besides, an accurate estimate of the loss of radiant heat attending the reflection of the rays by the mirrors is indispensable. Let us consider these points separately.

[Illustration: *Fig.* 2.]

Atmospheric Absorption.—The principal object of conducting the investigation during the summer solstice has been the facilities afforded for determining atmospheric absorption, the sun’s zenith distance at noon being only 17 deg. 12’ at New York. The retardation of the sun’s rays in passing through a clear atmosphere obviously depends on the depth penetrated; hence—neglecting the curvature of the atmospheric limit—the retardation will be as the secants of the zenith distances. Accordingly, an observation of the temperature produced by solar radiation at a zenith distance whose secant

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is *twice* that of the secant of 17 deg. 12’, *viz*., 61 deg. 28’, determines the minimum atmospheric absorption at New York. The result of observations conducted during a series of years shows that the maximum solar intensity at 17 deg. 12’ reaches 66.2 deg. F., while at a zenith distance of 61 deg. 28’ it is 52.5 deg. F.; hence, minimum atmospheric absorption at New York, during the summer solstice,

13.7
is 66.2 deg.-52.5 deg. = 13.7 deg. F., or ------ = 0.207 of the sun’s
66.2

radiant energy where the rays enter the terrestrial atmosphere.

[Illustration: CAPTAIN ERICSSON’S SOLAR PYROMETER, ERECTED AT NEW YORK, 1884.]

In order to determine the loss of energy attending the reflection of the rays by the diagonal mirrors, I have constructed a special apparatus, which, by means of a parallactic mechanism, faces the sun at right angles during observations. It consists principally of two small mirrors, manufactured of the same materials as the reflector, placed diagonally at right angles to each other; a thermometer being applied between the two, whose stem points toward the sun. The direct solar rays entering through perforations of an appropriate shade, and reflected by the inclined mirrors, act simultaneously on opposite sides of the bulb. The mean result of repeated trials, all differing but slightly, show that the energy of the direct solar rays acting on the polygonal reflector is reduced 0.235 before reaching the heater.

In accordance with the previous article, the investigation has been based on the assumption that *the temperatures produced by radiant heat at given distances from its source are inversely as the diffusion of the rays at those distances. In other words, the temperature produced by solar radiation is as the density of the rays.*

It will be remembered that Sir Isaac Newton, in estimating the temperature to which the comet of 1680 was subjected when nearest to the sun, based his calculations on the result of his practical observations that the maximum temperature produced by solar radiation was one-third of that of boiling water. Modern research shows that the observer of 1680 underrated solar intensity only 5 deg. for the latitude of London. The distance of the comet from the center of the sun being to the distance of the earth from the same as 6 to 1,000, the author of the “Principia” asserted that the density of the rays was as 1,000 squared to 6 squared = 28,000 to 1; hence the comet was subjected to a temperature of 28,000 x 180 deg./3 = 1,680,000 deg., an intensity exactly “2,000 times greater than that of red-hot iron” at a temperature of 840 deg.. The distance of the comet from the solar surface being equal to one-third of the sun’s radius, it will be seen that, in accordance with the Newtonian doctrine, the temperature to which it was subjected indicated a solar intensity of

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4 squared x 1,680,000
-------------- = 2,986,000 deg. F.
3

The writer has established the correctness of the assumption that “the temperature is as the density of the rays,” by showing practically that the *diminution* of solar temperature (for corresponding zenith distances) when the earth is in aphelion corresponds with the increased diffusion of the rays consequent on increased distance from the sun. This practical demonstration, however, has been questioned on the insufficient ground that “the eccentricity of the earth’s orbit is too small and the temperature produced by solar radiation too low” to furnish a safe basis for computations of solar temperature.

In order to meet the objection that the diffusion of the rays in aphelion do not differ sufficiently, the solar pyrometer has been so arranged that the density, *i. e.*, the diffusion of the reflected rays, can be changed from a ratio of 1 in 5,040 to that of 1 in 10,241. This has been effected by employing heaters respectively 10 inches and 20 inches in diameter. With reference to the “low” solar temperature pointed out, it will be perceived that the adopted expedient of increasing the density of the rays without raising the temperature by *converging* radiation, removes the objection urged.

Agreeably to the dimensions already specified, the area of the 10-inch heater acted upon by the reflected solar rays is 331.65 square inches, the area of the 20-inch heater being 673.9 square inches. The section of the annular sunbeam whose direct rays act upon the polygonal reflector is 3,130 square inches, as before stated.

Regarding the diffusion of the solar rays during the investigation, the following demonstration will be readily understood. The area of a sphere whose radius is equal to the earth’s distance from the sun in aphelion being to the sun’s area as 218.1 squared to 1, while the reflecter of the solar pyrometer intercepts a sunbeam of 3,130 square inches section, it follows that the reflector will receive the radiant heat developed by 3,130 / 218.1 squared = 0.0658 square inch of the solar surface. Hence, as the 10-inch heater presents an area of 331.65 square inches, we establish the fact that the reflected solar rays, acting on the same, are *diffused* in the ratio of 331.65 to 0.0658, or 331.65 / 0.0658 = 5,040 to 1; the diffusion of the rays acting on the 20-inch heater being as 673.9 to 0.0658, or 673.9 / 0.0658 = 10,241 to 1.

The atmospheric conditions having proved unfavorable during the investigation, maximum solar temperature was not recorded. Accordingly, the heaters of the solar pyrometer did not reach maximum temperature, the highest indication by the thermometer of the small heater being 336.5 deg., that of the large one being 200.5 deg. above the surrounding air. No compensation will, however, be introduced on account of deficient solar heat, the intention being to base the computation

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of solar temperature solely on the result of observations conducted at New York during the summer solstice of 1884. It will be noticed that the temperature of the large heater is proportionally higher than that of the small heater, a fact showing that the latter, owing to its higher temperature, loses more heat by radiation and convection than the former. Besides, the rate of cooling of heated bodies increases more rapidly than the augmentation of temperature.

The loss occasioned by the imperfect reflection of the mirrors, as before stated, is 0.235 of the energy transmitted by the direct solar rays acting on the polygonal reflector, hence the temperature which the solar rays are capable of imparting to the large heater will be 200.5 deg. x 1.235 = 247.617 deg.; but the energy of the solar rays acting on the *reflector* is reduced 0.207 by atmospheric absorption, consequently the ultimate temperature which the sun's radiant energy is capable of imparting to the heater is 1.207 x 247.617 deg. = 298.87 deg. F. It is hardly necessary to observe that this temperature (developed by solar radiation diffused fully ten-thousandfold) must be regarded as an *actual* temperature, since a perfectly transparent atmosphere, and a reflector capable of transmitting the whole energy of the sun's rays to the heater, would produce the same.

The result of the experimental investigation carried out during the summer solstice of 1884 may be thus briefly stated. The diffusion of the solar rays acting on the 20 inch heater being in the ratio of 1 to 10,241, the temperature of the solar surface cannot be less than 298.87 deg. x 10,241 = 3,060,727 deg. F. This underrated computation must be accepted unless it can be shown that the temperature produced by radiant heat is not inversely as the diffusion of the rays. Physicists who question the existence of such high solar temperature should bear in mind that in consequence of the great attraction of the solar mass, hydrogen on the sun's surface raised to a temperature of 4,000 deg. C. will be nearly twice as heavy as hydrogen on the surface of the earth at ordinary atmospheric temperatures; and that, owing to the immense depth of the solar atmosphere, its density would be so enormous at the stated low temperature that the observed rapid movements within the solar envelope could not possibly take place. It scarcely needs demonstration to prove that extreme tenuity can alone account for the extraordinary velocities recorded by observers of solar phenomena. But *extreme tenuity* is incompatible with low temperature and the pressure produced by an atmospheric column probably exceeding 50,000 miles in height subjected to the sun's powerful attraction, diminished only one-fourth at the stated elevation. These facts warrant the conclusion that the high temperature established by our investigation is requisite to prevent undue density of the solar atmosphere.

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It is not intended at present to discuss the necessity of tenuity with reference to the functions of the sun as a radiator; yet it will be proper to observe that on merely dynamical grounds the enormous density of the solar envelope which would result from low temperature presents an unanswerable objection to the assumption of Pouillet, Vicaire, Sainte-Claire Deville, and other eminent *savants*, that the temperature of the solar surface does not reach 3,000 deg. C.

J. ERICSSON.

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CHEMICAL NATURE OF STARCH GRAINS.

Dr. Brukner has contributed to the *Proceedings* of the Vienna Academy of Sciences a paper on the “Chemical Nature of the Different Varieties of Starch,” especially in reference to the question whether the granulose of Nageli, the soluble starch of Jessen, the amylodextrin of W. Nageli, and the amidulin of Nasse are the same or different substances. A single experiment will serve to show that under certain conditions a soluble substance maybe obtained from starch grains.

If dried starch grains are rubbed between two glass plates, the grains will be seen under the microscope to be fissured, and if then wetted and filtered, the filtrate will be a perfectly clear liquid showing a strong starch reaction with iodine. Since no solution is obtained from uninjured grains, even after soaking for weeks in water, Brukner concludes that the outer layers of the starch grains form a membrane protecting the interior soluble layers from the action of the water.

The soluble filtrate from starch paste also contains a substance identical with granulose. Between the two kinds of starch, the granular and that contained in paste, there is no chemical but only a physical difference, depending on the condition of aggregation of their micellae.

W. Nageli maintains that granulose, or soluble starch, differs from amylodextrin in the former being precipitated by tannic acid and acetate of lead, while the latter is not. Brukner fails to confirm this difference, obtaining a voluminous precipitate with tannic acid and acetate of lead in the case of both substances. Another difference maintained by Nageli, that freshly precipitated starch is insoluble, amylodextrin soluble in water, is also contested; the author finding that granulose is soluble to a considerable extent in water, not only immediately after precipitation, but when it has remained for twenty-four hours under absolute alcohol. Other differences pointed out by W. Nageli, Brukner also maintains to be non-existent, and he regards amidulin and amylodextrin as identical. Brucke gave the name erythrogranulose to a substance nearly related to granulose, but with a stronger affinity for iodine, and receiving from it not a blue but a red color.

Brukner regards the red color as resulting from a mixture of erythrodextrin, and the greater solubility of this substance in water.

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If a mixture of filtered potato starch paste and erythrodextrin is dried in a watch glass covered with a thin pellicle of collodion, and a drop of iodine solution placed on the latter, it penetrates very slowly through the pellicle, the dextrin becoming first tinctured with red, and the granulose afterward with blue. If, on the other hand, no erythrodextrin is used, the diffusion of the iodine causes at once simply a blue coloring.

With regard to the iodine reaction of starch, Brukner contests Sachsse's view as to the loss of color of iodide of starch at a high temperature. He shows that the iodide may resist heat, and that the loss of color depends on the greater attraction of water for iodine as compared with starch, and the greater solubility of iodine in water at high temperatures.

The different kinds of starch do not take the same tint with the same quantity of (solid) iodine. That from the potato *arum* gives a blue, and that from wheat and rice a violet tint; while the filtrate from starch paste, from whatever source, always gives a blue color.

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THE AMALGAMATION OF SILVER ORES.

DESCRIPTION OF THE FRANCKE "TINA" OR VAT PROCESS FOR THE AMALGAMATION OF SILVER ORES.

[Footnote: Paper read before the Institution of Mechanical Engineers at the Cardiff meeting.—*Engineering*.]

By Mr. EDGAR P. RATHBONE, of London.

In the year 1882, while on a visit to some of the great silver mines in Bolivia, an opportunity was afforded the writer of inspecting a new and successful process for the treatment of silver ores, the invention of Herr Francke, a German gentleman long resident in Bolivia, whose acquaintance the writer had also the pleasure of making. After many years of tedious working devoted to experiments bearing on the metallurgical treatment of rich but refractory silver ores, the inventor has successfully introduced the process of which it is proposed in this paper to give a description, and which has, by its satisfactory working, entirely eclipsed all other plans hitherto tried in Bolivia, Peru, and Chili. The Francke "tina" process is based on the same metallurgical principles as the system described by Alonzo Barba in 1640, and also on those introduced into the States in more recent times under the name of the Washoe process. [1]

[Footnote 1: Transactions of the American Institute of Mining Engineers, vol. ii., p. 159.]

It was only after a long and careful study of these two processes, and by making close observations and experiments on other plans, which had up to that time been tried with more or less success in Bolivia, Peru, and Chili—such as the Mexican amalgamation process, technically known as the “patio” process; the improved Freiberg barrel amalgamation process; as used at Copiapo; and the “Kronke” process—that Herr Francke eventually succeeded in devising his new process, and by its means treating economically the rich but refractory silver ores, such as those found at the celebrated Huanchaca and Guadalupe mines in Potosi, Bolivia. In this description of the process the writer will endeavor to enter into every possible detail having a practical bearing on the final results; and with this view he commences with the actual separation of the ores at the mines.

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Ore Dressing, etc.—This consists simply in the separation of the ore by hand at the mines into different qualities, by women and boys with small hammers, the process being that known as “cobbing” in Cornwall. The object of this separation is twofold: first to separate the rich parts from the poor as they come together in the same lump of ore, otherwise rich pieces might go undetected; and, secondly, to reduce the whole body of ore coming from the mine to such convenient size as permits of its being fed directly into the stamps battery. The reason for this separation not being effected by those mechanical appliances so common in most ore dressing establishments, such as stone breakers or crushing rolls, is simply because the ores are so rich in silver, and frequently of such a brittle nature, that any undue pulverization would certainly result in a great loss of silver, as a large amount would be carried away in the form of fine dust. So much attention is indeed required in this department that it is found requisite to institute strict superintendence in the sorting or cobbing sheds, in order to prevent as far as practicable any improper diminution of the ores. According to the above method, the ores coming from the mine are classified into the four following divisions:

1. Very rich ore, averaging about six per cent. of silver, or containing say 2,000 ounces of silver to the ton (of 2,000 lb.).

2. Rich ore, averaging about one per cent. of silver, or say from 300 to 400 ounces of silver to the ton.

3. Ordinary ore, averaging about 1/2 per cent. of silver, or say from 150 oz. to 200 oz. of silver to the ton.

4. Gangue, or waste rock, thrown on the dump heaps.

The first of these qualities—the very rich ore—is so valuable as to render advantageous its direct export in the raw state to the coast for shipment to Europe. The cost of fuel in Bolivia forms so considerable a charge in smelting operations, that the cost of freight to Europe on very rich silver ores works out at a relatively insignificant figure, when compared with the cost of smelting operations in that country. This rich ore is consequently selected very carefully, and packed up in tough rawhide bags, so as to make small compact parcels some 18 in. to 2 ft. long, and 8 in. to 12 in. thick, each containing about 1 cwt. Two of such bags form a mule load, slung across the animal’s back.

The second and third qualities of ore are taken direct to the smelting works; and where these are situated at some distance from the mines, as at Huanchaca and Guadalupe, the transport is effected by means of strong but lightly built iron carts, specially constructed to meet the heavy wear and tear consequent upon the rough mountain roads. These two classes of ores are either treated separately, or mixed together in such proportion as is found by experience to be most suitable for the smelting process.

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On its arrival at the reduction works the ore is taken direct to the stamp mill. At the Huanchaca works there are sixty-five heads of stamps, each head weighing about 500 lb., with five heads in each battery, and crushing about 50 cwt. per head per twenty-four hours. The ore is stamped dry, without water, requiring no coffers; this is a decided advantage as regards first cost, owing to the great weight of the coffers, from 2 to 3 tons —a very heavy item when the cost of transport from Europe at about 50_l_. per ton is considered. As fast as the ore is stamped, it is shoveled out by hand, and thrown upon inclined sieves of forty holes per lineal inch; the stuff which will not pass through the mesh is returned to the stamps.

Dry stamping may be said to be almost a necessity in dealing with these rich silver ores, as with the employment of water there is a great loss of silver, owing to the finer particles being carried away in suspension, and thus getting mixed with the slimes, from which it is exceedingly difficult to recover them, especially in those remote regions where the cost of maintaining large ore-dressing establishments is very heavy. Dry stamping, however, presents many serious drawbacks, some of which could probably be eliminated if they received proper attention. For instance, the very fine dust, which rises in a dense cloud during the operation of stamping, not only settles down on all parts of the machinery, interfering with its proper working, so that some part of the battery is nearly always stopped for repairs, but is also the cause of serious inconvenience to the workmen. At the Huanchaca mines, owing to the presence of galena or sulphide of lead in the ores, this fine dust is of such an injurious character as not unfrequently to cause the death of the workmen; as a precautionary measure they are accustomed to stuff cotton wool into their nostrils. This, however, is only a partial preventive; and the men find the best method of overcoming the evil effect is to return to their homes at intervals of a few weeks, their places being taken by others for the same periods. In dry stamping there is also a considerable loss of silver in the fine particles of rich ore which are carried away as dust and irrevocably lost. To prevent this loss, the writer proposed while at Huanchaca that a chamber should be constructed, into which all the fine dust might be exhausted or blown by a powerful fan or ventilator.

Roasting.—From the stamps the stamped ore is taken in small ore cars to the roasting furnaces, which are double bedded in design, one hearth being built immediately above the other. This type of furnace has proved, after various trials, to be that best suited for the treatment of the Bolivian silver ores, and is stated to have been found the most economical as regards consumption of fuel, and to give the least trouble in labor.

At the Huanchaca mines these furnaces cost about 100_l_. each, and are capable of roasting from 2 to 21/2 tons of ore in twenty-four hours, the quantity and cost of the fuel consumed being as follows:

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Bolivian dollars at 3s. 1d.
Tola (a kind of shrub), 3 cwt., at 60 cents. 1.80
Yareta (a resinous moss), 4 cwt., at 80 cents. 3.20
Torba (turf), 10 cwt., at 40 cents. 4.00
——
Bolivian dollars. 9.00, say 28s.

One man can attend to two furnaces, and earns 3s. per shift of twelve hours.

Probably no revolving mechanical furnace is suited to the roasting of these ores, as the operation requires to be carefully and intelligently watched, for it is essential to the success of the Francke process that the ores should not be completely or “dead” roasted, inasmuch as certain salts, prejudicial to the ultimate proper working of the process, are liable to be formed if the roasting be too protracted. These salts are mainly due to the presence of antimony, zinc, lead, and arsenic, all of which are unfavorable to amalgamation.

The ores are roasted with 8 per cent. of salt, or 400 lb. of salt for the charge of 21/2 tons of ore; the salt costs 70 cents, or 2s. 2d. per 100 lb. So roasted the ores are only partially chlorinized, and their complete chlorination is effected subsequently, during the process of amalgamation; the chlorides are thus formed progressively as required, and, in fact, it would almost appear that the success of the process virtually consists in obviating the formation of injurious salts. All the sulphide ores in Bolivia contain sufficient copper to form the quantity of cuprous chloride requisite for the first stages of roasting, in order to render the silver contained in the ore thoroughly amenable to subsequent amalgamation.

Amalgamating.—From the furnaces the roasted ore is taken in ore cars to large hoppers or bins situated immediately behind the grinding and amalgamating vats, locally known as “tinas,” into which the ore is run from the bin through a chute fitted with a regulating slide. The tinas or amalgamating vats constitute the prominent feature of the Francke process; they are large wooden vats, shown in Figs. 1 and 2, page 173, from 6 ft. to 10 ft. in diameter and 5 ft. deep, capacious enough to treat about 21/2 tons of ore at a time. Each vat is very strongly constructed, being bound with thick iron hoops. At the bottom it is fitted with copper plates about 3 in. thick, A in Fig. 1; and at intervals round the sides of the vat are fixed copper plates, as shown in Figs. 3 and 4, with ribs on their inner faces, slightly inclined to the horizontal, for promoting a more thorough mixing. It is considered essential to the success of the process that the bottom plates should present a clear rubbing surface of at least 10 square feet.

[Illustration: THE FRANCKE “TINA” PROCESS FOR THE AMALGAMATION OF SILVER ORES.]

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Within the vat, and working on the top of the copper plates, there is a heavy copper stirrer or muller, B, Figs. 1 and 2, caused to revolve by the shafting, C, at the rate of 45 revolutions per minute. At Huanchaca this stirrer has been made with four projecting radial arms, D D, Figs. 1 and 2; but at Guadalupe it is composed of one single bell-shaped piece, Figs. 3 and 4, without any arms, but with slabs like arms fixed on its underside; and this latter is claimed to be the most effective. The stirrer can be lifted or depressed in the vat at will by means of a worm and screw at the top of the driving shaft, Fig. 3.

The bevel gearing is revolved by shafting connected with pulley wheels and belting, the wheels being 3 ft. and 11/2 ft. in diameter, and 6 in. broad. The driving engine is placed at one end of the building. Each vat requires from 21/2 to 3 horse-power, or in other words, an expenditure of 1 horse-power per ton of ore treated.

At the bottom of the vat, and in front of it, a large wooden stop-cock is fitted, through which the liquid amalgam is drawn off at the end of the process into another shallow-bottomed and smaller vat, Figs. 1 and 2. Directly above this last vat there is a water hose, supplied with a flexible spout, through which a strong stream of water is directed upon the amalgam as it issues from the grinding vat, in order to wash off all impurities.

The following is the mode of working usually employed. The grinding vat or tina is first charged to about one-fifth of its depth with water and from 6 cwt. to 7 cwt. of common salt. The amount of salt required in the process depends naturally on the character of the ore to be treated, as ascertained by actual experiment, and averages from 150 lb. to 300 lb. per ton of ore. Into this brine a jet of steam is then directed, and the stirrer is set to work for about half an hour, until the liquid is in a thoroughly boiling condition, in which state it must be kept until the end of the process.

As soon as the liquid reaches boiling point, the stamped and roasted ore is run into the vat, and at the end of another half-hour about 1 cwt. of mercury is added, further quantities being added as required at different stages of the process. The stirring is kept up continuously for eight to twelve hours, according to the character and richness of the ores. At the end of this time the amalgam is run out through the stop-cock at bottom of the vat, is washed, and is put into hydraulic presses, by means of which the mercury is squeezed out, leaving behind a thick, pulpy mass, composed mainly of silver, and locally termed a “pina,” from its resembling in shape the cone of a pine tree. These pinas are then carefully weighed and put into a subliming furnace, Figs. 5 and 6, in order to drive off the rest of the mercury, the silver being subsequently run into bars. About four ounces of mercury are lost for every pound of silver made.

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The actual quantities of mercury to be added in the grinding vat, and the times of its addition, are based entirely on practical experience of the process. With ore assaying 150 oz. to 175 oz. of silver to the ton, 75 lb. of mercury are put in at the commencement, another 75 lb. at intervals during the middle of the process, and finally another lot of 75 lb. shortly before the termination. When treating “pacos,” or earthy chlorides of silver, assaying only 20 oz. to 30 oz. of silver to the ton, 36 lb. of mercury is added to 21/2 tons of ore at three different stages of the process as just described.

The *rationale* of the process therefore appears to be that the chlorination of the ores is only partially effected during the roasting, so as to prevent the formation of injurious salts, and is completed in the vats, in which the chloride of copper is formed progressively as required, by the gradual grinding away of the copper by friction between the bottom copper plates and the stirrer; and this chloride subsequently becoming incorporated with the boiling brine is considered to quicken the action of the mercury upon the silver.

Subliming.—The subliming furnace, shown in Figs. 5 and 6, is a plain cylindrical chamber, A, about 4 ft. diameter inside and 41/2 ft. high, lined with firebrick, in the center of which is fixed the upright cast-iron cylinder or retort, C, of 1 ft. diameter, closed at top and open at bottom. The furnace top is closed by a cast-iron lid, which is lifted off for charging the fuel. Round the top of the furnace is a tier of radial outlet holes for the fuel smoke to escape through; and round the bottom is a corresponding tier of inlet air-holes, through which the fuel is continually rabbled with poles by hand. The fuel used is llama dung, costing 80 cents, or 2s. 6d., per 250 lb.; it makes a very excellent fuel for smelting purposes, smouldering and maintaining steadily the low heat required for subliming the mercury from the amalgam. Beneath the furnace is a vault containing a wrought-iron water-tank, B, into which the open mouth of the retort, C, projects downward and is submerged below the water. For charging the retort, the water-tank is placed on a trolly; and standing upright on a stool inside the tank is placed the pina, or conical mass of silver amalgam, which is held together by being built up on a core-bar fitted with a series of horizontal disks. The trolly is then run into the vault, and the water-tank containing the pina is lifted by screw-jacks, so as to raise the pina into the retort, in which position the tank is then supported by a cross-beam. The sublimed mercury is condensed and collected in the water; and on the completion of the process the tank is lowered, and the spongy or porous cone of silver is withdrawn from the retort. The subliming furnaces are ranged in a row, and communicate by lines of rails with the weigh-house.

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INTERESTING FACTS ABOUT PLATINUM.

After an excellent day of weakfishing on Barnegat Bay and an exceptionable supper of the good, old fashioned, country tavern kind, a social party of anglers sat about on Uncle Jo Parker's broad porch at Forked River, smoking and enjoying the cool, fragrant breath of the cedar swamp, when somehow the chat drifted to the subject of assaying and refining the precious metals. That was just where one of the party, Mr. D.W. Baker, of Newark, was at home, and in the course of an impromptu lecture he told the party more about the topic under discussion, and especially the platinum branch of it, than they ever knew before.

"Our firm," he said, "practically does all the platinum business of this country, and the demand for the material is so great that we never can get more than we want of it. The principal portion, or, in fact, nearly all of it, comes from the famous mines of the Demidoff family, who have the monopoly of the production in Russia. It is all refined and made into sheets of various thicknesses, and into wire of certain commercial sizes, before it comes to us; but we have frequently to cut, roll, and redraw it to new forms and sizes to meet the demands upon us. At one time it was coined in Russia, but it is no longer applied to that use. We have obtained some very good crude platinum ore from South America and have refined it successfully, but the supply from that source is, as yet, very small. I am not aware that it has been found anywhere else than in Colombia, on that continent, but the explorations thus far made into the mineral resources of South America have been very meager, and it is by no means improbable that platinum may yet be discovered there in quantities rivaling the supply of Russia.

"A popular error respecting platinum is that its intrinsic value is the same as that of gold. At one time it did approximate to gold in value, but never quite reached it, and is now worth only $8 to $12 an ounce, according to the work expended upon it in getting it into required forms and the amount of alloy it contains. The alloy used for it is iridium, which hardens it, and the more iridium it contains the more difficult it is to work, and consequently the more expensive. When pure, platinum is as soft as silver, but by the addition of iridium it becomes the hardest of metals. The great difficulty in manipulating platinum is its excessive resistance to heat. A temperature that will make steel run like water and melt down fireclay has absolutely no effect upon it. You may put a piece of platinum wire no thicker than human hair into a blast furnace where ingots of steel are melting down all around it, and the bit of wire will come out as absolutely unchanged as if it had been in an ice box all the time.

"No means has been discovered for accurately determining the melting temperature of platinum, but it must be enormous. And yet, if you put a bit of lead into the crucible with the platinum, both metals will melt down together at the low temperature that fuses the lead, and if you try to melt lead in a platinum crucible, you will find that as soon as the lead melts the platinum with which it comes into contact also melts and your crucible is destroyed.

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“A distinguishing characteristic of platinum is its extreme ductility. A wire can be made from it finer than from any other metal. I have a sample in my pocket, the gauge of which is only one two-thousandth of an inch, and it is practicable to make it thinner. It has even been affirmed that platinum wire has been made so fine as to be invisible to the naked eye, but that I do not state as of my own knowledge. This wire my son made.”

Mr. Baker exhibited the sample spoken of. It looked like a tress of silky hair, and had it not been shown upon a piece of black paper could hardly have been seen. He went on:

“The draw plates, by means of which these fine wires are made, are sapphires and rubies. You may fancy for yourselves how extremely delicate must be the work of making holes of such exceeding smallness to accurate gauge, too, in those very hard stones. I get all my draw plates from an old Swiss lady in New York, who makes them herself to order. But, delicate as is the work of boring the holes, there is something still more delicate in the processes that produce such fine wire as this. That something is the filing of a long point on the wire to enable the poking of the end of it through the draw plate so that it can be caught by the nippers. Imagine yourself filing a long, tapering point on the end of a wire only one eighteen-hundredths of an inch in diameter, in order to get it through a draw plate that will bring it down to one two-thousandths. My son does that without using a magnifying glass. I cannot say positively what uses this very thin wire is put to, but something in surgery, I believe, either for fastening together portions of bone or for operations. A newly invented instrument has been described to me, which, if it does what has been affirmed, is one of the greatest and most wonderful discoveries of modern science. A very thin platinum wire loop, brought to incandescence by the current from a battery—which, though of great power, is so small that it hangs from the lapel of the operator’s coat—is used instead of a knife for excisions and certain amputations. It sears as it cuts, prevents the loss of blood, and is absolutely painless, which is the most astonishing thing about it.

“Our greatest consumers of platinum are the electricians, particularly the incandescent light companies. I supply the platinum wire for both the Edison and the Maxim companies, and the quantity they require so constantly increases that the demand threatens to exceed the supply of the metal. Sheets of platinum are bought by chemists, who have them converted into crucibles and other forms.”

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The reporter’s curiosity was awakened by Mr. Baker’s mention of the old lady who made those very fine draw plates, and on his return to the city he hunted her up. Mrs. Francis A. Jeannot, the lady in question, was found in neat apartments in a handsome flat in West Fifty-first street. Age has silvered her hair, but her eyes are still bright, and her movements indicate elasticity and strength. She is a native of Neufchatel, Switzerland, and speaks English with a little difficulty, but whenever the reporter’s English was a little hard for her a very pretty girl with brilliant eyes and crinkly jet-black hair, who subsequently proved to be a daughter of Mrs. Jeannot, came to the rescue. With the girl’s occasional aid, the old lady’s story was as follows:

“I have been in this business for thirty years. I learned it when I was a girl in Switzerland. Very few in this country know anything correctly about it. Numbers of people endeavor to find it out, and they experiment to learn it, especially to do it by machinery, but without success. But, ah, me! It is no longer a business that is anything worth. Thirty years ago many stone draw plates were wanted, for then there was a great deal done in filigree gold jewelry. Then the plates were worth from $2.50 up to as high as $15, according to the magnitude of the stones and the size of the holes I bored in them. Now, however, all that good time is past. Nobody wants filigree gold jewelry any more, and there is so little demand for fine wire of the precious metals that few draw plates are desired. The prices now are no more than from $1.25 up to say $8, but it is very rare that one is required the cost of which is more than $4. And of that a very large part must go to the lapidary to pay for the stone and for his work in cutting it to an even round disk. Then, what I get for the long and hard work of boring the stone by hand is very little. ‘By hand?’ Oh, yes. That must always be the only good way. The work of the machine is not perfect. It never produces such good plates as are made by the hand and eye of the trained artisan. ‘How are they bored?’ Ah, sir, you must excuse me that I do not tell you that. It is simple, but there is just a little of it that is a secret, and that little makes a vast difference between producing work which is good and that which is not. It has cost me no little to learn it, and while it is worth very little just now, perhaps fashion may change, and plates may be wanted to make gold wire again to an extent that may be profitable. I do not wish to tell everybody that which will deprive me of the little advantage my knowledge gives me. ’The stones?’ Oh, we of course do not use finely colored ones. They are too valuable. But those that we employ must be genuine sapphires and rubies, sound and without flaws. Here are some. You see they look like only irregular lumps of muddy-tinted broken glass. Here is a finished one.”

The old lady exhibited a piece of solid brass about an inch long, three-quarters of an inch in width, and one-sixteenth in thickness. In its center was a small disk of stone with a hole through it, a hole that was very smooth, wide on one side and hardly perceptible on the other. The stone was sunk deep into the brass and bedded firmly in it. She went on:

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“You will find, if you try, that you can with difficulty push through that hole a hair from your beard. But, small as it is, it must be perfectly smooth, and of an accurate gauge. I do not any longer myself set the stones in the brass, as I am not so strong as I once was. My son does that for me. But neither he nor my daughter, nor anybody else in this country, I believe, can bore the holes so well as I can even yet. ’How long does a draw plate last?’ Ah! Practically forever. Except by clumsy handling or accident, it does not need to be replaced, at least in one lifetime. And there is another reason why I sell so few now. Those who require them are supplied. ‘Watch jewels?’ Yes, I used to make them, but do so no longer. They can be imported from Europe at the price of $1 a dozen, and at such a figure one could not earn bread in making them here.”—*Manuf. Gazette.*

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BAYLE’S LAMP CHIMNEY.

The different types of lamps used in domestic lighting present several imperfections, and daily experience shows too often how difficult it is, even with the most careful and best studied models, to have a perfect combustion of the usual liquids—oil, kerosene, *etc*.

[Illustration: BAYLE’S NEW LAMP CHIMNEY.]

Mr. P. Bayle has endeavored to remedy this state of things by experiments upon the chimney, inasmuch as he could not think of modifying the arrangements of the lamps of commerce “without injury to man” interests, and encountering material difficulties.

The chimney is not only an apparatus designed to carry off the smoke and gases due to combustion, for its principal role is to break the equilibrium of the atmospheric air, which is the great reservoir of oxygen, and to suck into the flame, through the difference of densities, this indispensable agent to combustion. The lamps which we now use are provided with cylindrical chimneys either with or without a shoulder at the base. The shouldered chimney would be sufficient to suck in the quantity of air necessary for a good combustion if we could at will increase its dimensions in the direction of the diameter or height. But, on account of the fragile nature of the material of which it consists, as also because of the arrangement of the lighting apparatus, we are forced lo give the chimney limited dimensions. The result is an insufficient draught, and consequently an imperfect combustion. It became a question, then, of finding a chimney which, with small dimensions, should have great suctional power. Mr. Bayle has taken advantage of the properties of convergent-divergent ajutages, and of the discovery of Mr. Romilly that a current of gas directed into the axis and toward the small base of a truncated cone, at a definite distance therefrom, has the property of drawing

along with it a quantity of air nearly double that which this same current could carry
along

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if it were directed toward a cylinder. In getting up his new chimney, Mr. Bayle has utilized these principles as follows: Round-burner lamps have, as well known, two currents of air—an internal current which traverses the small tube that carries the wick, and an external one which passes under the chimney-holder externally to the wick. In giving the upper part of the chimney, properly so called, the form of a truncated cone whose smaller base is turned toward the internal current of air, that is to say, in directing this current toward the contracted part of the upper cone, at the point where the depression is greatest, a strong suction is brought about, which has the effect of carrying along the air between the wick and glass, and giving it its own velocity. The draught of the two currents having been effected through the conical form of the upper part of the chimney, it remained to regulate the entrance of the external current into the flame. If this current should enter the latter at too sharp an angle, it would carry it toward the mouth of the chimney before the chemical combustion of the carbon and oxygen was finished; and if, on the contrary, it should traverse it at too obtuse an angle, it would depress and contract it. Experience has shown that in the majority of cases the most favorable angle at which the external current of air can be led into the flame varies between 35 deg. and 45 deg.. We say in the majority of cases, for there are exceptions; this depends upon the combustive materials and upon the conditions under which they enter the flame. The annexed figure shows the form adopted by the inventor for oil and kerosene lamps. As may be seen, the chimney consists of two cones, A and B, connected end to end by their small bases. The upper one, A, or divergent cone, is constructed according to a variable angle, but one which, in order to produce its maximum effect, ought not to differ much from 5 deg.. This cone rests upon the convergent one, B, whose angle, as we have said, varies between 35 deg. and 45 deg.. To the large base of this cone there is soldered a cylindrical part, c, designed for fixing the chimney to the holder. The height given the divergent cone is likewise variable, but a very beautiful light is obtained, when it is equal to six times the diameter of the contracted part. When the lamp is designed to be used in a still atmosphere, free from abrupt currents of air, the height may be reduced to four times the diameter of the base, without the light being thereby rendered any the less bright. As for the height to be given the convergent cone, B, that is determined by the opening of the angle according to which it has been constructed. Finally, as a general thing, the diameter of the small base should be equal to half the large base of the convergent cone, B.

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The new chimney should be placed upon the holder in such a way that the upper part of the wick tube, D, is a few millimeters beneath the base of the convergent cone. The height to be given the wick varies according to the lamp used. It is regulated so as to obtain a steady and regular combustion. In oil lamps it must project about 11/2 centimeters. If two lamps of the same size be observed, one of which is fitted with the new chimney and the other with the old style, we shall be struck with the difference that exists in the color of the flame as well as in its intensity. While in the case of the cylindrical glass the flame is red and dull, in that of the circuit it is white and very bright. This, however, is not surprising when we reflect upon the theoretical conditions upon which the construction of the new chimney is based—the strong influx of air having the result of causing a more active combustion of the liquid, and consequently of raising to white heat the particles of carbon disseminated through the flame. As it was of interest to ascertain what the increase of illuminating power was in a given lamp provided with the new chimney, Mr. Felix le Blanc undertook some photometric experiments. The trials were made with a Gagneau lamp provided with a chimney of the ordinary shape, and then with one of Mr. Bayle's. The measurements were made after each had been burned half an hour. The light of the standard Carcel lamp being 1, there was obtained with the Gagneau lamp with the ordinary chimney 1.113 carcels, and with the Bayle chimney 1.404 carcels. Thus 1.113:1.404 represents the ratio of the same lamp with the ordinary chimney and with that of Bayle. Whence it follows that the light of the lamp with the old chimney being 1, that with the new one is 1.26, say an increase of about 25 per cent. There is nothing absolute about this figure, however. On kerosene lamps the new chimney, compared with the contracted Prussian one, gives an increase of 40 per cent. in illuminating power, and the oil is burned without odor or smoke.

As it was of interest to see whether this increase in intensity was not due to a greater consumption of oil, a determination was made of the quantity of the latter consumed per hour. The Gagneau lamp, with the old chimney, burned 62.25 grammes per hour, and with the Bayle 63 grammes in the same length of time.

It may be concluded, then, that the increase in light is due to the special form given the chimney. This new burner is applicable to gas lamps as well as to oil and petroleum ones.

The effects obtained by the new chimney may be summed up as follows: increase in illuminating power, as a natural result of a better combustion; suppression of smoke; and a more active combustion, which dries the carbon of the wick and thus facilitates the ascent of the oil. The velocity of the current of air likewise facilitates the action of capillarity by carrying the oil to the top of the wick. Moreover,

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the great influx of air under the flame continually cools the base of the chimney as well as the wick tube, and the result is that the excess of oil falls limpid and unaltered into the reservoir, and produces none of those gummy deposits that soil the external movements and clog up the conduits through which the oil ascends. Finally, the influx of air produced by this chimney permits of burning, without smoke and without charring the wick, those oils of poor quality that are unfortunately too often met with in commerce.—*La Nature.*

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MODERN LOCOMOTIVE PRACTICE.

[Footnote: Paper read before the Civil and Mechanical Engineers' Society, April 2, 1884.]

By H. MICHELL WHITLEY, Assoc. M.I.C.E., F.G.S.

A little more than half a century ago, but yet at a period not so far distant as to be beyond the remembrance of many still living, a clear-headed North-countryman, on the banks of the Tyne, was working out, in spite of all opposition, the great problem of adapting the steam engine to railway locomotion. Buoyed up by an almost prophetic confidence in his ultimate triumph over all obstacles, he continued to labor to complete an invention which promised the grandest benefits to mankind. What was thought of Stephenson and his schemes may be judged by the following extracts from the *Quarterly Review* of 1825, in which the introduction of locomotive traction is condemned in the most pointed manner:

"As to those persons who speculate on making railways general throughout the kingdom, and superseding every other mode of conveyance by land and water, we deem them and their visionary schemes unworthy of notice.... The gross exaggeration of the locomotive steam engine may delude for a time, but must end in the mortification of all concerned.... It is certainly some consolation to those who are to be whirled, at the rate of 18 or 20 miles per hour, by means of a high-pressure engine, to be told that they are in no danger of being sea-sick while on shore, that they are not to be scalded to death or drowned by the bursting of a boiler, and that they need not mind being shot by the shattered fragments, or dashed in pieces by the flying off or breaking of a wheel. But with all these assurances, we would as soon expect the people of Woolwich to suffer themselves to be fired off upon one of Congreve's ricochet rockets, as trust themselves to the mercy of such a machine going at such a rate."

These words, strange and ludicrous as they seem to us, but tersely expressed the general opinion of the day; but fortunately the clear head and the undaunted will persevered, until success was at last attained, and the magnificent railway system of the present, which has revolutionized the world, is the issue. And the results are almost overwhelming in their magnitude. Here, in Great Britain alone, 654,000,000 people travel annually. There are 14,000 locomotives, and the rolling stock would form a train nearly 2,000 miles long; while the number of miles traveled in a year by trains is more than 10,000 times round the world; and the passengers would form a procession 100 abreast, a yard apart, and 3,700 miles long.

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These stupendous results have been attained gradually; if we go back to 1848, we find that on the London and Birmingham Railway the number of trains in and out of Euston was forty-four per day. The average weight of the engines was 18 tons, and the gross loads were, for passenger trains 76 tons, and for goods 160. Now, the weight of an express engine and tender is about 65 tons, and gross loads of 250 to 300 tons for an express, and 500 tons for a coal train are not uncommon, while not only have the trains materially increased in weight, owing to the carriage of third-class passengers by all (except a few special) trains, and also to the lowering of fares and consequent more frequent traveling, but the speed, and therefore the duty of the engines, is greatly enhanced. A “Bradshaw’s Guide” of thirty-five years ago is now a rare book, but it is very interesting to glance over its pages, and in doing so it will be found that the fastest speed in all cases but one falls far short of that which obtains at present. The following table will show what the alteration has been:

	1849. Speed miles per hour.	1884. Speed miles per hour.
Great Western--London to Didcot.	56	--
" " to Swindon.	--	53
North-Western--Euston to Wolverton.	37	--
" Northampton to Willesden.	--	511/2
South-Western--Waterloo to Farnborough.	39	--
" Yeovil to Exeter.	--	46
Brighton--London Bridge to Reigate.	36	--
" Victoria to Eastbourne.	--	45
Midland--Derby to Masborough.	43	--
" London to Kettering.	--	47
North-Eastern--York to Darlington.	38	--
" "	--	50
Great Eastern--London to Broxbourne.	29	--
" Lincoln to Spalding.	--	49
Great Northern--King’s Cross to Grantham.	--	51
Cheshire Lines--Manchester to Liverpool.	--	51

With this problem then before them, increased weight, increased speed, and increased duty, the locomotive superintendents of our various railways have designed numerous types of engines, of which the author proposes to give a brief account, confining himself entirely to English practice, as foreign practice in addition would open too wide a field for a single paper.

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Commencing then with passenger engines for fast traffic, and taking first in order the Great Western Railway, we find that it holds a unique position, as its fast broad gauge trains are worked by the same type of engine as that designed by Sir Daniel Grooch in 1848, although, of course, the bulk of the stock has been rebuilt, almost on the same lines, and rendered substantially new engines. They are single engines of 7 ft. gauge with inside cylinders 18 in. diameter, and 24 in. stroke; the driving-wheels are 8 ft. in diameter, and there are two pairs of leading wheels, and one of trailing, all of 4 ft. 6 in. diameter. The total wheel base is 18 ft. 6 in.; the boiler is 4 ft. 6 in. diameter, and 11 ft. 3 in. long. The grate area is 21 square feet, and the heating surface is, in the fire-box, 153 square feet; tubes, 1,800 square feet; total, 1,953 square feet. The weight in full working order is, on the four leading wheels, 15 ton 18 cwt.; driving wheels, 16 tons; trailing wheels, 9 tons 10 cwt.; total, 41 tons 8 cwt. The tender, which is low-sided and very graceful in appearance, weighs 15 tons 10 cwt., and will hold 2,700 gallons of water.

The boiler pressure is 140 lb. on the square inch, and the tractive power per pound of steam pressure in the cylinders is 81 lb. These engines take the fast trains to the West of England; the Flying Dutchman averages 170 tons gross load, and runs at a mean time-table speed of 53 miles per hour, which allowing for starting, stopping, and slowing down to 25 miles per hour through Didcot gives a speed of nearly 60 miles an hour.

[Illustration: FIG. 1.—GREAT WESTERN RAILWAY.]

The average consumption of coal per mile, of thirteen of these engines, with the express trains between London and Bristol, during the half-year averaged 24.67 lb. per mile, the lowest being 23.22 lb., and the highest 26.17 lb., the average load being about eight coaches, or 243 tons. We have already seen that in 1849 the Great Western express ran at a higher rate than at present, being an exception to the general rule; and the fastest journey on record was performed at this time by one of these engines, when on May 14, 1848, the Great Britain took this Bristol express, consisting of four coaches and a van, to Didcot, fifty-three miles, in forty-seven minutes, or at the average speed of sixty-eight miles an hour. The maximum running speed was seventy-five miles an hour, and the indicated horse-power 1,000. A class of engines corresponding to this type in their general dimensions, but with 7 ft. coupled wheels, was introduced on the line, but it was not found successful. Through the courtesy of Mr. Dean, I am enabled to give a table showing the running speeds and loads of the principal express trains, broad and narrow gauge, to the West and North of England, run on the Great Western Railway.

Great Western Railway.—Average Speed and Weight of Express Trains.

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	Speed to first stopping station.			Weight of train.		
Train.	Station	Distance	Average speed--miles per hour.	Engine and tender.	Carriages and vans, empty.	Total
		miles		tons.	tons.	
BROAD GAUGE TO WEST OF ENGLAND:						
9.0 Paddington to Plymouth	Reading	36	47	67	149	216
11.45 do.	Swindon	771/4	53	67	104	171
NARROW GAUGE TO THE NORTH						
10.0 Paddington to Birkenhead	Reading	36	39.2	60	190	250
4.45 do.	Oxford	631/2	48.8	60	129	189

[Illustration: FIG 2.—GREAT WESTERN RAILWAY.]

The narrow gauge trains are worked by two classes of engines. The first is a single engine with inside cylinders 18 in. diameter, 24 in. stroke. The driving wheels are 7 ft. diameter, and the leading and trailing wheels 4 ft. The frames are double, giving outside bearings to the leading and trailing axles, and outside and inside bearings to the driving axle; this arrangement gives a very steady running engine, and insures, as far as can possibly be done, safety in case of the fracture of a crank axle. The frames are 15 inches deep, of BB Staffordshire iron. The wheel base is, leading to driving wheels, 8 ft. 6 in; driving to trailing wheels, 9 ft.; total, 17 ft. 6 in. The boiler is of Lowmoor iron, 10 ft. 6 in. long and 4 ft. 2 in. outside diameter. The grate area is 17 square feet, and the heating surface is, tubes, 1,1451/2 square feet; fire-box 133 square feet; total, 1,2781/2 square feet. The boiler pressure is 140 lb. on the square inch, and the tractive power per lb. of mean pressure in cylinders, 92 lb. The weight in full working order is, engine, leading wheel, 10 tons; ditto driving wheels, 14 tons; ditto trailing wheels, 9 tons 10 cwt.; tender, with 40 cwt. coal and 2,600 gals. water, 26 tons 10 cwt.; total, 60 tons. These engines are extremely simple, but well proportioned, and are a very handsome type, and their average consumption of coal, working trains averaging ten coaches, is about 24.87 lb. per mile. The standard coupled passenger express engine on the narrow gauge has inside cylinders 17 in. diameter and 24 in. stroke; the coupled wheels are 6 ft. 6 in. diameter, and the leading wheels 4 ft.; the wheel base is 16 ft. 9 in. The frames are double, giving outside bearings to the leading axle, and inside bearings

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to the coupled wheels. The boiler is 11 ft. long by 4 ft. 2 in. diameter; the grate area is 16.25 square feet; and the heating surface is, tubes, 1,216.5 square feet; fire-box, 97.0 square feet; total, 1,313.5 square feet. The boiler pressure is 140 lb., and the tractive power per lb. of steam pressure in the cylinders, 88 lb. The weight in full working order is on the leading wheels, 10 tons 5 cwt.; driving wheels, 11 tons; trailing wheels, 9 tons 15 cwt.; total, 31 tons.

[Illustration: FIG. 3.—LONDON & NORTH-WESTERN RAILWAY.]

[Illustration: FIG. 4.—JOY’S VALVE GEAR.]

Turning now to the London and North-Western Railway, we find that between 1862 and 1865 the express trains were worked with a handsome type of engines, known as the “Lady of the Lake” class. They have outside cylinders 16 in. diameter and 24 in. stroke, with single driving wheels of 7 ft. 6 in. diameter, and leading and trailing wheels 3 ft. 6 in. diameter, with a total wheel base of 15 ft. 5 in. The frames are single, with inside bearings to all the wheels. The boiler is 11 ft. long and 4 ft. diameter, and the heating surface is in the tubes, 1,013 feet; fire-box, 85 ft.; total, 1,098 feet. The tractive power per lb. of steam pressure in the cylinders is 68 lb. The weight in full working order is on the leading wheels, 9 tons 8 cwt.; driving wheels, 11 tons 10 cwt.; trailing wheels, 6 tons 2 cwt.; total, 27 tons. The tender weighs 171/2 tons in working order. These engines burn about 27 lb. of coal per mile with trains of the gross weight of 117 tons, which is not at all an economical duty. About 1872, the weight of the heavier express trains on the North-Western had so increased, that a new standard type for this service was designed, and is now the standard passenger engine; it has inside cylinders 17 in. diameter and 24 in. stroke; the driving and trailing wheels are coupled, and are 6 ft. 6 in. diameter, and the leading wheels 3 ft. 6 in. The frames of steel are single, with inside bearings to all the wheels, and the boiler, of steel, is 9 ft. 10 in. long and 4 ft. 2 in. diameter. The steel used has a tensile strength of 32 to 34 tons per square inch, all the rivets are put in by hydraulic pressure, and the magnetic oxide on the surface of the plates where they overlap is washed off by a little weak sal-ammoniac and water. In testing, steam is first got up to 30 lb. on the square inch, the boiler is then allowed to cool, it is then proved to 200 lb. with hydraulic pressure, and afterward to 160 lb. with steam. The fire-box is of copper, fitted with a fire brick arch for coal burning, and the grate area is 15 square feet. The heating surface is, in the tubes, 1,013 square feet; fire-box, 89 square feet; total, 1,102 square feet. The wheel base is 15 ft. 8 in., and the tractive power 88 lb. for each lb. of steam pressure in the cylinders. These engines, working the fast passenger trains at a speed of about 45 miles per hour, burn about 35 lb. of coal per mile, when

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taking trains weighing about 230 tons gross. A variation from this type has been adopted on the Northern and Welsh sections, known as the “Precursor” class. These engines have 5 ft. 6 in. coupled wheels, and weigh 31 tons 8 cwt. in working order, but in other respects are very similar to the standard engines just described; with the Scotch express, averaging in total weight 187 tons, between Crewe and Carlisle, over heavy gradients, they burn 33 lb. of coal per mile. These engines, although much more powerful than the standard type, are not nearly of so handsome an appearance, the drivers seeming much too small for the boiler under which they are placed. But by far the boldest innovation on existing practice is the new class of compound locomotives now being introduced by Mr. Webb. It is a six wheel engine, with leading wheels 4 ft. diameter, and two pairs of drivers, 6 ft. 6 in. diameter. The trailing drivers are driven by a pair of outside cylinders, 18 in. diameter and 24 in. stroke; and the leading drivers by a single low-pressure cylinder—which takes the exhaust steam from the high-pressure cylinders—of 26 in. diameter and 24 in. stroke, placed under the center of the smoke-box. The boiler is the same as that in the standard type of engine, but the wheel base is 17 ft. 7 in., and in order to allow it to traverse curves easily, the front axle is fitted with a radial axle-box, which is in one casting from journal to journal, and fitted at each end with brass steps for the bearings; the box is radial, struck from the center of the rigid wheel base, and the horn plates are curved to suit the box, the lateral motion being controlled by strong springs. Another peculiarity of this engine is that, instead of the ordinary link motion, it is fitted with Joy’s valve gear, which is now being more and more adopted. This gear—which is of a most ingenious decription—dispenses altogether with eccentrics, and so allows the inside bearings to be much increased, those on these engines being 131/2 in. long; and it is also claimed for it that it is simpler and less costly, weighs less, and is more correct in its action than the ordinary link motion; the friction is less, the working parts are simplified, it takes less oil, and is well under the driver’s eye. It also allows larger cylinders to be got in between the frames of inside cylinder engines, as, the slide valves may be placed on the top or bottom of the cylinders. This latter advantage is a great one, as, with the ordinary link motion, large cylinders are exceedingly difficult to design so as to get the requisite clear exhaust. The action of the gear is as follows: A rod, a, is fixed by a pin at b, on which it is free to turn, and is attached to a rod, c, at d, the other end of which link is fastened to the connecting rod at e. At the point, f, in this rod another lever, g, is connected to it, the upper end of which is coupled to the valve rod, h, at i, and just below this point a second connection is made to a block at j, sliding

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in a short curved piece, k. The inclination of the block, k, governs the travel of the valve. The total weight of the engine in working order is: On the leading wheels, 10 tons 8 cwt.; front drivers, 14 tons 4 cwt.; rear drivers, 13 tons 10 cwt.; total, 37.75 tons. The tender weighs 25 tons in full working order. The boiler pressure is 150 lb., and the usual point of cut-off in the high pressure cylinders, when running at speed, is half-stroke, while the pressure of steam admitted to the large cylinder is never to exceed 75 lb. per square inch. The average consumption of coal between London and Crewe is 26.6 lb. per train mile, or about 8 lb. per mile less than the standard coupled engine. In an experiment made in October, 1883, one of these engines took the Scotch express from Euston to Carlisle at an average speed, between stations, of 44 miles an hour, the engine, tender, and train weighing 230 tons, with a consumption of 291/2 lb. of coal per mile, and an evaporation of 8.5 lb. of water per pound of fuel.

Mr. Webb’s object, in designing this engine was to secure in the first place a greater economy of fuel, and secondly, to do away with coupling rods, while at the same time obtaining greater adhesion, with the freedom of a single engine. The cost is much more than an ordinary locomotive, but the saving in fuel is said to be 20 per cent. over the other engines of the North Western Rail way. These engines run very sweetly, and are said to steam freely, although with only half the usual number of blasts; but from the small size of the high pressure cylinders, they are liable to slip when starting heavy trains, as the low pressure cylinders are not then effective, while the consumption of coal does not seem to show the saving that would have been expected, when compared with ordinary engines doing similar duty on other lines; for instance, the Great Northern single engine takes trains of the same weight with the same consumption of coal and at a somewhat higher speed. But it must, of course, be borne in mind in making such a comparison, that the fuel used may not be of the same quality.

Mr. Stirling, of the Great Northern, has adopted an entirely different type of engine to those last described. Holding strongly that single engines are more economical not only in running, but in repairs, and that cylinder power is generally inadequate to the adhesion, he has designed his magnificent well-known class of express engines. They have single driving wheels 8 ft. in diameter, with a four-wheel bogie in front and a pair of trailing wheels, 4 ft. diameter, behind. The frames are single, and inside of one solid piece; the cylinders are outside 18 in. diameter and 28 in. stroke; and the valve gear is of the usual shifting link description. The boiler is of Yorkshire plates, 11 ft. 5 in. long and 4 ft. diameter, and the steam pressure is 140 lb.; while the tractive power per lb. of steam in the cylinders is 94 lb. The fire-box is of copper, and the roof is stayed to the outer shell by wrought iron radiating stays screwed into both; a sloping mid-feather is placed in the fire-box.

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[Illustration: FIG. 5.—GREAT NORTHERN RAILWAY.]

The tubes, 217 in number, are of brass, 1-9/16 in. diameter; and the heating surface is in the tubes, 1,043 square feet; fire-box, 122 square feet; total, 1,165 square feet. The fire-grate area is 17.6 square feet. The wheel base from the center of the bogie pin to the trailing axle is 19 ft. 5 in., and the weight in working order is, on the bogie wheels, 15 tons; driving wheels, 15 tons; trailing wheels, 8 tons; total, 38 tons. The tender weighs 27 tons. These engines are remarkable for their efficiency; the traffic of the Great Northern Railway is exceedingly heavy, and the trains run at a high rate, the average speed of the Flying Scotchman being fifty miles an hour, and no train in the kingdom keeps better time. "Those who remember this express at York in the icy winter of 1879-80, when the few travelers who did not remain thawing themselves at the waiting-room fires used to stamp up and down a sawdusted platform, under a darkened roof, while day after day the train came gliding in from Grantham with couplings like wool, icicles pendent from the carriage eaves, and an air of punctual unconcern; or those who have known some of our other equally sterling trains—these will hardly mind if friendship does let them drift into exaggeration when speaking of expresses." The author well remembers how, when living some years ago at Newcastle-on-Tyne, it was often his custom to stroll on the platform of the Central Station to watch the arrival of the Flying Scotchman, and as the hands of the station clock marked seven minutes past four he would turn around, and in nine cases out of ten the express was gliding into the station, punctual to the minute after its run of 272 miles. Such results speak for themselves, and for the power of the engines employed, and one of the best runs on record was that of the special train, drawn by one of these locomotives, which in 1880 took the Lord Mayor of London, to Scarborough. The train consisted of six Great Northern coaches, and ran the 188 miles to York in 217 minutes, including a stop of ten minutes at Grantham, or at the average rate of 541/2 miles an hour. The speed from Grantham to York, 821/2 miles, with three slowing downs at Retford, Doncaster, and Selby, averaged 57 miles an hour, and the 59 miles from Claypole, near Newark, to Selby, were run in 601/2 minutes, and for 221/2 consecutive miles the speed was 64 miles an hour. In ordinary working these engines convey trains of sixteen to twenty-six coaches from King's-Cross with ease, and often twenty-eight are taken and time kept. Considering that the Great Northern main line rises almost continuously to Potter's Bar, 13 miles, with gradients varying from 1 in 105 to 1 in 200, this is a very high duty, while, with regard to speed, they have run with sixteen coaches for 15 miles at the rate of 75 miles an hour. Their consumption of coal with trains averaging sixteen ten ton carriages

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is 27 lb. per mile, or 8 lb. per mile less than the standard coupled engine of the North-Western with similar loads. Mr. Stirling's view, that the larger the wheel the better the adhesion, seems borne out of these facts; thus to take twenty-eight coaches, or a gross load of 345 tons, up 1 in 200 at a speed of 35 miles an hour, would require an adhesive force of 8,970 lb., or 600 lb. per ton—more than a quarter the weight on the driving wheels. These engines are magnificent samples of the most powerful express engines of the present day.

The London, Brighton, and South Coast Railway Company has in the last few years had its locomotive stock almost entirely replaced, and instead of seventy-two different varieties of engines out of a total of 233, which was the state of locomotive stock in 1871. a small number of well-considered types, suited to the different class of work required, are now in use. Mr. Stroudley considers—contrary to the opinion once almost universally held—that engines with a high center of gravity are the safest to traverse curves at high speed, as the centrifugal force throws the greatest weight on the outer wheels, and prevents their mounting; also that the greatest weight should be on the leading wheels, and that there is no objection to these wheels being of a much larger diameter than that usually adopted; in fact, by coupling the leading and driving wheels where the main weight is placed a lighter load is thrown on the trailing wheels, thus enabling them to traverse curves at a high speed with safety, while it permits of a larger fire-box being used; and these principles have been carried out in the newest class of engines, especially designed for working the heavy fast passenger traffic of the line.

The modern express engines are of two types. The first is a single engine with 6 ft. 6 in. driving wheels, and leading and trailing wheels 4 ft. 6 in. in diameter and a wheel base of 15 ft. 9 in. The frames are single, with inside bearings to all the wheels; the cylinders are inside, 17 in. diameter and 24 in. stroke. The boiler is 10 ft. 2 in. long and 4 ft. 3 in. diameter; the fire-box is of copper with a fire-grate area of 17.8 square feet, and the heating surface is in the tubes 1,080 square feet, fire-box 102 square feet; total, 1182 square feet. The weight in working order is about 35 tons. These engines have a tractive power of 89 lb. per pound of mean steam pressure in the cylinders, and their consumption of coal with trains averaging nine coaches is about 20 lb. per mile. The next type of engine designed has coupled wheels under the barrel of the boiler 6 ft. 6 in. diameter, with cylinders 171/4 in. diameter and 26 in. stroke, and were found so successful that Mr. Stroudley designed a more powerful engine of the same class, especially to take the heaviest fast trains in all weathers.

The 8:45 A.M. train from Brighton has grown to be one of the heaviest fast trains in the kingdom, although the distance it runs is but very short, while it is also exceptional in consisting entirely of first class coaches, and the passengers mainly season ticket holders; it often weighs in the gross 350 tons, and to take this weight at a mean speed of forty-five to fifty miles an hour over gradients of 1 in 264 is no light work.

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[Illustration: FIG. 6.—LONDON, BRIGHTON, AND SOUTH COAST RAILWAY.]

The engines known as the “Gladstone” type have inside cylinders 181/4 in. diameter and 26 in. stroke, with coupled wheels 6 ft. 6 in. diameter under the barrel of the boiler; the trailing wheels are 4 ft. 6 in. diameter, and the total wheel base is 15 ft. 7 in. The frames are inside, of steel 1 in. thick, with inside bearings to all the axles. The cylinders are cast in one piece 2 ft. 1 in. apart, but in order to get them so close together the valves are placed below the cylinders, the leading axle coming between the piston and slide valve. The boiler is of iron, 10 ft. 2 in. long, and 4 ft. 6 in. diameter; and the heating surface is, in the tubes, 1,373 square feet; fire-box, 112 square feet; total, 1,485 square feet. The grate area is 20.65 square feet, and the tractive power per pound of mean cylinder pressure is 111 lb. The weight in full working order is—leading wheels, 13 tons 16 cwt.; driving wheels, 14 tons 10 cwt.; trailing wheels, 10 tons 8 cwt.; total, 38 tons 14 cwt. The tender weighs 27 tons.

To enable these engines to traverse curves easily a special arrangement of draw-bar is used, consisting of a T-piece with a wheel at each end working in a curved path in the back of the frame under the foot plate; on the back buffer beam a curved plate abuts against a rubbing piece on the tender, through which the draw-bar is passed and screwed up against an India-rubber washer, thus allowing the engine to move free of the tender as the curvature of the road road requires; the flanges on the driving wheel are also cut away, so as not to touch the rail. In order to reduce the wear of the leading flanges, a jet of steam from the exhaust is directed against the outer side of each wheel. The center line of the boiler is 7 ft. 5 in. above the rails, and the tubes, of which there are as many as 331, are bent upward 11/2 in., which permits expansion and contraction to take place without starting the tubes, and they are stated never to leak or give trouble. The feed-water is heated by a portion of the exhaust steam and the exhaust from the Westinghouse brake, and the boiler is consequently fed by pumps, is kept cleaner, and makes steam better. The reversing gear is automatic and exceedingly ingenious, the compressed air from the Westinghouse brake reservoir being employed to do the heavy work. A cylinder 41/2 in. diameter is fitted with a piston and rod attached to the nut of the reversing screw, and a three-way cock supplies the compressed air behind the piston; this forces the engine into back gear, and by allowing the air to escape, the weight of the valve motion puts the engine in forward gear. There are no balance weights, and the screw regulates the movement. There is also a very ingenious speed indicator, which consists of a small brass case filled with water, in which is a small fan driven by a cord from the driving wheel; a copper pipe leads from the fan case to a glass gauge tube; the faster the fan runs the higher the water will stand in the tube, thus indicating the speed.

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The author has been led to describe this engine fully on account of the numerous ingenious appliances which have been adopted in its design. In a trial trip on October 3, 1883, from Brighton to London Bridge and back, with an average load of 191/2 coaches, or 285 tons gross, and with a speed of 45 miles per hour, the consumption of coal was 31 lb. per train mile, evaporating 8.45 lb. of water per pound of coal, and with as much as 1,100 indicated horse-power at one portion of the run. The finish and painting of these engines is well considered, but the large coupled wheels give a very high shouldered appearance, and as a type they are not nearly as handsome as the single engines previously described.

From the Brighton to the South-Western Railway is but a step; but here a totally different practice obtains to that adopted on most lines, all the passenger engines having outside cylinders, where they are more exposed to damage in case of accident, and, from being less protected, there is more condensation of steam, while the width between the cylinders tends to make an unsteady running engine at high speeds, unless the balancing is perfect; but the costly crank axle, with its risk of fracture, is avoided, and the center of gravity of the boiler may be consequently lowered, while larger cylinders may be employed. On the other hand, inside cylinders are well secured, protected, and kept hot in the smoke-box, thus minimizing the condensation of steam. The steam ports are short, and the engine runs steadier at high speeds, while with Joy's valve gear much larger cylinders can be got in than with the link motion. Thus modern improvements have minimized the advantages of the outside class.

The passenger engines for the fast traffic are of two types, the six-wheel engines with 7 ft. coupled wheels, and the new bogie engines which are being built to replace them. The former have 17 in. cylinders with 22 in. stroke, and a pair of coupled wheels 7 ft. in diameter, the leading wheels being 4 ft. diameter, and the wheel base 14 ft. 3 in. The grate area is 16.1 square feet, and the heating surface 1,141 square feet. The total weight in working order is 33 tons. The chief peculiarity of this type of engine consists in the boiler, which is fitted with a combustion chamber stocked with perforated bricks, the tubes being only 5 ft. 4 in. long. These engines are very expensive to build and maintain, owing to the complicated character of the boiler and fire-box, but as a coal burning engine there is no doubt the class was very efficient, but no more are being built, and a new type has been substituted. This is an outside cylinder bogie engine, with cylinders 181/2 in. diameter and 26 in. stroke; the driving and trailing coupled wheels are 6 ft. 6 in. diameter, and the bogie wheels 3 ft. 3 in. The wheel base to the center of the bogie pin is 18 ft. 6 in.; the heating surface is, in the tubes, 1,112; fire box, 104; total, 1,216 sq. ft. The weight of the engine in working order is 42 tons.

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[Illustration: FIG. 7.—MIDLAND RAILWAY.]

The Midland Railway route to the North is distinguished by the heavy nature of its gradients; between Settle and Carlisle, running through the Cumberland hills, attaining a height of 1,170 ft. above sea level, the highest point of any express route in the kingdom; and to work heavy fast traffic over such a line necessitates the employment of coupled engines. The standard express locomotive of this company has inside cylinders 18 in. in diameter and 26 in. stroke. The coupled wheels are 6 ft. 9 in. diameter, and the leading wheels 4 ft. 3 in., the total wheel base being 16 ft. 6 in., and the tractive force 104 lb. for each lb. of mean cylinder pressure. The boiler is of best Yorkshire iron, 10 ft. 4 in. long and 4 ft. 1 in. diameter. The grate area is 17.5 square feet, and the heating surface is, in the tubes, 1,096; fire-box, 110; total, 1,206. There are double frames to give outside bearings to the leading axle, as in the Great Western engine, and the engine is fitted with a steam brake. The weight in full working order is —leading wheels, 12 tons 2 cwt.; driving wheels, 15 tons; trailing wheels, 11 tons 6 cwt.; total, 38 tons 8 cwt. The tender weighs 26 tons 2 cwt., and holds 3,300 gallons of water and 5 tons of coal. Latterly a fine type of bogie express engine has been introduced, with inside cylinders 18 in. diameter and 26 in. stroke, and four coupled driving wheels 7 ft. diameter. The total wheel base to the center of the bogie pin is 18 ft. 6 in. The grate area is 17.5 square feet, and the heating surface is, in tubes, 1,203 square feet, and fire-box, 110; total, 1,313; and the engine weighs 42 tons in working order. These engines take fourteen coaches, or a gross load of 222 tons, at 50 miles an hour over gradients of 1 in 120 to 1 in 130, with a consumption of 28 lb. of coal per mile. The London, Chatham, and Dover Company has also some fine engines of a similar type. They have inside cylinders 171/2 in. diameter and 26 in. stroke; the coupled wheels are 6 ft. 6 in. diameter, and the bogie wheels 3 ft. 6 in., the wheel base to the center of the bogie pin being 18 ft. 2 in. The boiler is 10 ft. 2 in. long and 4 ft. 2 in. diameter, the grate area is 16.3 square feet, and the heating surface is, in the tubes, 962 square feet; fire-box, 107 square feet; total, 1,069. The boiler pressure is 140 lb., and the tractive force per lb. of steam in the cylinder 102 lb. The weight in full working order is, on the bogie wheels, 15 tons 10 cwt.; driving wheels, 13 tons 10 cwt.; trailing wheels, 13 tons; total, 42 tons.

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Mr. Worsdell has lately designed for the Great Eastern Railway a fine type of coupled express engine, which deserves mention. It has inside cylinders 18 in. diameter and 24 in. stroke, with coupled wheels 7 ft. diameter and leading wheels 4 ft. diameter, the latter being fitted with a radial axle on a somewhat similar plan to that previously described as adopted by Mr. Webb for the new North-Western engines; the frames are single, with inside bearings to all the wheels, and Joy's valve gear is used. The boiler pressure is 140 lb., and the tractive power per lb. of mean cylinder pressure 92 lb. The total wheel base is 17 ft. 6 in. The boiler, which is fed by two injectors, is of steel, 11 ft. 5 in. long and 4 ft. 2 in. diameter. The grate area is 17.3 square feet, and the heating surface is, in the tubes, 1,083; fire-box, 117; total, 1,200 sq. ft. The weight in working order is, on the leading wheels, 12 tons 19 cwt.; driving wheels, 15 tons; trailing wheels, 13 tons 4 cwt.; total, 41 tons 3 cwt. These engines burn 27 lb. of coal per train mile with trains averaging thirteen coaches. It has been seen that the Cheshire lines express between Liverpool and Manchester is one of the fastest in England, and the Manchester, Sheffield, and Lincolnshire Railway Company, who works the trains, has just introduced a new class of engine specially for this and other express trains on the line. The cylinders are outside, 171/2 in. diameter and 26 in. stroke, with single driving wheels 7 ft. 5 in. diameter, the leading and trailing wheels being 3 ft. 8 in. diameter. The total wheel base is 15 ft. 9 in., and the frames are double, giving outside bearings to the leading and trailing axles, and inside bearings to the driving axle. The boiler is 11 ft. 6 in. long and 3 ft. 11 in. diameter, and the grate area is 17 square feet. The heating surface is in the tubes 1,057 square feet; fire-box, 87 square feet; total, 1,144 square feet. The tractive force per pound of mean cylinder pressure is 88.4 lb. The weight in full working order is, on the leading wheels, 11 tons 3 cwt.; driving wheels, 17 tons 11 cwt.; trailing wheels, 11 tons 18 cwt.; total, 40 tons 12 cwt. This engine is remarkable for the great weight thrown on the driving wheels, and its cylinder power is great in proportion to its adhesion, thus allowing the steam to be worked at a high rate of expansion, which is most favorable to the economical consumption of fuel. There are numerous fine engines running on other lines, such as the new bogie locomotives on the North-Eastern and Lancashire and Yorkshire railways, and the coupled express engines on the Caledonian; but those already described represent fairly the lending features of modern practice, and the author will now notice briefly the two other classes of engines—tank passenger engines for suburban and local traffic and goods engines. The Brighton tank passenger engine is a good example of the former class; it has inside cylinders 17 in.

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diameter and 24 in. stroke. The two coupled wheels under the barrel of the boiler are 5 ft. 6 in. diameter, and the trailing wheels 4 ft. 6 in.; there are single frames with inside bearings to all the axles. The boiler pressure is 140 lb., and the tractive force per pound of mean cylinder pressure 106 lb.; the total wheel base is 14 ft. 6 in. The boiler is 10 ft. 2 in. long and 4 ft. 4 in. diameter, and the heating surface is in the tubes, 858 square feet; fire-box, 90 square feet; total, 948 square feet. The engine is furnished with wing tanks holding 860 gallons of water, and carries 30 cwt. of coal. The weight in working order is 38 tons. These engines have taken a maximum load of twenty-five coaches between London and Brighton, but are mainly employed in working the suburban and branch line traffic; their average consumption of coal is 23.5 lb. per mile, with trains averaging about ten coaches.

Another example is Mr. Webb's tank engine on the North-Western Railway, which presents a contrast to the foregoing. It has inside cylinders 17 in. diameter and 20 in. stroke, coupled wheels 4 ft. 6 in. diameter, and a tractive power per lb. of mean cylinder pressure of 107 lb.; the wheel base is 14 ft. 6 in. with a radial box to the leading axle; the heating surface is in the tubes, 887; fire-box, 84; total, 971 square feet; the weight in working order is 35 tons 15 cwt. The engine is fitted with Webb's hydraulic brake, and steel, manufactured at Crewe, is largely used in its construction. The consumption of coal-working fast passenger trains has been 281/2 lb. per mile. There are many other types, such as the ten wheel bogie tank engines of the London, Tilbury, and Southend and South-Western railways; the saddle tank bogie engines, working the broad gauge trains on the Great Western Railway, west of Newton; and the familiar class working the Metropolitan and North London traffic. But the same principle is adopted in nearly all—-a flexible wheel base to enable them to traverse sharp curves, small driving wheels coupled for adhesion, and wing or saddle tanks to take the water. One notable exception is, however, the little six wheel all-coupled engines weighing only 24 tons, which work the South London traffic, burning 241/4 lb. of coal per mile, with an average load of eleven coaches.

Goods engines on all lines do not vary much. As a rule they are six wheel all-coupled engines, with generally 5 ft. wheels, and cylinders varying between 17 in. and 18 in. diameter and 24 in. to 26 in. stroke; the grate area is about 17 square feet, and the total heating surface from 1,000 to 1,200 sq. ft.; the average weight in full working order varies from 30 to 38 tons. One noteworthy exception occurs, however, on the Great Eastern Railway, where a type of goods engine with a pony truck in front has been introduced. The cylinders are outside 19 in. diameter and 26 in. stroke, there are six coupled wheels 4 ft. 10 in. diameter, and the pony truck wheels are 2 ft. 10 in. diameter; the total wheel wheel base is 23 ft. 2 in., but there are no flanges on the driving wheels. The boiler is 11 ft. 5 in. long and 4 ft. 5 in. diameter, the boiler pressure is 140 lb., and the tractive force per lb. of mean cylinder pressure 162 lb.; the grate area is 18.3 square feet, and the heating surface is in the tubes, 1,334 square feet; fire-box, 122 square feet; total, 1,456 square feet.

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The weight in working order is on the pony truck, 8 tons 10 cwt.; leading coupled, 12 tons 8 cwt.; driving coupled, 13 tons 5 cwt.; trailing coupled, 12 tons 15 cwt.; total, 47 tons.

The tender weighs 28 tons in full working order. These engines take 40 loaded coal trucks or sixty empty ones, and burn 52 lb. of coal per train mile, the worst gradient being 1 in 176. A notice of goods engines would not be complete without alluding to a steep gradient locomotive, and a good example is the engine which works the Redheugh Bank on the North-Eastern Railway. This incline is 1,040 yards long, and rises for 570 yards 1 in 33, then for 260 yards 1 in 21.7, for 200 yards 1 in 25, and finally for 110 yards 1 in 27. The engine, which is an all-coupled six wheel tank engine, weighs 481/2 tons in working order, it has cylinders 18 in. diameter and 24 in. stroke, and 4 ft. wheels, the boiler pressure is 160 lb., and the tractive force per lb. of mean steam pressure in the cylinders is 162 lb. This engine will take up the incline twenty-six coal wagons, or a gross load of 218 tons, which is a very good duty indeed.

Having now passed in review the general types of engines adopted in modern English practice, the author would briefly draw attention to some points of design and some improvements effected in late years. And first, as to the question of single or coupled engines, there is a great diversity of opinion. Mr. Stirling conducts his traffic at a higher rate of speed, and certainly with equal punctuality, with his magnificent single 8 ft. engines, as Mr. Webb on the North-Western with coupled engines, and the economy of fuel of the former class over the latter is very remarkable; this is, no doubt, owing, as has been previously pointed out, to their ample cylinder power, which permits of the steam being worked at a high rate of expansion. There is no doubt that if single engines can take the load they will do so more freely and at a less cost than coupled engines, burning on the average 2 lb. of coal per mile less with similar trains. With, regard to loads, it is a question whether any express train should be made up with more than twenty-five coaches. The Great Northern engine will take twenty-six and keep time, and the Brighton single engine has taken the five P.M. express from London Bridge to Brighton, consisting of twenty-two coaches, at a speed of forty-five miles per hour. Of course where heavy gradients have to be surmounted, such as those on the Midland route to Scotland, coupled engines are a necessity. Single engines are said to slip more than coupled; thus an 8 ft. single Great Northern engine running down the incline from Potter’s Bar to Wood Green with twelve coaches at the rate of sixty miles an hour was found to be making 242 revolutions per mile instead of 210; and in an experiment tried on the Midland Railway it was found that a coupled engine with ten coaches at fifty miles an hour made seventeen extra revolutions a mile, but when the side

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rods were removed it made forty-three. The Great Western, Great Northern, and Brighton mainly employ single engines for their fast traffic; and the Manchester, Sheffield, and Lincolnshire have now adopted the single type in preference to the coupled for their express trains; while the North-Western, Midland, South-Western, and Chatham adopted the coupled type. One noticeable feature in modern practice is the increased height of the center line of boiler; formerly it was the great aim to keep this low, and numerous schemes to this effect were propounded, but now it has become generally recognized that a high pitched engine will travel as steadily and more safely round a curve—given a good road—than a low pitched one; and thus while in 1850 the average height of the center line of boilers varied between 5 ft. 3 in. and 6 ft. 3 in., now in the latest designs it lies between 7 ft. and 7 ft. 6 in. Single frames are very generally adopted, but double frames and outside bearings to the leading and trailing wheels, as in the Great Western engines, give great steadiness in running, and this class has also double bearings to the driving wheels, thus entailing greater security in case of the facture of a crank axle. The general adoption of cabs on the foot-plate for the men is another improvement of late introduction, although at first not universally appreciated by those for whose comfort it was designed—"I felt as if I was in my coffin," said an old driver when asked how he liked the new shelter. Mild steel fire-boxes, which have been employed in America, are not in favor here, copper being universally used; they have been tried on the Caledonian, Great Southern and Western, North London, and North-Western, and were found not to succeed. Brake blocks of cast iron have now generally superseded wood; steel is being more and more used, especially on the North Western. There is less use of brasswork for domes and fittings, although it is claimed for brass that it looks brighter and can easily be kept clean. There is greater simplicity of design generally, and the universal substitution of coal as coke for fuel, with its consequent economy; and last, but not least, the adoption of standard types of engines, are among the changes which have taken place in locomotive practice during the past quarter of a century.

[Illustration: FIG. 8.—LONDON, CHATHAM, & DOVER RAILWAY.]

[Illustration: FIG. 9.—GREAT EASTERN RAILWAY.]

[Illustration: FIG. 10.—MANCHESTER, SHEFFIELD, AND LINCOLNSHIRE RAILWAY.]

Having now reviewed, as far as the limits of this paper will allow, the locomotive practice of the present day, the author would in conclusion draw attention to what may possibly be one course of locomotive development in the future. Time is money, and it may be in the coming years that a demand will arise for faster means of transit than that which we possess at present. How can we meet it? With our railways laid out

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with the curves and gradients existing, and with our national gauge, and our present type of locomotive, no great advance in speed is very probable; the mean speed of express trains is about fifty miles an hour, and to take an average train of 200 tons weight at this speed over a level line requires between 650 and 700 effective horse-power, within the compass of the best engines of the present day. But if instead of fifty miles an hour seventy is required, an entirely different state of things obtains. Taking a train of 100 tons, with engine and tender weighing 75 tons, or 175 tons gross, the first question to determine will be the train resistance, and with reference to this we much want careful experiments on the subject, like those which Sir Daniel Gooch made in 1848, on the Bristol and Exeter Railway, which are even now the standard authority; the general use of oil axle-boxes and long bogie coaches, irrespective of other improvements, would render this course desirable. With regard to the former, they appear to run with less friction, but are heavier to start, oil boxes in some experiments made on the South-Western Railway giving a resistance of 2.5 lb. per ton, while grease boxes ranged from 6 lb. to 9 lb. per ton. Again, the long and heavy bogie Pullman and other coaches have the reputation among drivers, rightly or wrongly, of being hard to pull. The resistance of an express train on the Great Western Railway at seventy-five miles an hour was 42 lb. per ton, and taking 40 lb. per ton for seventy miles an hour would give a total resistance on the level of 7,000 lb., corresponding to 1,400 horse-power—about double the average duty of an express engine of the present day. The weight on the driving wheels required would be 183/4 tons, allowing one-sixth for adhesion, about the same as that on the driving axle of the Bristol and Exeter old bogie engines. Allowing 21/2 lb. of coal per horse-power per hour would give a total combustion of 3,500 lb. per hour and to burn this even at the maximum economic rate of 85 lb. per square foot of grate per hour would require a grate area of 41 square feet, and about 2,800 square feet of heating surface. Unless a most exceptional construction combined with small wheels is adopted, it appears almost impossible to get this amount on the ordinary gauge. It is true the Wootten locomotives on the Philadelphia and Reading Railway have fire-boxes with a grate area of as much as 76 square feet, but these boxes extend clean over the wheels, and the heating surface in the tubes is only 982 square feet; but although these engines run at a speed of forty-two miles an hour, they are hardly the type to be adopted for such a service as is being considered. On the broad gauge, however, such an engine could easily be designed on the lines now recognized as being essential for express engines without introducing any exceptional construction, and there appears but little doubt that were Brunei’s magnificent gauge the national one, competition would have introduced a higher rate of speed between London and our great towns than that which obtains at present.

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The whole question of the future introduction of trunk lines, exclusively for fast passenger traffic, is fraught with the highest interest, but it would be foreign to the subject matter of this paper to enter more fully on it, the author merely desiring to state his opinion that if the future trade and wealth of our country require their construction, and if a very high rate of speed much above our present is to be attained, their gauge will have to be seriously considered and settled, not by the reasons which caused the adoption of the present gauge, but by the power required to carry on the traffic—in fact, to adapt the rail to the engine, and not, as at present, the engine to the rail. High speed requires great power, and great power can only be obtained by ample fire-grate area, which for a steady running engine means a broad gauge. The Gauge Commissioners of 1846 in their report esteemed the importance of the highest speed on express trains for the accommodation of a comparatively small number of persons, however desirable that may be to them, as of far less moment than affording increased convenience to the general commercial traffic of the country. The commercial traffic of England has grown and prospered under our present system, and if its ever increasing importance demands high speed passenger lines, we may rest assured that the ingenuity of man, to which it is impossible to assign limits, will satisfactorily solve the problem.

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SCREW STEAM COLLIER FROSTBURG.

[Illustration: NEW STEAM COLLIER.]

Our diagram shows the screw steam collier Frostburg, built by Henry H. Gorringe (the American Shipbuilding Co.), Philadelphia, Pa. Length, 210 ft. Beam, 33 ft. Depth, 17 ft, Register tonnage, 533. Carrying capacity on 14ft., 1,100 tons, and 100 tons coal in bunker. Cubical contents of cargo space, 55,168 cub. ft. Carrying capacity on 16 feet draught, 1,440 tons. Engines, compound surface condensing. High pressure 26 in. diameter, low pressure 48 in. diameter, stroke 36 in. Two boilers, each 13 ft. diameter. 10 ft. long, and one auxiliary 5 ft. diameter and 10 ft. high. 100 lb. working pressure. Sea speed with full cargo, 11 knots.

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A thirteen year old girl, who is perfect in other ways, but who has simply little blue spots that puff out slightly where her eyes should be, is said to be living at Amherst, Portage County, Wisconsin.

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DESTRUCTION OF THE TARDES VIADUCT.

The railroad from Montlucon to Eygurande, which is being constructed by the state engineers, crosses the valley of the Tardes in the environs of Evaux (Creuse).

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At the spot selected for the establishment of the viaduct the gauge is deep and steep. The line passes at 300 feet above the river, and the total length of the metallic superstructure had to be 822 feet. To support this there was built upon the right bank a pier 158 feet in height, and, upon the left, another one of 196 feet. The superstructure had been completed, and a portion of it had already been swung into position, when a violent, gale occurred and blew it to the bottom of the gorge. At the time of the accident the superstructure projected 174 feet beyond the pier on the right bank, and had to advance but 121 feet to reach the 33 foot scaffolding that had been established upon the other pier.

It blows often and violently in this region. For example, a gale on the 20th of February, 1879, caused great damage, and, among other things, blew the rear cars of a hay train from the top of the Louvoux viaduct to the Bouble.

The superstructure of the Tardes viaduct had already withstood the tempest of the 23d and the 24th of January, 1884, and neither any alteration in its direction nor any change in the parts that held it upon the pile could be perceived. But on the night of January 26-27 the storm doubled in violence, and the work was precipitated into the ravine. No one was witness of the fall, and the noise was perceived only by the occupants of the mill located below the viaduct.

The workmen of the enterprise, who lived about 325 feet above this mill and about 650 feet from the south abutment, heard nothing of it, the wind having carried the noise in an opposite direction. It was not until morning that they learned of the destruction of their work and the extent of the disaster.

One hundred and sixty-nine feet of the superstructure, weighing 450 tons, had been precipitated from a height of nearly 200 feet and been broken up on the rock at 45 feet from the axis of the pier. The breakage had occurred upon the abutment, and the part 195 feet in length that remained in position in the cutting was strongly wedged between walls of rock, which had kept this portion in place and prevented its following the other into the ravine.

Upon the pier there remained a few broken pieces and a portion of the apparatus used in swinging the superstructure into place.

Below, in the debris of the superstructure, the up-stream girder lay upon the down-stream one. The annexed engraving shows the state of things after the disaster.

Several opinions have been expressed in regard to the cause of the fall. According to one of these, the superstructure was suddenly wrenched from its bearings upon the pier, and was horizontally displaced by an impulse such that, when it touched the masonry, its up-stream girder struck the center of the pier, upon which it divided, while the down-stream one was already in space. The fall would have afterward continued without the superstructure meeting the face of the pier.

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[Illustration: DESTRUCTION OF THE TARDES VIADUCT.]

Upon taking as a basis the horizontal displacement of the superstructure, which was 45 meters to the right of the pier, and upon combining the horizontal stress that produced it with that of the loads, the stress exerted upon the body may he deduced. But this hypothesis seems to us scarcely tenable, especially by reason of the great stress that it would have taken to lift the superstructure. On another hand, it was possible for the latter to slide over one edge of the pier, and this explains the horizontal distance of 45 feet by which its center of gravity was displaced. It is probable, moreover, that the superstructure, before going over, moved laterally upon its temporary supports.

The girders were, in fact, resting upon rollers, and the roller apparatus themselves were renting upon wedges, and there was no anchorage to prevent a transverse sliding.

Under the prolonged thrust of a very high wind, the superstructure, by reason of its considerable projection, must have begun to swing like a pendulum. These oscillations acquired sufficient amplitude to cause the superstructure to gradually move upon its rollers until the latter no longer bore beneath the webs. The flanges therefore finally bent upward where they rested upon the rollers, through the action of the weight which they had to support, and the entire superstructure slid off into space.

An examination of the bent pieces seems to give great value to this hypothesis.—*Le Genie Civil*.

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JOY'S REVERSING AND EXPANSION VALVE GEAR.

[Footnote: A paper read before the Mechanical Section of the British Association, at Montreal, August, 1884.]

Four years ago, in August, 1880, a paper was read on this subject before the Annual Summer Meeting of the Mechanical Engineers' Society of Great Britain, then held in Barrow-in-Furness, describing this valve motion and its functions, which was then comparatively new. It was, however, illustrated by its application to a large express goods (freight) engine, built by the London and North-Western Railway Company (England) specially to test the advantages and the endurance of the gear. This engine had cylinders of 18 inches in diameter and 24 inch stroke, and six wheels coupled 5 feet 1 inch diameter, and was designed by Mr. Webb, the Company's chief engineer, for their heavy fast goods traffic on the main line. The engine has been running this class of traffic ever since. In January, 1884, it was passed through the repair shops for a general overhauling, when it was found that the valve motion was in such good condition as to be put back on the engine without any repairs.

The main object of this present paper is to deal with the advantages of the valve gear and its application to various classes of engines both on land and at sea, and with the results of such applications, rather than treating it as a novelty, to give an exhaustive description of its construction and functions, which was done in the paper above referred to. A very short description of its action and main features will, however, be necessary to the completeness of the paper, and as a basis from which the improved results to be recorded should necessarily be shown to spring.

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The essential feature of this valve gear is that movement for the valve is produced by a combination of two motions at right angles to each other; and by the various proportions in which these are combined, and by the positions in which the moving parts are set with regard to each other, it gives both the reversal of motion and the various degrees of expansion required. Eccentrics are entirely dispensed with and the time-honored link gear abandoned, the motion is taken direct from the connecting rod, and by utilizing independently the backward and forward action of the rod, due to the reciprocation of the piston, and combining this with the vibrating action of the rod, a movement results which is suitable to work the valves of engines, allowing the use of any proportions of lap and lead desired, and giving an almost mathematically correct “cut-off” for both sides of the piston and for all points of expansion intermediately, as well as a much quicker action at the points of “cut-off” and “release” than is given by a link gear.

The machinery for accomplishing this is both less costly and less complicated than the ordinary link motion, and is shown in elevation on cut, which is a view of the complete motion as on the first London and North-Western locomotive. Here E is the main valve lever, pinned at D to a link, B, one end of which is fastened to the connecting rod at A, and the other end maintained in about the vertical by the radius rod, C, which is fixed at the point, C. The center or fulcrum, F, of the lever, E, partaking of the vibrating movement of the connecting rod at the point, A, is carried in a curved slide, J, the radius of which is equal to the length of the link, G, and the center of which is fixed to be concentric with the fulcrum, F, of the lever when the piston is at either extreme end of its stroke. From the upper end of the lever, E, the motion is carried direct to the valve by the rod, G. It will be evident thus that by one revolution of the crank the lower end of the lever, E, will have imparted to it two different movements, one along the longer axis of the ellipse, traveled by the point, A, and one through its minor axis up and down, these movements differing as to time, and corresponding with the part of the movement of the valve required for lap and lead, and that part constituting the port opening for admission of steam.

[Illustration: JOY’S REVERSING AND EXPANDING VALVE GEAR.]

The former of these is constant and unalterable, the latter is controllable by the angle at which the curved slide, J, may be set with the vertical.

It will further be evident that if the lever, E, were pinned direct to the connecting rod at the point, A, which passes through a practically true ellipse, it would vibrate its fulcrum, F, unequally on either side of the center of the curved slide, J, by the amount of the versed sine of the arc of the lever, E, from F D; it is to correct this error that the lever, E, is pinned at the point, D, to a parallel motion formed by the parts, B and C. The point, D, performing a figure which is equal to an ellipse, with the error to be eliminated added, so neutralizing its effect on the motion of the fulcrum, F.

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The “lap” and “lead” are opened by the action of the valve lever acting as a lever, and the port opening is given by the incline of the curved slide in which the center of that lever slides, and the amount of this opening depends upon the angle given to that incline. When these two actions are in unison, the motion of the valve is very rapid, and this occurs when the steam is being admitted. Then follows a period of opposition of these motions, during which time the valve pauses momentarily, this corresponding to the time when the port is fully open. Further periods of unison follow, at which time the sharp “cut-off” is obtained.

The “compression” resulting with this gear is also reduced to a minimum, owing to the peculiar movement given to the valves (*i. e.*, the series of accelerations and retardations referred to), as, while the “lead” is obtained later and quicker, the port is also shut for “compression” later and quicker, doing away with the necessity for a special expansion valve, with its complicated and expensive machinery, and allowing the main valve to be used for expansion, as the “compression” is not of an injurious amount, even with a “cut-off” reduced to 15 per cent., or about 1/6 of the stroke.

Thus, so far as the distribution of the steam and its treatment in the cylinder is concerned, a marked advantage is shown in favor of this valve gear. But next in its favor, as before said, is that the above advantages are not gained at the cost of added complication of parts or increased cost of machinery, but the reverse, as this gear can be built at a less cost than link gear, varying according to the circumstances, but reaching as high as a saving of 25 per cent., or, if it be compared with a link gear supplemented by the usual special expansion valve and gear as employed on marine engines, then the total saving is fully 50 per cent., and an equally good result is obtained as to the distribution and subsequent treatment of the steam.

After accuracy of result and reduction in cost may rank saving room and the advantages arising therefrom (though for steamships perhaps this should have come first). Taking locomotives of the inside cylinder type, which is the general form in use in England and the continent of Europe, by clearing away the eccentrics and valves from the middle of the engine, much larger cylinders may be introduced and a higher rate of expansion employed, and this is being done. Also room is left for increasing the length and wearing surfaces of all the main bearings with even less crowding than is now the case with engines with the smaller cylinders.

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But this advantage of saving room comes much more prominently forward in marine engines, especially in war ships, where every inch of room saved is valuable; and in the new type of triple-cylinder engines now coming so much into vogue in the mercantile marine, whether those engines be only the ordinary three-cylinder engines with double expansion, or the newer, triple expansion engine, expanding the steam consecutively through three cylinders—the form of marine engine which promises to come into use wherever high-class work and economy are required. On this system, by placing all the valve chests in front of the cylinders instead of between them, or in a line with them, sufficient room is saved to get the new-type three-cylinder engine into the space occupied by the old form of two-cylinder engine.

Besides these prominent advantages there are others which, though of minor importance, are still necessary to the practical and permanent success of any new mechanical arrangement, such as the accessibility of all the working parts while in motion, for examination and oiling; the ease with which any part or the whole can be stripped and cleaned, or pinned up out of the way in case of break down or accident, or got at and dismantled for ordinary repair; the ease with which the whole may be handled, started, reversed, or set at any point of expansion—all these being recommendations to enlist the care and attention of the engineers in charge by lightening their duties and rendering the engines easy to work.

With those advantages it is perhaps not surprising that this valve gear has been very considerably adopted for many classes of steam engines, especially where a high result has been required, with economy of space, and a minimum of complication.

Having crucially tested the original engine on the London and North-Western Railway, Mr. Webb proceeded to build others similar, and on his bringing out his Compound Express Engine—notably the most advanced step in locomotive design of the present day—he adopted this valve gear throughout. There are now a number of these engines running some of the fastest trains on the London and North-Western Railway, with the most satisfactory results.

Following these, others of the leading railways took up the system, and prominently among these Mr. Worsdell, of the Great Eastern Railway, built a number of large express engines for his fast and heavy traffic, and is now building a number of others similar as to the valve gear for his suburban traffic, which is specially heavy. Also the Lancashire and Yorkshire and the Midland and others of the chief railways are employing the system specially for large express engines; the Midland engines having cylinders of 19 inches diameter by 26 inches stroke, and four coupled wheels of 7 feet diameter. A number of the above-named engines have run large mileages, in many cases already exceeding 100,000 miles per engine. For other countries also a number of locomotive engines have been built or contracted for—both of inside and outside cylinder types—making a total of nearly 800 locomotives built and building, many of them being of special design and large size, up to 20 inches and 21 inches diameter of cylinder.

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In all these the absence of wire-drawing may be specially noted by the full line at the top of the diagram, showing the admission of steam—this fullness arising from the rapid and full opening of the port for admission.

Passing now to the other great type of engines, those covered under the general designation of marine engines, this gear has been applied to nearly 40,000 H.P. indicated, built and building, and to all classes and sizes, from the launch engine with cylinders 8 inches by 9 inches, running at 600 to 700 revolutions per minute, up to engines for the largest class of war ships, such as her Britannic Majesty's steel cruiser Amphion, of 5,000 H.P., with cylinders in duplicate of 46 inches and 86 inches diameter, and 3 feet 3 inches stroke, running 100 revolutions per minute. An examination of the indicator diagrams taken from these engines shows that no wire-drawing takes place, and that, though the expansion is carried to a point beyond the ordinary requirements, the compression is but slightly increased. In all the diagrams taken from this valve motion there is seen the clear, full upper line showing an abundant admission of steam without any wire-drawing, and also the distinctly marked points where "cut-off" or "suppression" and where "release" takes place, showing the rapid action of the valves at those points.

It is well known to engineers that to obtain the maximum advantage out of compounding, it is necessary to cut off in the low pressure cylinder at a point corresponding to the relation between the low and the high, and that point should be unaltered, whereas the point of cut-off in the high may at the same time be varied to suit the work to be done.

In an ordinary link motion engine (where both links are connected to the same weigh shaft), when linking up the high pressure cylinder to cut-off short, the same change is necessarily made in the low. By the use of the Joy gear, cut-off valves may be fitted to both cylinders, that for the low pressure being fixed at the constant position required by the proportion of the cylinders, while that on the high is adjustable; of course, in this case, the position of the quadrants must be only changed for reversing. In arranging the independent cut-off on the Joy gear, it is only necessary to increase the length of the vibrating link beyond the point of attachment for the main valve spindle connection to obtain a point from which motion may be taken to actuate the cut-off valve; even then the cost of the Joy gear for both cylinders is but little more than for a single set of link gear.

This arrangement gives an absolutely perfect distribution of steam for compounding, also equalizes the power developed by both cylinders, and is far more simple and inexpensive than any other gear in existence.

* * * * *

THE STEAM BELL.

[Illustration: FIG. 1.]

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[Illustration: FIG. 2.]

The secondary railways in rural districts in Austria having no gates or bars at the level crossings, or guards at such points, but being open like tramways, special precautions are required to avoid accidents, and the public has to be warned of the approach of the train from a sufficient distance. This is done by ringing bells preferably to sounding whistles, as these are more likely to startle horses. The steam bell shown by our illustrations has been adopted for this purpose on the Austrian lines, and is a simple contrivance. It consists of a cylindrical chamber, a, ending in a narrower tube, c, which forms the seating for a flap valve, d, to which the hammer or clapper, e, is fixed. Steam is admitted through a small pipe, b, at the bottom, and after a certain interval attains sufficient pressure to lift the valve. The opening being large compared with the pipe, b, steam escapes more rapidly than it arrives through the small orifice; the pressure falls, and the valve drops down and causes the hammer to strike a bell surrounding the cylinder. The valve is provided with an internal collar as shown, so that it has to rise for the width of this before the steam is let out, and thus determines the swing of the clapper and the force of the blow. To intensify the latter and multiply the number of blows, the clapper spring is prolonged over the fulcrum and bent back so as to form a spring, which is tightened by the lifting of the flap, and sends the clapper down on the bell with increased force. The hinge of the flap does not require any lubrication besides what it gets through the steam. The bell is fixed upon the roof of the driver’s cab, so that the steam does not interfere with his lookout, and fastened by three bolts or screws. The diameter of the steam-pipe is from 1/4 to 1/2 inch according to the size of the bell, and the distance of the clapper from the bell is a little less than the diameter of the corresponding cock. The steam cock is perforated as shown by the illustration to drain the pipe when shut, and a small hole, b, in the bell cylinder drains the latter. The steam-pipe is made with a bend as usual, to allow for contraction and expansion. The number of blows given varies according to the steam pressure, and the opening of the steam cock; it is

With 90 lb. pressure, and cock 1/2 open, 170 blows per min.
" " " " 1/3 " 136 "
105 " " " 1/2 " 240 "
" " " " 1/3 " 156 "
" " " " 1/5 " 136 "
120 " " " 1/3 " 228 "
135 " " " 1/5 " 200 "

To start the bell, the cock is opened full, and afterward partly closed. The blows follow in such rapid succession that a kind of uniform sound with louder intervals is produced, but not of the same shrill character as by a steam whistle. The same kind of bell is used on the shunting engines in goods yards, where roadways have to be crossed on which lurries and handtrucks circulate, and the results as far as prevention of accidents is concerned are stated to be very satisfactory.

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LIEUT. GREELY BEFORE THE BRITISH ASSOCIATION.

Lieuts. Greely and Ray were received with distinguished honors at the meeting of the British Association in Montreal. A complimentary luncheon was tendered him by the members of the British Association for the Advancement of Science, at the Windsor Hotel. General Sir Henry Lefroy presided. In response to the toast “Our Distinguished Guests,” coupling the names of Lieuts. Greely and Ray and Mrs. Greely, Lieut. Greely said:

“*Mr. President, Ladies and Gentlemen*: I need scarcely say that this flattering reception from representative men of one of England’s most distinguished societies touches deeply my feelings as a soldier and as a man. It is not alone that you represent the science and learning of England and the world, but that you are all countrymen of those daring seamen and explorers whose names and whose deeds have become household words throughout the world. Hudson, Baffin, Cook, Nelson, Parry, Franklin, and a score of others among the dead; McClintock, Nares, and Markham, and last, but not least, the man whose name was oftenest on our lips when praying for relief during the past terrible winter—Bedford Pim. What those men have done the whole world knows. That you should deem aught that I have done worthy to placed with the deeds of those illustrious men must always be a source of pride to me. For three centuries England maintained against the world the honors of the farthest north. Step by step every advance was made by Englishmen. Now England’s grandest colony presses to the front; but none the less is the honor England’s, for at the price of her sons’ lives and by their toil the path was cleared. But for Beaumont’s dauntless pluck and indomitable energy in 1876, Lockwood would never had made his great northing in 1882. I have during a quarter of a century’s service, as becomes a soldier, been jealous of my honor. I have striven to maintain it in the field, fighting and bleeding for my country, and at my desk studying and discussing scientific data; in the Arctic Circle, when pursuing scientific and geographical work, or later, when stranded by adverse fate, and starving and freezing upon the barren coast. This marked and public testimonial of your approval cannot fail to make me doubly jealous of it in days to come.”

Lieut. Ray followed, returning thanks in his own behalf.

After other speeches Sir Henry Lefroy presented Lieutenant Greely with the following informal address:

“Montreal, Sept. 2, 1884.

“The undersigned, on behalf of many warm friends and admirers, and as representing various professional and scientific pursuits, desire to express to you their appreciation of the courage and devotion which has characterized your conduct during the trying circumstances of your late Arctic service. We trust that your health may soon be restored, and that you may long be spared to tender, as during your past distinguished career, those valuable and distinguished services to your great country which have already placed you among the foremost of scientific explorers of the age.

“Yours faithfully, Rayleigh, President.”

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In introducing Lieut. Greely, Sir Henry Lefroy, referring to the persistence of purpose shown by his party in bringing back the pendulum apparatus, remarked that there was nothing nobler in the annals of scientific heroism than the determination of these hungry men to drag the cumbersome box along their weary way.

It was fully two minutes after rising before Lieut. Greely could speak, so great was the outburst of enthusiasm which greeted him. He remarked that he was surprised to learn that the ground did not thaw lower at Lieut. Ray’s station, which was ten degrees farther south than his own, where the ground thawed to a much greater depth—namely, twenty to thirty feet. In regard to an open polar sea, he differed from Lieut. Ray. He did not believe there was a navigable sea at the pole, but he was of the opinion that there was open water somewhere about.

The geographical work of the Lady Franklin Bay expedition covers nearly three degrees of latitude and over forty degrees of longitude. Starting from latitude 81 deg. 44 min. and longitude 84 deg. 45 min., Lieut. Lockwood reached, May 18, 1882, on the north coast of Greenland, latitude 83 deg. 24 min. and longitude 40 deg. 46 min. From the same starting point he reached to the southwest, in May, 1883, Greely Fiord, an inlet of the Western Polar Ocean, latitude 80 deg. 48 min. and longitude 78 deg. 26 min. This journey to the northward resulted in the addition to our charts of a new coast line of nearly 100 miles beyond the farthest point seen by Lieut. Beaumont, R.N. It also carried Greenland over 400 miles northward, giving that continent a much greater extension in that direction than it had generally been credited with.

In a subsequent speech he took occasion to say that a fact had surprised him. It was the discovery that when the tide was flowing from the North Pole it was found by his observations that the water was warmer than when flowing in the opposite direction. He took the trouble to have prepared an elaborate set of observations showing this wonderful phenomenon, which would eventually be published. To him these pecularities were unexplainable, and be hoped that the observations would be studied by his hearers, and some explanation found in regard to the thermometric observations of the expedition. He remarked that the mean temperature for the year of the hourly observations was 5 degrees below zero, which justified him in saying his station was the coldest point of earth ever reached.

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DIAMOND MINING IN BRAZIL.

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It was in 1729 that the Portuguese government learned of the discovery of the diamond that had been made in the rivers of the environs of Diamantina by some adventurers who had entered this region in search of gold. Since that epoch the exploitation of this gem, pursued under varied regimes, and with diverse success, has never ceased. As soon as it heard of this discovery, the Portuguese government thought it would make as much profit out of it as possible, so it no longer authorized any other exploitation in the Diamantina regions than that of the diamond, and it imposed upon such exploitation a tax that was fixed at 28 francs per laborer in 1729 and 224 in 1734. From 1734 to 1739 all operations were suspended, and a more lucrative organization for the treasury was sought for. In 1739 the era of contracts was inaugurated. The exploitation of the diamond was farmed out for four years to a *contratador*, who was to work a certain territory with a number of men, fixed at 600 as a maximum, and to pay into the treasury a sum per workman (whether working or not) that varied from 1,288 francs per year in 1734 to 1,344 francs for the last contract, that ended in 1772. At this epoch the government took the exploitation of the diamond in hand, and gave it in charge of a special administration, which was submitted to the direction of the treasury of Lisbon, and which had at its head a comptroller. This new regime lasted till 1845. In order to render the surveillance of the treasury agents efficient, and prevent smuggling (which can be so easily done with an object like the diamond), it was necessary to impose a special regime over the entire region of Diamantina, and, in fact, the latter was, up to the independence of Brazil, submitted to Draconian regulations.

[Illustration: FIG. 1.—DAM ON THE RIBEIRAO INFERNO AT PORTATO DE FERRO.]

We only know the quantity of stones that were discovered during the period when operations were directed by the Royale Extraccao, from 1772 to 1845, and this was 269,870 grammes, or more than 1,300,000 carats. It should be understood that what was taken by stealth does not enter into this total, and it must be stated that during the latter years, when the Extraccao existed only in name, smuggling must have been active.

[Illustration: FIG. 2.—ARRANGEMENT OF THE MACHINERY AT THE PORTATO DE FERRO DIAMOND DEPOSITS.]

Since that epoch the exploitation has been continued by lessees of the diamondiferous grounds. It is almost impossible to estimate what the territory has produced. The discovery of the Cape deposits has given it a terrible blow. Although the Brazilian diamond is much more beautiful, and for this reason is held at a much higher price, these new exploitations, by annually throwing large quantities of stones upon the market, have led to a great reduction in the price, and the Diamantina exploitations, which have become long, difficult, and costly, have received a serious set-back. So the annual production of this region, which was estimated for the years preceding 1870 at 3,000 oitavas (about 52,000 carats), is now scarcely 500.

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The rivers in the environs of Diamantina rim at the bottom of deep and narrow gorges that have been scooped out to depths of 300 or 400 meters through the denuded plateau in whose center stands the city of Diamantina. In the bed of these rivers, in places where they have not yet been worked, there may be found, underneath a stratum of modern sand, another of rocks, and finally a diamondiferous deposit of rounded pebbles, mixed with sand. This gravel, which is characterized in the first place by the fact that all its elements are rounded, and next by the presence of a large number of minerals (among which the most important are all the oxides of titanium, different oxides of iron, tourmaline, and a whole series of hydrated phosphates of complex composition), is called in the language of the country *cascalho*. It is the matrix of the diamond, and the latter is extracted from it by washing. It is arranged in roundish masses upon the beds of the rivers, and is met with at depths ranging from a few decimeters up to 25 and 30 meters.

The same material, with the same name, is also found deposited at all heights upon small terraces at the sides of the valleys through which the rivers flow. It is coarser and less rolled, and has very likely been deposited by risings of the rivers during the period when the valleys were being formed. These deposits bear the name of *gupiarras*. Finally, it is found in a still coarser state, mixed with red earth and deposited in horizontal strata upon the upper plateau. It is then called *gorgulho*.

Of these different deposits, the most important are those of the river beds, the material here having undergone a true mechanical preparation and being richer. These are the deposits that have been the object of the most important exploitations.

The year is divided into two distinct seasons—the dry, from May to September, during which rain is exceptional, and the rainy, from October to April. As water is necessary for all the operations, no work can be done upon the high plateaux except through rain water stored up in large reservoirs. These beds form what are called the “rainy season washings.” In the rivers the working of the beds requires a preliminary drying, which is effected by diverting the river’s course. Now in all this rocky and denuded region the water that falls runs immediately to the river, and causes terrible freshets therein; so operations capable of keeping the bed dry would be out of proportion to the probable results of the exploitation, whence it follows that the latter is only possible in dry weather, and these deposits are therefore called “dry season washings.”

These deposits are still worked in our day as they were in the time of the Portuguese. In order to dry the bed a dam is constructed, and the river is either diverted into a plank flume supported by piles, or into a canal dug along the shore, or by means of tight walls, according to the lay of the place. The second process, which is preferable to the first, is in fact impossible when the river runs, as is often the case, in a narrow, abrupt, walled channel. These works are sometimes very important. In 1881, the Acaba Mundo flume was 140 meters in length and 5.2 m. wide, and, with a velocity of 2.25 m., discharged

4,500 liters per second; still longer ones might be cited that discharged as much as 8,000 liters.

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In the dry part of the river the extraction of the sand, stones, and cascalho is done solely by hand. The men carry the sand upon their heads in small wooden bowls called *carumbes,* which hold about 15 kilogrammes, and throw it somewhere where the deposit will not interfere with the exploitation. Almost all of these men are negroes, who run with their load upon their head over the white sand, singing some song of their country. It, is very picturesque, but it is doubtful whether it is economical.

Since the century and a half that these rivers have been dug and redug, it may be admitted that wherever the cascalho has been easy of access it has been removed; and that wherever it has not been, little attempt has been made to work it. How have these attempts, which have doubtless been made at several periods, come out? This would at present be very difficult to ascertain. The exploitations have been too numerous to allow us now to estimate the value of a bed from the data furnished by geology, and local tradition is too uncertain or exaggerated to allow us to place much confidence in it.

We can, at the very most, say that if some points still remain intact it must be because the exploitation of them was too difficult with the processes that were employed, and this should be a reason, were it desired to attempt new operations, for having recourse to entirely different modes of work.

It would seem rational, as regards this, to try to put to profit the hydraulic power that the flumes and canals render disposable for mechanically extracting the sand. The field to be worked being naturally long and narrow, it would be the proper thing to employ a series of inclined planes distributed along the banks, actuated by water wheels, and corresponding to so many small working points. The river often flows through a genuine canon with nearly vertical walls, where space would be absolutely wanting for installing wheels elsewhere than at the exit of the canal, and if may become necessary to distribute the power of these wheels along the works. In these regions of difficult access and few resources it is necessary to dispense with complicated apparatus, and one might in such a case, it would seem, try electric motors, whose installation would be easy. An exploitation in accordance with these ideas was begun for the first time in 1883 upon the Ribeirao de Inferno at Portao de Ferro. We shall describe it.

Once established in the country, the first thing to do is to form roads so as to secure communications with the neighboring villages and forests, and afterward to cut down trees for building houses. These latter are usually constructed, for these works, of untrimmed wood and mud, with thatched roof. There were thus constructed at Portao de Ferro a few kilometers of roads, then some houses for the engineers and special workmen, barracks for 200 laborers, stores, kitchens, *etc*., a forge, and a shop with a lathe and a saw run by a wheel at the side. It was afterward necessary to repair the old lateral canal which had been dug out of the rock in the times of the Royal Extraction, but which had been torn open for a considerable length. This necessitated the erection of tight walls of dry stone, grass, and mud, for a length of 200 meters, and with thicknesses of from 6 to 10 meters.

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In order to divert the water into this canal, it was necessary to raise its level 5 meters. The dam, then, had to support a strong pressure, and it could not be built upon sand. It therefore became necessary to build a temporary dam and to turn the river into a plank flume, so as to make it possible to dig at the location of the permanent dam in order to reach a solid bottom at a depth of nearly 4 meters. The permanent dam thus had a total height of 10 meters, with a thickness of 15 at the base and 7 at the top. It was constructed of dry stone, grass, and earth, with the addition of strong wood-work. The rocks upon which it had to be built were full of fissures, and when it was desired to close it great leakages of water occurred, which came near ruining it and necessitated the construction of a second wall behind it and a talus of earth in front. The dam as shown in Fig. 1, when finished, had a thickness of 25 meters at the base. It was closed on the second of July, and had a storage capacity of 55,000 cubic meters.

The principal excavation was begun at the point where the bed was deepest, and which consequently the older miners must have had most trouble in reaching. Here were set up two Letestu pumps that were actuated by a four-horse wheel.

These pumps lifted 50 cubic meters per hour. All except the pump chambers and pipes was made of wood on the spot. The water that was lifted was carried away from the works in a flume 160 meters in length, which likewise removed the water from the motive wheels.

For the service of the same excavation two simple acting inclined planes were installed that were moved by a four-horse wheel. Fig. 2 gives a general view of the arrangement.

The tracks of these planes were made of wood. Steel rails, however, had been brought for the cars, along with the cables and the metallic parts of the windlass; but all else was made upon the spot, including all the wooden pulleys for transmitting motion from the wheel to the windlasses.

This excavation reached bottom at a depth of 16 meters. The second touched bottom at about 10 meters, and gave access to a subterranean canal, which was followed for about 20 meters. The extraction of sand was effected here by an inclined plane moved by a Gramme machine. The generatrix had to make 1,500 revolutions, and be set in motion by an overshot wheel. As time was wanting, it became necessary to diminish to as great a degree as possible the number of parts to be employed in the transmission of motion, and since there was an abundance of water, a velocity of 15 revolutions was accepted for the wheel, which, with a total fall of 4.8 meters, had to give a power of eight horses. A three meter pulley was placed upon the shaft of the wheel. This was made of freshly cut wood that had been exposed to the sun. In order to give it sufficient stability and prevent its warping, it was placed against the wheel in such a way as to rest upon the latter’s spokes.

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This rendered it necessary to give up the idea of using a belt, since it was not possible to prevent its getting wet. Cords could not be found in the country, and so it was necessary to make use of a too heavy chain, which was in no wise intended for such a purpose, and which at a velocity of 15 revolutions began to swing and necessarily absorbed much power. The large pulley drove one of 0.4 m. upon an intermediate shaft. Upon this latter a 2.6 m. wooden pulley directly drove, through a belt, the 0.2 m. pulley of the generatrix.

From this may be judged what the country's resources are. The motor, by means of a belt, actuated a windlass provided with suitable checking gearings. The distance of the two machines was 116 meters. Save the transmission by chain, the whole worked in a satisfactory manner. The performance could only be estimated in a lump, by comparing on the one hand the theoretical work of the fall of water, and, on the other, that of the vertical elevation of the car; and, further, one was obliged to estimate the weight of the latter. If we allow 1,000 kilogrammes for the weight of a car that received 360 liters of dry sand or 300 of wet, the performance was 19 per cent., and appeared to be satisfactory, considering the conditions under which the installation was made. This experiment was at all events of such a nature as to indicate the use of these machines in cases where the arrangement of the locality absolutely necessitates a transmission of power.

The first workmen reached Portao de Ferro December 15, 1882, and the material shipped from France did not arrive until April 25, 1883. Operations were suspended about the 25th of September, since, for a fortnight already, there had no longer been any doubt as to the manner in which the river bed had been cleaned by former operators.

As a result of this first experiment, the proof remained that it would be easy in future exploitations to introduce into the country methods of work that are quicker and more economical than those now in use. In fact, all the operations were performed with natives of the country, with the exception of a carpenter and blacksmith from Rio Janeiro.—*La Nature.*

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WHAT WE REALLY KNOW ABOUT ASIATIC CHOLERA.

NEW YORK, September 1, 1884.

To the Editor of the New York Medical Journal:

SIR: I have been exceedingly interested in Dr. Bartlett's suggestive article in your issue of August 30. But a sufficient number of well-established facts are known to account for all the peculiarities and vagaries of cholera.

1. Cholera has existed in Hindostan for centuries. It was found there by Vasco da Gama in 1496, and there is a perfectly authentic history of it from that time down to the present.

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2. It is never absent from India, from whence it has been conveyed innumerable times to other countries. It has never become domiciled in any other land, not even in China, parts of which lie in the same latitude; nor in Arabia, to which country pilgrims go every year from India; nor in Egypt, nor Persia, with which communication is so frequent; much less in any other part of the world. Canton in China, Muscat and Mecca in Arabia, lie nearly in the same degree of latitude as Calcutta, in which cholera is always existent; yet these places only have cholera occasionally, and then only after arrivals of it from Hindostan.

3. The arrival of cholera in other countries is often involved in some easily removable obscurity, which is deepened only by the ignorance and want of veracity of quarantine and other officials.

4. Cholera is almost always preceded by a premonitory diarrhoea, which lasts from one or two to three or four or more days before urgent and characteristic symptoms show themselves. Of 6,213 cases, no less than 5,786 had preceding diarrhoea. The sufferers from this sow the germs of the disease in numerous, often distant and obscure, places, to which no choleraic person is supposed to have come.

5. The discharges swarm with infective bacteria of various kinds, some of which, especially Koch’s comma bacilli, seem to be specific.

6. The disease has been reproduced in men and some few animals by their swallowing the discharges.

7. The discharges, according to the experiments of Thiersch, Burdon-Sanderson, and Macnamara, are not virulent and poisonous for the first twenty-four hours; on the second day eleven per cent. of those who swallow them will suffer; on the third day, thirty-six per cent.; on the fourth day, ninety per cent.; on the fifth day, seventy-one per cent.; on the sixth day, forty per cent.; and after that the discharges have no effect—the bacteria die, and the poison becomes inert.

Professor Robin reproduced cholera in dogs, and the celebrated dog Juno died of cholera in Egypt last year. Professor Botkin, of the University of Dorpat, reproduced cholera in dogs by the subcutaneous injection of the urine of cholera patients. Even if the comma bacilli are not found in the urine, other bacteria are; and even Koch supposes that they secrete a virulent poison similar to that of some insects, which may be absorbed into the blood and escape from the kidneys.

8. Some of the manners and customs of the Hindoos are very peculiar. They always defecate upon the open ground, and will not use privies or latrines This is a matter of religious obligation with them. It is also obligatory upon them to go to stool every morning; to use the left hand only in wiping themselves; to wash their fundaments after stool; to wash their whole persons and clothing every day; and, finally, also to rinse their

mouths with water, and this they often do after washing in foul tanks, or still fouler pools of water. On steamships, where tubs of water were provided for washing their fundaments after defecation, Surgeon-General De Renzy saw many Hindoos rinse their mouth with the same water.

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9. The population of Hindostan is nearly three hundred millions, and at least one hundred million pounds of faecal matter is deposited on the open ground everyday, and has been for centuries.

10. Much of this foul matter is washed by rains into their tanks and pools of water, which they use indiscriminately for washing, cooking, and drinking purposes.

11. The poison of cholera has repeatedly been carried in soiled clothing packed in trunks and boxes, and conveyed to great distances.

12. Articles of food, even bread and cake, as well as apples, plums, and other fruit, handled by persons in the incipient stages of cholera, have been known to convey the disease.

13. The number of epidemics produced by cholera discharges getting into drinking water are almost innumerable, and those from contaminated milk are not few.

14. The first case of cholera is generally counted from the first fatal one, whereas this is almost always preceded by non-fatal ones, which have escaped notice. And each subsequent fatal case is interwoven by one, or several, or even many, non-fatal causes. If the string of a row of beads is broken, and the beads scattered everywhere, it would be just as improper to say that they had never been upon a string as to say that, because all the fatal cases of cholera cannot be traced to equally fatal ones, no connection ever existed between them.

These points are necessarily stated categorically, but every one can be proved, if proof is called for. The numerous and very large pilgrimages of the Hindoos must not be forgotten.

John C. Peters, M.D.

83 Madison Avenue.

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DR. KOCH ON THE CHOLERA.

An important and influential conference[1] upon cholera was opened in Berlin at the Imperial Board of Health on the evening of July 26. There were present Drs. v. Bergmann, Coler, Eulenbrg, B. Fraenkel, Gaffky, Hirsch, Koch, Leyden, S. Neumann, Pistor, Schubert, Skreczka, Struck, Virchow, and Wollfhuegel. The conference had been called at the instance of the Berlin Medical Society, whose President, Prof. Virchow, explained that it was thought advisable Dr. Koch should, in the first instance, give a demonstration of his work before a smaller body than the whole society, so that the proceedings might be fully reported in the medical press. He mentioned that Herr Director Lucanus and President Sydow had expressed their regret at being unable to be present, as well as many others, including Drs. Von Lauer, Von Frerichs, Mehlhausen, and Kersaudt. Before the meeting Dr. Koch exhibited microscopical specimens and drawings of the cholera bacillus, and demonstrated the method of its preparation and cultivation. The preparations included specimens of choleraic dejections dried on covering glasses, stained with fuchsin or methyl-blue, and examined with oil immersion, one-twelfth, and Abbe's condenser; also sections of intestine preserved in absolute alcohol, and stained with methyl-blue. There were also cultures in gelatin, *etc*.

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[Footnote 1: A detailed report is published in the *Berliner Klinische Wochenschrift* Aug. 4.]

Dr. Koch commenced by remarking that what was required for the prevention of cholera was a scientific basis. Many and diverse views as to its mode of diffusion and infection prevailed, but they furnished no safe ground for prophylaxis. On the one hand, it was held that cholera is a specific disease originating in India; on the other, that it may arise spontaneously in any country, and own no specific cause. One view regards the infection to be conveyed only by the patient and his surroundings; and the other that it is spread by merchandise, by healthy individuals, and by atmospheric currents. There is a like discrepancy in the views on the possibility of its diffusion by drinking water, on the influence of conditions of soil, on the question whether the dejecta contain the poison or not, and on the duration of the incubation period. No progress was possible in combating the disease until these root questions of the etiology of cholera are decided.

Hitherto the advances in knowledge upon the etiology of other infective diseases have done little toward the etiology of cholera. These advances have been made within the last ten years, during which time no opportunity—at least not in Europe—has occurred to pursue researches; and in India, where there is abundant material for such research, no one has undertaken the task. The opportunity given by the outbreak of cholera in Egypt last year to study the disease before it reached European soil was taken advantage of by various governments, who sent expeditions for the purpose. He had the honor to take part in one of these, and in accepting it he well knew the difficulties of the task before him, for hardly anything was known about the cholera poison, or where it should be sought; whether it was to be found only in the intestinal canal, or in the blood, or elsewhere. Nor was it known whether it was of bacterial nature, or fungoid, or an animal parasite—e.g., an amoeba. But other difficulties appeared in an unexpected direction. From the accounts given in text-books he had imagined that the cholera intestine would show very slight changes, and would be filled with a clear “rice-water” fluid. He had not fully recollected the conditions met with in post-mortem examinations had formerly made, and was therefore at first surprised to meet with quite a different state of things. For he soon found that in a large majority of cases remarkably severe lesions were present in the intestines. In other cases the changes were slighter, and eventually he met with some which, to a certain extent, corresponded with the type described in text-books. But it was some time, and after many inspections, before he was enabled to correctly interpret the varied changes met with. In spite of a most careful examination of all other organs and of the Mood, nothing was found to establish the presence of an infective material, and attention was finally concentrated on the intestinal conditions.

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There were cases in which the lower segment of the small intestine, most marked immediately above the ileocaecal valve, extending thence upward, was of a dark reddish-brown color, the mucous membrane being covered with superficial haemorrhages. In many cases the mucous membrane appeared to be superficially necrosed, and covered with diphtheritic patches. The intestinal contents in such cases were not colorless, but consisted of a sanguinolent, ichorous, putrid fluid. Other cases showed a gradual transition to a less marked change. The redness was less intense, and was in patches, while in others the injection was limited to the margins of the follicular and Peyerian glands, giving an appearance which is quite peculiar to cholera. In comparatively few cases were the changes so slight as to consist in a somewhat swollen and opaque condition of the superficial layers of the mucous membrane, with delicate rosy-red injection, and some prominence of the solitary follicles and Peyer's patches. In such cases the intestinal contents were colorless, but resembling meal-soup rather than rice-water. In only a solitary instance were the contents watery and mucoid. Microscopical examination of the intestine and its contents revealed, especially in the cases where the margins of Peyer's patches were reddened, a considerable invasion of bacteria, occurring partly within the tubular glands, partly between the epithelium and basement membrane, and in some parts deeper still. Then he found cases in which, besides bacteria of one definite and constant form, there were others also accumulated within and around the tubular glands, of various size, some short and thick, others very fine; and be soon concluded that he had to do here with a primary invasion of pathogenic bacilli, which, as it were, prepared the tissues for the entrance of the non-pathogenic forms, just as he had observed, in the necrotic, diphtheritic changes in the intestinal mucosa and in typhoid ulcers.

Passing to speak of the microscopical character of the contents of the bowel, Dr. Koch said that owing to the sanguinolent and putrescent character of these in the cases first examined, no conclusion was arrived at for some time. Thus he found multitudes of bacteria of various kinds, rendering it impossible to distinguish any special forms, and it was not until he had examined two acute and uncomplicated cases, before haemorrhage had occurred, and where the evacuation had not decomposed, that he found more abundantly the kind of organism which had been seen so richly in the intestinal mucosa. He then proceeded to describe the characters of this bacterium. It is smaller than the tubercle bacillus, being only about half or at most two-thirds the size of the latter, but much more plump, thicker, and slightly curved. As a rule, the curve is no more than that of a comma (,) but sometimes it assumes a semicircular shape, and he has seen it forming a double curve like an S, these two variations from the normal being suggestive

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of the junction of two individual bacilli. In cultures there always appears a remarkably free development of comma shaped bacilli. These bacilli often grow out to form long threads, not in the manner of anthrax bacilli, nor with a simple undulating form, but assuming the shape of delicate long spirals, a corkscrew shape, reminding one very forcibly of the spirochaete of relapsing fever. Indeed, it would be difficult to distinguish the two if placed side by side. On account of this developmental change, he doubted if the cholera organism should be ranked with bacilli; it is rather a transitional form between the bacillus and the spirillum. Possibly it is a true spirillum, portions of which appear in the comma shape, much as in other spirilla—*e. g*., spirilla undula, which do not always form complete spirals, but consist only of more or less curved rods. The comma bacilli thrive well in meat infusion, growing in it with great rapidity. By examining, microscopically, a drop of this broth culture the baccilli are seen in active movement, swarming at the margins of the drop, interspersed with the spiral threads, which are also apparently mobile. They grow also in other fluids—*e. g*., very abundantly in milk, without coagulating it or changing its appearance. Also in blood serum they grow very richly.

Another good nutrient medium is gelatine, wherein the comma bacilli form colonies of a perfectly characteristic kind, different from those of any other form of bacteria. The colony when very young appears as a pale and small spot, not completely spherical as other bacterial colonies in gelatine are wont to be, but with a more or less irregular, protruding, or jagged contour. It also very soon takes on a somewhat granular appearance. As the colony increases, the granular character becomes more marked, until it seems to be made up of highly refractile granules, like a mass of particles of glass. In its further growth the gelatine is liquefied in the vicinity of the colony, which at the same time sinks down deeper into the gelatine mass, and makes a small thread-like excavation in the gelatine, in the center of which the colony appears as a small white point. This again is peculiar; it is never seen, at least so marked, with any other bacterium. And a similar appearance is produced when gelatine is inoculated with a pure culture of this bacillus, the gelatine liquefying at the seat of inoculation, and the small colony continually enlarging; but above it there occurs the excavated spot, like a bubble of air floating over the bacillary colony. It gives the impression that the bacillus growth not only liquefies the gelatine, but causes a rapid evaporation of the fluid so formed. Many bacteria also have the power of so liquefying gelatine with which they are inoculated, but never do they produce such an excavation with the bladder-like cavity on the surface.

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Another peculiarity was the slowness with which the gelatine liquefied, and the narrow limits of this liquefaction in the case of a gelatine disk. Cultures of the comma bacillus were also made in agar-agar jelly, which is not liquefied by them. On potato these bacilli grow like those of glanders, forming a grayish-brown layer on the surface. The comma bacilli thrive best at temperatures between 30 deg. and 40 deg. C., but they are not very sensitive to low temperatures, their growth not being prevented until 17 deg. or 16 deg. C. is reached. In this respect they agree with anthrax bacilli. Koch made an experiment to ascertain whether a very low temperature not merely checked development but killed them, and subjected the comma bacilli to a temperature of 10 deg. C. They were then completely frozen, but yet retained vitality, growing in gelatine afterward. Other experiments, by excluding air from the gelatine cultures, or placing them under an exhausted bell jar, or in an atmosphere of carbonic acid, went to prove that they required air and oxygen for their growth; but the deprivation did not kill them, since on removing them from these conditions they again began to grow.

The growth of these bacilli is exceptionally rapid, quickly attaining its height, and after a brief stationary period as quickly terminating. The dying bacilli lose their shape, sometimes appearing shriveled, sometimes swollen, and then staining very slightly or not at all. The special features of their vegetation are best seen when substances which also contain other forms of bacteria are taken—*e. g*., the intestinal contents or choleraic evacuations mixed with moistened earth or linen and kept damp. The comma bacilli in these conditions multiply with great rapidity so as to far outnumber the other forms of bacteria, which at first might have been in far greater abundance. This state of affairs does not last long; in two or three days the comma bacilli began to die off, and the other bacteria began to multiply. Precisely the same thing takes place in the intestine, where, after the rapid initial vegetation is over, and when exudation of blood occurs in the bowel, the comma bacilli disappear and putrefactive bacteria predominate. Whether the occurrence of putrefaction is inimical to the comma bacilli has not been proved, but from analogy it is very probable. At any rate, it is important to know this for certain, for if it be so, then the comma bacilli will not thrive in a cesspit, and then further disinfection would be unnecessary. These bacilli thrive best in fluids containing a certain amount of nutriment. Experiments have not yet shown the limits in this respect, but Koch has found them capable of growing in meat broth diluted ten times.

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Again, if the nutrient medium become acid in reaction their growth is checked, at least in gelatine and meat infusion; but singularly enough, they continue to grow on the surface of a boiled potato which has become acid, showing that all acids are not equally obnoxious to them. But here, as with other substances which hinder their growth, they do not kill the bacilli. Davaine has shown that iodine is a strong bactericide. He experimented with anthrax bacilli in water to which iodine was added, and the bacilli were destroyed. But practically the organisms have to be dealt with in the alkaline contents of the bowel, or in the blood or fluids of the tissues, where iodine cannot remain in the free state. Koch found that the addition of an aqueous solution of iodine (1 in 4,000) to meat infusion, in the proportion of 1 in 10, did not in the least interfere with the growth of the bacilli in that medium. He did not pursue this line of inquiry, seeing that in practice larger quantities of iodine than that could not be given. Alcohol first checks the development of the comma bacilli when it is mixed with the nutrient fluid in the proportion of 1 in 10, a degree of concentration which renders it impracticable for treatment. Common salt was added to the extent of 2 per cent. without influencing the growth of the bacilli. Sulphate of iron, in the proportion of 2 per cent., checks this growth, probably by precipitating albumimites from the fluids, and possibly also by its acid reaction; certainly it does not seem to have any specific disinfecting action—i.e., in destroying the bacilli. Indeed, Koch thinks that the admixture of sulphate of iron with faecal matter may arrest putrefaction, and really remove what may be the most destructive process to the comma bacilli. Hence he would distinguish between substances which merely arrest putrefaction and those which are bactericidal; for the former may simply serve the purpose of preserving the infective virus. Among other substances which prevent the growth of the comma bacilli may be mentioned alum, in solutions of the strength of 1 in 100; camphor, 1 in 300; carbolic acid, 1 in 400; oil of peppermint, 1 in 2,000; sulphate of copper, 1 in 2,500 (a remedy much employed, but how much would really be needed merely to hinder the growth of the bacilli in the intestine!); quinine, 1 in 5,000; and sublimate, 1 in 100,000. In contrast with the foregoing measures for preventing the growth of these bacilli is the striking fact that they are readily killed by drying. This fact is proved by merely drying a small drop of material containing the bacilli on a cover-glass, and then placing this over some of the fluid on a glass slide. With anthrax bacilli vitality is retained for nearly a week; whereas, the comma bacillus appears to be killed in a very short time. Thus it was found that although vitality was retained—depending largely upon the number of bacilli—for a short time, yet withdrawal of the nutrient fluid for

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an hour or even less often sufficed; and it never happened that the bacilli retained vitality after a deprivation lasting twenty-four hours. These results would seem to point to the fact that the comma bacillus does not, like the organisms of anthrax and vaccinia, pass into the resting state (Daner-zustande) by drying; and if so, it is one of the most important facts in the etiology of cholera. Much, however, remains to be done, especially with regard to the soiled linen of cholera patients being kept in a damp state. He found that in soiled articles, when dried for a time, varying from twenty-four hours and upward, the comma bacilli were quite destroyed. Nor was the destruction delayed by placing choleraic excreta in or upon earth, dry or moist, or mixed with stagnant water. In gelatine cultures the comma bacilli can be cultivated for six weeks, and also in blood serum, milk, and potato, where anthrax bacilli rapidly form spores. But a resting state of the comma bacilli has never been met with—a very exceptional thing in the case of bacilli, and another reason why the organism must be regarded rather as a spirillum than a bacillus, for the spirilla require only a fluid medium, and do not, like the anthrax bacilli, thrive in a dry state. It is quite unlikely that a resting state of the comma bacillus will ever be discovered; and, moreover, its absence harmonizes with our knowledge of cholera etiology.—*The Lancet*.

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[THE MEDICAL RECORD.]

MALARIA.—THE NATURAL PRODUCTION OF MALARIA, AND THE MEANS OF MAKING MALARIAL COUNTRIES HEALTHIER.

[Footnote: An Address delivered at the Eighth Session of the International Medical Congress, Copenhagen, August 12, 1884.]

By Conrad Tommasi Crudeli, M.D., Professor of Hygiene, University of Rome, Italy.

Before entering upon my subject, I must crave the indulgence of those of my colleagues whose language I have borrowed for any italicisms that I may use, as well as for the foreign accent which must strike their ears more or less disagreeably. Desiring to respond as well as lay in my power to the invitation with which I have been honored to discuss the hygienic questions relating to malaria, I have chosen the French language as being the one in which, apart from my mother tongue, I could express myself with the greatest ease and precision.

I shall be pardoned also, I hope, for having employed the terms “malaria” and “malarial districts” in place of the more commonly used expressions “paludal miasm” (*miasme paludeen*) and “marshy regions” (*contrees marecageuses*). The substitution is not a happy one from a literary point of view, but I have made it deliberately and for the following reason: The idea that intermittent and pernicious fevers are engendered by putrid emanations from swamps and marshes is one of those semi-scientific assumptions which

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have contributed most to lead astray the investigations of scientists and the work of public administrations. This idea, so widespread and so well established by the traditions of the school, is radically false. The specific ferment which engenders those fevers by its accumulation in the atmosphere which we breathe is not exclusively of paludal origin, and still less is it a product of putrefaction. Indeed, in every region of the globe between the two Arctic circles there are swamps and marshes, steeping-tanks of hemp and flax, large deltas where salt and fresh waters mix, and yet there is no malaria there, although putrid decomposition is on every side. On the other hand, in the same parts of the globe there are places which are not and never were marshy, and in which there is not the least trace of putrefaction, but which, nevertheless, produce malaria in abundance. I reject, therefore, wholly the paludal assumption, and in order to express this view in the title of my paper, have been forced to employ terms which to my hearers may sound like italicisms.

The Italians generally have not this paludal notion, for experience taught them long ago that malaria is produced nearly everywhere—in marshy districts as well as in those which might almost be called arid; in a volcanic soil as well as in the deposits of the Miocene and Pliocene periods and the ancient and modern alluvia; in a soil rich in organic matters as well as in one containing almost none; in the plains as well as on the hills or mountains. The word malaria (bad air), which it is the sad privilege of Italy to have lent to all languages to express the cause of intermittent and pernicious fevers, represents, then, among the majority of our rural populations, the idea of an agent which may infect any sort of country, whatever may be its hydraulic and topographical conditions, and whatever may be its geological formation. This word, therefore, is the one best suited to designate this specific ferment in question, and I have on this account, employed it and its adjectival derivatives in order not to resuscitate the idea of the exclusively paludal origin of the morbific agent.

I shall not tarry long to speak of the nature of this ferment, for the studies bearing upon that point, although far advanced, are not yet completed. I may remark, however, that the idea that the ferment is formed of living organisms is a very old one, and has not arisen suddenly because of the modern theories of the parasitic nature of disease. From the time of Varrar (who believed that malaria was made up of invisible mites suspended in the atmosphere) to our own day this theory has been several times advanced by hygienists. Independently of the general considerations which led Rasori, and later Henle, to formulate the doctrine of the *contagium vivum* of infection (long before the progress of microscopical science had revealed the existence of living ferments), there were peculiar circumstances as regards malaria which should have impelled minds to look in that direction, even in times long past.

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Some of these circumstances are of a nature to strike every serious observer, and deserve a few moments' attention. How could one maintain, for example, that this ferment is a product of chemical reactions taking place in the ground, when it is seen to remain constantly the same whatever may be the composition of the soil from which it emanates! As long as the paludal theory held sway, the chemical interpretation of this identity of the product in every latitude was easy. Rica does not hesitate to admit that when a swampy tract is heated by the sun's rays to the necessary point for the putrid decomposition of the organic matters contained in it, the "chemical ferment," or rather the "mephitic gases," to which is attributed the morbific action, are developed, whatever may be the distance from the equator at which this marshy region lies. But since it has been ascertained that malaria is produced in soils of the most varied chemical composition, *the persistent identity of this product* has become chemically inexplicable; while it is however readily conceivable, if one admits that malaria is an organized ferment which easily finds the necessary conditions for its life and multiplication in the most varied soils, as is the case with millions of other organisms vastly superior to the rudimentary vegetables which constitute the living ferments.

The same thing may be said of *the progressive intensity of the morbific production in abandoned malarious districts*. This fact has been historically proved in several parts of the earth, and especially in Italy. A large number of Grecian, Etruscan, and Latin cities, even Rome itself, sprang up in malarious territories and attained a high state of prosperity. First among the reasons for this success must be placed the works undertaken with a view of rendering these places more salubrious, and which lessened the evil production, *but almost never extinguished it completely*. After the abandonment of these localities, the production of malaria recommenced in a degree which went on increasing from age to age, and which has rendered some of these places actually uninhabitable. This was seen, in the time of the ancient Romans, in Etruria, when it was conquered and laid waste, and in several parts of Magna Graecia, and of Sicily. From the fall of Rome even to the present day, this phenomenon has been manifested in a very evident manner in the Roman Campagna, in certain parts of which, even up to the time of the Renaissance, it was possible to maintain pleasure houses, but which are now unhabitable during the hot season. In many cases the physical conditions of the soil have undergone no appreciable change during centuries, so that it is impossible to attribute so enormous an augmentation of malaria to an increase in its annual production, itself increased by a progressive alteration of the chemical composition of the soil. But if, on the contrary, it be admitted that malaria is caused by a living organism whose successive generations accumulate in the soil, the interpretation of this fact becomes very simple.

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There are, finally, *peculiarities in the local charging of the atmosphere with malaria* which can be explained only in this manner. If the malarial miasm were composed of gaseous bodies emanating from the soil, or rather of chemical ferments formed beneath the ground and raised into the air by gases or watery vapor, the charging of the atmosphere with the specific poison ought to arrive at its maximum during the hottest part of the day, when the ground is heated the most by the sun's rays, and when the evaporation of water and all chemical actions attain their maximum intensity. But this is very different from what actually occurs. The local charging of the atmosphere is always less strong during the meridian hours than at the beginning and the end of the day, that is to say, after the rising, and especially after the setting, of the sun. Now it is precisely at these hours that the difference between the temperature of the lower layers of the atmosphere and that of the surface of the ground is the greatest, and that the ascending currents of air starting from the ground are the strongest. If malaria consists of solid particles contained in the soil, one may readily understand how their elevation *en masse* into the atmosphere should take place especially at these two periods of the day.

All these facts, which can be easily verified if the subject of malaria be studied on the spot and without any preconceived notions, explain the tendency which has always been manifested to attribute this specific poisoning of the air to a living organism which is multiplied in the soil; and they also explain the ardor with which hygienists have applied themselves to the production of the scientific proof.

Unfortunately the investigations undertaken for this end have for a long time been fruitless, for the preconceived paludal theory has led investigators to occupy themselves exclusively with the inferior organisms inhabiting marshes. Among these organisms they studied especially the *hyphomycetes,* which had already acquired so great an importance in dermatology; and their entire attention was concentrated upon the aquatic algae, without even taking the precaution to determine whether the varieties which they thought to be malarial were found in all malarious swamps, or whether they were capable of living within the human organism. It has thus happened that each observer has indicated as the cause of malaria a different variety of alga, whichever he found to be most abundant in the swampy ground that he had to examine. Thus Salisbury has indicated the *palmella gemiasma,* which is found with us in places perfectly free from malaria, while it is often wanting in malarious marshes in the center of Italy; Balestra, a species of alga which is as yet indeterminate; Bargellini, the *palmogloea micrococca;* Safford and Bartlett, the *hydrogastrum granulatum;* and Archer, the *chitonoblastus oeruginosus*. There is not a single one of these species the parasitic nature of which has been demonstrated; and as regards the two last named varieties, it can be positively denied that they are capable of producing a general infection, for the diameter of their spores and filaments is greater than that of the capillary blood vessels.

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It was only in 1879 that Klebs and myself, after having been thoroughly freed, by a long series of preparatory studies, from the unfortunate paludal idea, undertook together some investigations in malarious districts of the most varied character, marshy and not marshy. We employed the system of fractional cultivation, making experiments on animals with the final products thus obtained. We felt ourselves justified in recognizing the malarial ferment in the *schizomycete bacillus*. The numerous researches made subsequently by us, and by many other observers, in the soil and in the air of several malarious localities, as well as in the blood and in the organs of men and animals specifically infected, have put it henceforth almost beyond doubt that we really have to do with a schizomycete. Very recently, MM. Marchiafava and Celli have succeeded in demonstrating that the germs of this schizomycete attack directly the red blood-globules, and destroy them, causing them to undergo a series of very characteristic changes which admit of easy verification, and which render certain the existence of a malarial infection.

Several observations made recently in Rome tend to demonstrate that the schizomycete of malaria does not always assume the complete bacillary form described by Klebs and myself; but this morphological question possesses no further interest for the hygienist. For him the essential thing is to know that he has to deal with a living ferment which can flourish in soils of very varied composition, and without the presence of which neither marshes nor stagnant pools of water are capable of producing malaria.

We must not think, however, that all earth containing this ferment is capable of poisoning the superjacent atmosphere. Popular experience, certain modern scientific investigation, and the facts which one can often verify when the soil, which was malarious in ancient times and which has since ceased to be so, is turned up to a great depth, all agree in proving that the ground remains inoffensive as long as it is not placed in certain conditions indispensable for the multiplication of this specific ferment. Up to this point the organism lives, so to speak, in an inert state, and may remain so during centuries without losing any of its deleterious power. There is nothing in this fact that ought to surprise us, since we know that the life and the power of evolution belonging to the seeds of plants of a much higher order than these vegetable organisms constituting ferments, may remain latent for centuries, and may then revive at once when these grains are placed in the conditions suitable for their germination.

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Among the conditions favorable to the multiplication of the malarial ferment contained in the soil, and to its dispersion through the superjacent atmosphere, there are three which are absolutely essential, and the concurrence of which is indispensable for the production of bad air (malaria). First, a temperature which does not fall below 20 deg.C. (67.5 deg.F.); next, a very moderate degree of permanent humidity of the soil; and finally, the direct action of the oxygen of the air upon the strata of earth which contain the ferment. If a single one of these three conditions be wanting, the development of malaria becomes impossible. This is a point of prime importance in the natural history of malaria, and it gives us the key to most of the methods of sanitary improvement attempted by man.

Let us see first what can be done in this direction without the labor of man. For nature herself makes localities salubrious by *suspending* for a greater or less time the production of malaria. It is thus that winter brings about in every country a freedom from malaria which is *purely thermic*, for it is due simply and entirely to a sinking of the temperature below the required minimum. Indeed, if the temperature in winter rises above this minimum, there are often sudden outbreaks of malaria. Sometimes, during very warm and dry summers, the heat extracts all the humidity from the malarious soil, and thus procures for us a freedom from the disease which is *purely hydraulic*. This may continue for a long time (as happened in the Roman Campagna during the years 1881 and 1882), but may also be completely destroyed by a single shower. Nature also sometimes renders a district healthy in a manner *purely atmospheric*, by covering a malarious soil with earth which does not contain the malarial ferment, or with a matting formed of earth and the roots of grasses growing closely together in a natural meadow.

In the attempts of purification by suspending the malarial action, which have been devised by man, the same thing has been done; that is to say, it has been sought, to eliminate at least one of the three conditions essential to the development of the specific ferment contained in the infected soil. Naturally, they have not thought of bringing about a thermic purification, such as nature produces in winter, because of the impossibility of moderating the action of the sun; but they have tried from all time to procure hydraulic or atmospheric purifications, and sometimes to combine these together in a very happy way.

The hydraulic systems are very numerous, for the problem which is presented, namely, that of depriving the ground of its humidity during the hot season, necessitates different solutions according to the nature and the bearing of the soil. Sometimes this is done by digging open or closing ditches intended to draw away large bodies of water. At other limes a system of drainage is established, by means of which the water

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is drawn out of the earth and its level is depressed, so that the upper malarious strata, exposed to the direct action of the air, are deprived of moisture during the hot season. This system of drainage is not a modern invention; the Italian monks understood it as well as, and even better than, we do. In deep and loose soils they used sometimes, just as we do now, porous clay pipes; but when the subsoil was formed of compact and nearly impermeable matters, they employed a system of drainage, the extent and grandeur of which astonishes us. It is that of drainage by cavities, applied by the Etruscans, Latins, and Volsci to all the Roman hills formed of volcanic tufa, the tradition of which I have found still preserved in some countries of the Abruzzi.

We may sometimes establish a double drainage, from below and from above; that is to say, to drain the subsoil, and at the same time increase the evaporation of water from the surface of the ground. It is well known that clearing off the forests of malarious countries has often proved an excellent means of making lands salubrious which were before too damp; for, by removing every obstacle to the direct action of the sun's rays upon the ground, we cause an increase of evaporation from its surface, and may thus be enabled to exhaust the superficial strata completely of their water during the hot season. In very moist lands, which lend themselves readily to deep drainage, the combination of the latter with a clearing of the surface has, in almost every quarter of the globe, rendered possible a very widespread and sometimes a quite lasting freedom from malaria. But, although a nearly universal experience proclaims this fact, there is a school which, following in the footsteps of Lancisi, maintains the contrary opinion, that it is necessary to preserve the forests in malarious districts, and even to increase their extent, since the trees filter the infected atmosphere and arrest the malaria in their foliage. This strange theory was formulated by Lancisi in 1714, on the occasion of the proposed clearing of a forest belonging to the Caetani family, and lying between the Pontine Marshes and the district of Cistema. Lancisi was completely imbued with the paludal notion, and consequently believed that the very severe malaria of Cistema was brought by the winds from the coast marshes, instead of being produced in the soil surrounding the district, which was then covered by this forest. He believed then that the forest acted as a protective rampart, and he prevented its being cut down. But toward the middle of the present century the Caetani had the woods cleared off from the entire belt of land surrounding Cistema. Twenty years later I was able to show that Cistema had gained greatly in salubrity. I published my observation in 1879, and, naturally, was taken to task rather sharply in the name of the sacred tradition. Happily these recriminations led our Minister of Agriculture to have the question

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studied by a special commission. This commission, after a conscientious examination extending over three years of all the malarious localities in the province of Rome, has just published its report,[1] the conclusions of which are entirely in accord with the facts of universal experience. They were not able to verify a single fact in support of Lancisi's theory, while they found many of the same nature as that of Cistema, and which have resulted in overturning the theory entirely.

[Footnote 1: Della influenza dei boshi sulla malaria dominante nella regiona marittima della provincia di Roma. Annali di Agricoltura, No. 77, 1884. Roma: Eredi Botta.]

It has also been thought possible to practice drainage from above by means of plantations of certain trees which would draw considerable moisture from the earth, a method which might really be serviceable in some malarious districts. But in accordance with the idea that malaria is a product of paludal decomposition, the trees selected have almost always been the *eucalyptus*. It has been maintained that trees of so rapid a growth ought to drain the soil very actively, and also that the aroma of their foliage ought to destroy the miasmatic emanations. I have hitherto been unable to verify a single instance of the destruction of malaria by eucalyptus plantations, but I do not consider myself justified in denying the facts which have been stated by others. There is nothing to oppose the admission that these plantations, when properly made, may sometimes have been of great utility. I maintain frankly, however, that they have not always been so, and that it is necessary to guard against the exaggerations into which some have allowed themselves to fall in recent times. Such exaggerations might have been avoided if, instead of talking about these plantations on the basis of a theoretical assumption, the results only had been studied in places where the eucalyptus abounds. It would then have been known that even in the southern hemisphere, the original home of the eucalyptus, there are eucalyptus forests which are very malarious. This fact has been demonstrated by Mr. Liversige, professor in the University of Sydney, Australia. Among us also, although everybody was convinced by the statements of the press that the locality of the Tre Fontaine, near Rome, had been freed from malaria by means of the eucalyptus, people were disagreeably surprised by an outbreak of very grave fever occurring throughout the whole of this colony in 1882, a year in which all the rest of the Roman Campagna enjoyed an exceptional salubrity. If, alongside of these hygienic uncertainties, we place the agricultural uncertainties, we must conclude that it is necessary to contend strongly against this fanatical prejudice in favor of the eucalyptus tree. These plants are, in fact, very capricious in their growth. In full vegetation during the winter in our climate, they are often killed instantly by a sharp winter

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frost, by damp cold, by the frosts of spring, or by other causes which the botanists have not yet been able to determine. At other times, if the winters are very mild, these plants grow too rapidly in height, and then are broken short off by moderately strong winds. It should further be mentioned that these plantations are sometimes very expensive. In fact, if the earth contains too much water, it must be drained under penalty of seeing the roots of the eucalyptus rot. Then again, if the subsoil is compact, it is necessary to dig deep trenches in order to give room to the long roots of these trees, and often indeed these trenches must also be drained, as is done for olive trees. The conclusion evidently is that it is better to confine ourselves to hydraulic methods of promoting the health fulness of a locality, the immediate effects of which are less uncertain. And then, when the local conditions are such as to make it desirable to try the effects of plants possessed of strongly absorbing powers, it is better to choose them from among the flora of our own hemisphere. This is more sure, and will cost less.

Simple hydraulic methods of purification, even the most perfect, do not, however, produce permanent hygienic effects, since the moisture necessary for the multiplication of the malaria in the soil is so slight that these effects may be compromised by anything whatever that is capable of restoring a moderate degree of humidity to the ground during the hot season. It has often been thought that a suspension of malarial production would be better assured by suppressing at the same time the humidity of the soil and the direct action of the oxygen of the air upon the superficial strata of earth which contain the ferment. This has been successfully accomplished by the system of overlaying (*comblees*). This consists in covering the infected soil by thick layers of uninfected earth, carried there either by the muddy waters of rivers or by the hand of man. At the same time the steady drainage of the surface and underground water is provided for. Last year I advised our Minister of War to undertake in another form a hydraulico-atmospheric purification of the district of the Janiculum surrounding the Salviati Palace on the Via della Longara, by draining the soil carefully and covering with a layer of very close turf all the parts of the surface which could not be macadamized. It would seem as if this system had been rather successful, since there has not been this year a single case of fever in the *personnel* of the new military college, established in the Salviati Palace; while in the Corsimi Palace, which is situated on the same side of the Via della Longara, but which looks out upon that part of the Janiculum which is still uncovered, there have been some fatal cases of fever.

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Furthermore, we have had in Rome, during the past few years, some very evident proofs of the efficacy of atmospheric methods of purification. I will confine myself to the relation here only of the most striking instance, one which has been furnished us in the building up of new quarters of the city. There was much discussion at first as to whether the improvements should be undertaken in the parts where they now are or in the valley of the Tiber, for the uncovered lands of the Esquiline and of the Quirinal were malarious, and, as nearly everybody then thought that the malaria of Rome was carried into the city from the coast marshes, it was supposed that this state of things was irremediable. We opposed to this view the fact of the salubrity of the Viminal, which is situated between the Esquiline and the Quirinal, and which ought to be as unhealthy as the two other hills were the malaria of the latter imported into the city instead of being indigenous. Believing it to be indigenous, we hoped that by shielding the surface of these hills from the direct action of the air (by building houses and paving the streets), the malaria would cease to be produced there. That is precisely what has happened, for the new quarters are very healthy. But the malaria is only held in abeyance, and is not definitely overcome; for if an extensive excavation is made in these hills, and the contact of the air with the malarious soil is thus re-established, during a hot and damp season, the production of malaria commences anew. A complete atmospheric purification is nevertheless the most stable of all the methods of obtaining a suspension of malarial production, but unfortunately its realization is very limited, for it is restricted to inhabited localities and to sodded surfaces.

The ideal method of insuring freedom from malaria should be to obtain a permanent immunity, that is, to be able to modify the composition of the infected soil in such a way as to make it sterile as regards malaria, without taking from it the power of furnishing products useful for the social economy. But all the elements indispensable for obtaining such a result fail us utterly just here. We do not yet know what ought to be, in general terms, the composition of a soil incapable of producing malaria, yet retaining those properties which are suitable for vegetation. When we shall have arrived at this first stage, there will still be a long road to travel; and the most difficult part will be to discover a practical means of imparting this salutary composition to all the numerous varieties of malarious soils.

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Scientifically, then, in the present state of our knowledge we are unable to affirm anything on this point. Practically, we are not much further advanced. It is very probable that the combination of hydraulic purification with a forced cultivation of the soil has sometimes determined changes in its composition by which it has been rendered sterile as regards malaria. If that has happened, it has happened by chance, and we are unable to reproduce the result at will; for we have not all the data which might enable us to understand how it has come about. Most of the purifications obtained in ancient times, by means of forced cultivation, continued during centuries, have not been definite at all, but the production of malaria has been simply suspended. Hardly was the regular cultivation of the fields interrupted than the production of malaria recommenced. Among the numerous examples that I might cite in this connection, I will limit myself to that of the Roman Campagna. This seemed to have been made permanently healthy under the Antonii, but after the fall of the empire it began again to produce malaria, as if the forced cultivation through so many centuries had never been.

One might, strictly speaking, be content with such a result, and boldly undertake forced cultivation of all malarious districts, without stopping to ascertain whether the freedom from malaria so obtained would be definite, or whether the production of the poison were only suspended. Unfortunately, one is never sure of arriving at such a result, and no one can say, *a priori*, whether the forced cultivation of a given malarious tract will render it healthful. It must always be remembered that the first effect of forced cultivation, which requires an overturning of the soil by means of the plow, the spade, and the pick, is an unfortunate one, from a hygienic point of view, whenever we have to deal with a malarious country. Experience has shown, especially in Italy and America, that this overturning of the soil almost invariably increases the local production of malaria. And this can be readily understood, since the plowing and the digging in a soil containing the specific ferment increase the extent of surface of the ground in immediate contact with the atmosphere. This first mischievous effect is often gradually weakened by the continued cultivation, and may end by disappearing. At other times, on the contrary, it persists obstinately, and one is often forced in desperation to the resolve to level the ground again and to varnish it, so to speak, with a thick sowing of grass, if he wishes to suspend or weaken the malarial production.

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However, when the local conditions will permit, it is well to try whether, by means of forced cultivation of the soil, it may not be possible to increase the efficacy of the hydraulic method of procuring immunity from malaria, or of the hydraulico-atmospheric method of “overlaying.” The moment that it is known that this cultivation has frequently been advantageous, there comes forward a crowd of social reasons which induce us to attempt it, even though we be persuaded that we are about to engage in a game of chance. But to dare to attempt it is not all that is necessary; we need also the possibility of so doing, and just here we find ourselves in a vicious circle from which it is not easy to emerge. Forced cultivation cannot be accomplished without the presence of agriculturists in the region during the entire year; and the agriculturists cannot remain in the region during the fever season, for they run thereby too great a risk. For the solution of this question there is but one means: *try to increase the power of resistance of the human organism to the attacks of the malaria*. It is to a search after the means of accomplishing this result that I have devoted myself during the past few years.

There is nothing to hope for, as regards malaria, in acclimation. *Individual acclimation* is, and always has been, impossible. The malarial infection is not one of those a first attack of which confers immunity from other attacks. It is, on the contrary, a progressive infection, the duration of which is indeterminate, and which is of such a nature that a single attack may suffice to ruin the constitution for life. Collective or *racial acclimation* certainly existed in the past, at a time when specific remedies for pernicious malaria were unknown; and even later, when the employment of these remedies was very limited. The acclimation was due to a natural selection made by the malaria upon successive generations, from which it took away, almost without opposition, all those who possessed but a feeble individual power of resistance to the specific poison, while it spared those who possessed this power of resistance in an extraordinary degree. The first were, according to the Grecian myth, *the human victims destined to appease the monster or demon who opposed the violation of the territory over which he had up to that time exercised an absolute sovereignty*. The second became the founders of the race, and through them, from generation to generation, the collective power of resistance to the malaria was progressively increased. In our own days a like selection may take place among barbarous races, as it does among the cattle and the horses in a malarious region, but it has become an impossibility among civilized nations. By means of the specific remedies which we possess, the use of which is now so general, the lives of a large number of individuals whose resisting powers are very feeble are preserved; and these individuals beget others whose power of resistance to the action of the specific poison is still more feeble. This results after a number of generations in the physical degradation of that part of the human race which inhabits malarious countries.

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We cannot, therefore, in the future, count upon the assistance of external natural forces to increase the power of resistance of human society against the assaults of malaria. Such an object can be obtained only by artificial means. It has been sought to attain this end by the daily administration of the salts of quinine, of the salicylates, and of the tincture of eucalyptus, each and every one tried in turn. But the salts of quinine are dear, exercise a prompt, though very transient anti-malarial action, and, when administered for a long time, disturb rather seriously the functions of the digestive and nervous systems. The salicylates, when well prepared, are rather dear, and there is as yet no proof that they possess prophylactic powers against malaria. The alcoholic tincture of eucalyptus is useful in malarious regions (as are all the alcoholics, beginning with wine) in quickening the circulation of the blood; may it, perhaps, also act as a preservative against light attacks of malaria? Possibly. But it is very certain that it possesses no efficacy in places where malaria is severe. It will suffice to prove this to recall the two epidemics of fever which afflicted the colony of the Tre Fontaine, near Rome, in 1880 and 1882. Everybody was attacked, and there were several cases of pernicious fever, although a good preparation of eucalyptus is manufactured in the place and is distributed largely to the colonists during the dangerous season of the year.

ARSENIC FOR MALARIA.

Having several times had occasion to observe, in malarious regions, that when recourse was had to arsenic in order to subdue fevers over which quinine had exerted almost no effect, relapses occurred but rarely; and having been able to satisfy myself that the arsenical treatment sometimes procured a permanent, immunity in individuals who are subject to frequent attacks of malaria, I began in 1880 to employ arsenic (arsenious acid) as a prophylactic in certain portions of the Roman Campagna. This remedy was indicated in an experiment of this sort, not only by reason of its durable anti-malarialae effects, but also by its low price, by the beneficial influence it exerts upon all the nutritive functions, and because it has no disagreeable taste and may therefore be given to everybody, even to children. My first trials in 1880 were rather encouraging, and I felt myself justified in engaging some proprietors and the association of our southern railroads to repeat the experiments on a large scale the following year, recommending them, however, to use arsenic in a solid form as offering an easy and certain dosage. This extensive prophylactic experiment began in 1881, and acquired constantly increasing proportions in 1882 and 1883, which have become still larger this year. An experiment of this kind is not easy to conduct in the beginning. The name, arsenic, frightens not only those whom we desire to

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submit to its action, but also the physicians, whose exaggerated fears have sometimes rendered the experiments of no avail, since they were conducted too timidly and the doses of arsenic employed were altogether insufficient. But some intelligent men, especially M. Ricchi, physician in chief to the southern railroads, were able speedily to triumph over these obstacles, and to place the experiment on a firm basis. The general testimony of all the facts which they have collected tends really to prove that when the administration of arsenic is begun some weeks before the presumed season for the appearance of the fever, and when it is continued regularly throughout the whole of this season, the power of resistance of the human organism to malaria is increased. Many individuals gained thereby a complete immunity, others a partial immunity, that is to say, they were sometimes attacked by the fever, but it never, even in very malarious districts, assumed a pernicious form, and was easily subdued by very moderate doses of quinine. Last year, for example, in the district of Borino, where the malaria is very severe, M. Ricchi experimented upon seventy-eight employes of the southern railroads, dividing them into two equal divisions, one of which received no prophylactic treatment, while the other was submitted to a systematic arsenical treatment. At the end of the fever season it was found that several employes among the first half had been attacked by fevers of a severe type; while thirty-six of those in the second division had enjoyed a complete immunity, the three others having been attacked, but so lightly that they cured themselves by quinine without seeking medical aid.

Facts of this sort are very encouraging, and the more so as the general health of those submitted to the prophylactic treatment was much improved. It was found almost invariably, upon the termination of the experiment, that there had been an increase in bodily weight and an amelioration of the anaemia which is so common in milarious districts. But, in order to arrive at such results, it is necessary to be at once bold and prudent. On the one hand, it is necessary to graduate very carefully the daily dose, never exceeding at the commencement the dose of two milligrammes (3/100 grain per diem) for adults, and never giving the arsenic upon an empty stomach. On the other hand, it is necessary to gradually push the dose up to ten or twelve milligrammes (15/100 or 18/100) a day for adults, in districts where the malaria is very severe, giving the arsenic in such a way that there is never an accumulation of the drug in the stomach. Most of the experiments which have been undertaken this year are being conducted on this plan, and there is reason to hope that they will give satisfactory results.

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We must not, however, rest here if we wish to attain promptly the end proposed, namely, that of planting colonies in malarious districts without exposing the colonists to grave danger. Even if we realize perfectly the hope which I conceived in 1880, and if we are enabled to prove that arsenic increases man's power of resistance to the assaults of malaria, we must not imagine that everything is accomplished. It will take a long time before the use of a preservative method of this kind becomes generalized; we have first to contend against the fear which nearly every one experiences when arsenic is mentioned, and then there will also be difficulty in establishing everywhere a proper control over its administration. In every attempt at the colonization of malarious regions it will be necessary to combat for a long time the diseases caused by malaria, and we must seek for a method of combating them by a means which is in the possession of everybody, and which shall not be dangerous to the general economy of the human organism. Those who do not know from actual experience the miseries of a malarious country, think only of combating the acute forms of infection, which often place the patient in danger of death. But this danger, though great, is for the most part imaginary, provided that assistance be obtained in time. But that which desolates families, and which causes a physical degradation of the human race exposed to the attacks of malaria, is the chronic poisoning, which undermines the springs of life and produces a slow but progressive anaemia. This infection often resists all human therapeutic measures, and is even aggravated by the use of quinine, which is given during the recurrent paroxysms of fever. Quinine is, when given for a long period of time, a true poison to the vaso-motor nerves. The question, then, is to replace quinine, and the alkaloids which possess an analogous physiological action, by an agent the efficacy of which against, chronic malarial poisoning may be greater and the dangers of its employment less.

THE LEMON FOR MALARIA.

A happy chance has led Dr. Magliori to the discovery of an agent of this sort which was traditionally in use by certain Italian families. It is an exceedingly simple thing—merely a decoction of lemon. It is prepared by cutting up one lemon, peel and all, into thin slices, which are then put into three glassfuls of water and the whole boiled down to one glassful. It is then strained through linen, squeezing the remains of the boiled lemon, and set aside for some hours to cool. The whole amount of the liquid is then taken fasting. It is well known that in Italy, Greece, and North Africa, they often use lemon juice or a decoction of lemon seeds, as a remedy in malarial fevers of moderate intensity; and in Guadaloupe they use for the same purpose a decoction of the bark of the roots of the lemon tree. All these popular practices tend to show that the lemon tree produces

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a febrifuge substance, which resides in all parts of the plant, but which would seem to be most abundant in the fruit. In fact, among the popular remedies employed against malarial infection, that which I have just described is the most efficacious, for it can be employed with good effects in acute fevers. But it is especially advantageous in combating the chronic infection, which is rebellious to the action of quinine, and in removing or moderating its deplorable effects.

Hardly had I learned of this method of medication, when I hastened to induce some proprietors in the Roman Campagna to try it with their farm hands; and, after witnessing the good results there, I endeavored to persuade practitioners to make a trial of the same treatment. I was ridiculed a little at first, for they thought it rather singular that a professor should be trying to popularize on old woman's remedy. In reply to that I answered that practical medicine would not have existed, had it not known how to treasure up from age to age the facts of popular experience; and I ventured to remark that, had the Countess de Chinchon waited until methodical researches had been made into the physiological action of cinchona bark, before popularizing the remedy, the use of which she had learned from the semi-barbarous Peruvians, in all probability humanity would still, as regards malaria, be dependent upon the medication practiced in the middle ages. Happily these arguments had the desired effect upon certain distinguished practitioners, some of whom, especially in Sicily and Tuscany, have already collected together a tolerably large number of very encouraging observations. One of them, Dr. Mascagni, of Avezzo, tried the remedy in his own person, and succeeded in promptly curing an obstinate malarial fever which had resisted the action of quinine.

Gentlemen, in dealing with malaria we ought always to hold popular experience in high esteem, for we owe much to it. We owe to it the fact that we have been liberated from the paludal idea, and furthermore, that we have learned that it is often better, instead of trying to prevent the importation, for the most part imaginary, of malaria from distant marshes, to suppress its production in the soil under our feet or in that immediately surrounding us. We owe to it the knowledge, which we now have, that malaria rises up into the atmosphere only to a limited height, so that by placing ourselves a little above this limit in order to eliminate the possibility of the malaria being carried up to us by oblique atmospheric currents, we are enabled to breathe an air which does not contain this ferment, or which contains it only in insignificant amounts; thus one may even sleep in the open air during the night in very unhealthy districts without running any risks. The knowledge of this fact has led some peoples of Greece, and the inhabitants of the Pontine Marshes, to sleep in the open air on platforms raised on poles four or five meters (twelve to fifteen

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feet) in height. Some people in the Roman Campagna have built houses for themselves on top of the ancient tombs, the walls of which are perpendicular; the American Indians fasten their hammocks as high up as possible to the trees of the malarious forests; and very recently, the engineers of the Panama Railroad had little wooden huts built in the trees in order to procure safety against the terrible outbreak of malaria which occurred during the construction of that iron way. We owe, finally, to this popular experience the discovery of the specific action of quinine, and the consequent preservation of thousands and thousands of human lives. Why should we reject *a priori* and without investigation other useful data which it may yet present to our consideration? If we wish to make progress in this question of rendering malarious countries healthy, we must always hold before our eyes a double object—to find a means of prophylaxis which may be accessible to everybody; and, at the same time, to find a means equally within everybody's reach, to overcome chronic malarial poisoning and its evil consequences. Science is still too far behind to permit us to hope that we shall soon succeed in discovering this second means by purely scientific researches. We ought, therefore, to gather together with great care all the facts which point to the possibility of a solution of this problem, and if the measures to which these facts point seem to be incapable of doing harm, we ought to try them boldly, and not be restrained by a false idea of the dignity of science. The social importance of the problem is too great to allow of its solution being retarded by the fear that scientific men may be accused of having been outrun by the ignorant. True science has none of these puerile susceptibilities; on the contrary, it deems it an honor to be able to seize all the observations of fact, whoever may have been their first recorder, to put them to the crucial test of methodical experiment, and to convert them into a new stepping stone on the march of human progress.

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HALESIA HISPIDA.

[Illustration: HALESIA HISPIDA: HARDY SHRUB: FLOWERS WHITE.]

This fine hardy shrub is perhaps best known under the name of Pterostyrax, but we think gardeners will, quite independently of botanical grounds, be inclined to thank Messrs. Bentham and Hooker for reducing the genus to the more easily remembered name of Halesia. Halesia hispida is a hardy Japanese shrub of recent introduction, with numerous white Deutzia-like flowers in long terminal racemes. A peculiar appearance is produced by the arrangement of the flowers on one side only of the branchlets of the inflorescence. The botanical history of the plant is well known, and our illustration is sufficient to show the general appearance of the plant. It is decidedly one of the best recent additions to the number of hardy deciduous flowering shrubs. For the specimen whence our figure was taken we are indebted to W.E. Gumbleton, Esq.—*The Gardeners' Chronicle*.

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WINDFLOWERS.

[Illustration: FLOWERS OF ANEMONE DECAPETALA (Natural Size).]

The genus Anemone has a great future. Even at present its popularity is only a little less than that of roses and daffodils, but when we trust to seeds as a means of reproducing the best of windflowers instead of buying dried roots from the shops, then, and then only, will “coy anemone” become a garden queen. A. coronaria, if treated as an annual, furnishes glowing blossoms from October until June, after which A. dichotoma and A. japonica in all its forms—white and rosy—carry on the supply and complete the cycle of a year’s blossoming. By sowing good, newly-saved seed in succession from February until May in prepared beds out of doors, the common crown anemone may in many sunny, sheltered gardens be had in bloom all the year round. This is saying a great deal, but it is true; indeed, it is questionable if we have any other popular garden flower which is at once so showy, so hardy, and so continuous in its blossoming. A friend beside me says: “Ah! but what of violas?” To which I reply: “Grow both in quantity, since both are as variable as they are beautiful.” But when viola shrinks in foggy November from the frost demon, anemone rises Phoenix-like responsive to the first ray of sunshine. Besides, fair Viola, richly as she dresses in velvet purple or in golden sheen, has not yet donned that vivid scarlet robe which Queen Anemone weareth, nor are her wrappers of celestial azure so pure; and blue is, as we all know, the highest note of coloring in floral music. But comparisons are not required, Anemones are variable and beautiful enough to be grown for themselves alone. No matter whether we look at a waving mass of sparkling windflowers in a vineyard or cornfield by the Mediterranean, or walk knee deep among the silvery stars of A. nemorosa in an English wood—“silvery stars in a sea of bluebells”—they are alike satisfying. I believe that there is any amount of raw material in the genus Anemone—-hardihood, good form and habit, and coloring alike delicate and brilliant; and what we now want is that amateurs should grow them with the attention and care that have been lavished upon roses and lilies and daffodils. But, alas! we have some capricious beauties in this group. A. coronaria and some other species succeed well treated as seedling hardy annuals, and others, as A. apennina, A. Robinsoni, A. Pulsatilla, A. dichotoma, and A. japonica, may be multiplied *ad infinitum* by cuttings of the root. It is when we come to the aristocratic Alpine forms, to A. alpina, A. sulphurea, A. narcissiflora, *etc*., that difficulties alike of propagation and of culture test our skill to the uttermost. Tourists fond of gardens walk over these plants in bloom every year; they dig up roots and send them home; but they are as yet very rare in even the best of gardens. Nor is it easy to

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rear them from seeds. A year ago I sowed seed by the ounce each of A. alpina and of A. sulphurea, but as yet not a single plantlet has rewarded me for my trouble. Even freshly gathered seeds of A. narcissiflora will not germinate with me, but I live in hopes of surmounting little difficulties of this kind, and in the mean time, perhaps, others more fortunate will tell us how to amend our unsuccessful ways. One of the prettiest species which is now in flower in our gardens is the pure white A. dichotoma, which carries on the succession after the Snowdrop anemone (A. sylvestris) has passed away. Then we have dreams, and lend willing ears to the oral traditions of Anemone alba. Is this species in cultivation, or where may a figure of it be seen? It is said to be of neat habit, 12 inches high, with erect, saucer-shaped, white blossoms 3 inches in diameter. The species we now figure is well worth a place, being easily raised from seeds. It is called Anemone decapetala, and if not by any means a showy species, tufts of it three years from seed have this season been very pretty. It grows less than a foot in height, and bears pale creamy yellow flowers the size of a shilling on branched flowering stems; each blossom has eight or nine sepals around a yellowish green center. Some of our clumps had from a dozen to twenty flowers open at the same time, and the general effect in the early morning sunshine is a very pretty one. We have another species similar in habit which is just now a mass of rosy buds, and if you blow open its sepals, they are of a bright magenta color inside, but I never yet saw a flower open naturally on this plant. Just as the sepals open at the tips, and you think they are about to expand, they shrivel and fall away, leaving a tuft of greenish yellow stamens in the center. Is it A. Hudsoni? Another species not often seen, but well worth culture, is A. coerulea, a kind with finely cut leaves and purplish blue flowers. Then A. coronaria, The Bride, a pure creamy white kind, with flowers 3 inches across, raised by Van Velsen, of Haarlem, is really a good addition to these dainty blossoms, and affords a vivid contrast to the fiery A. fulgens. I have received this year some roots of anemones, iris, and other hardy flowers from the site of ancient Troy, and trust that some of these, if not new, will be beautiful additions to our gardens. The true A. vitifolia from northern India does well in mild localities; but best of all of this perennial large-leaved race is A. japonica alba, the queen of all autumnal kinds, rivaling the best of all hardy border flowers in purity and freedom of blossoming. Taken as a class, windflowers are so beautiful that we cannot grow them too plentifully, and but few other genera will so well repay cultural attention at all seasons.—*F.W.B., in The Garden*.

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STORY OF LIEUT. GREELY’S RECOVERY.

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The story of Lieut. Greely's recovery after his rescue from Cape Sabine is given by Passed Assistant Surgeon Edward H. Green, U.S.N, of the relief ship Thetis, in a communication to the *Medical Record*. The cases of Greely's six fellow survivors, it is remarked, were very similar to his. The condition of all was so desperate that a delay of two hours in the camp was necessary before they could be removed to the relief vessels. Brandy, milk, and beef essence were administered.

Lieut. Greely's disease is called by the surgeon asthenia, a diminution of the vital forces. Greely fainted after being carried to the wardroom of the Thetis. When he was brought to, a teaspoonful of minced raw fresh beef was given to him. His clothes were carefully cut off of him, and heavy red flannels, previously warmed, were-substituted. He was excessively enacted, and his body emitted an offensive odor. His skin hung from his limbs in flaps. His face, hands, and scalp were black with a thick crust of soot and dirt. He had not washed himself or changed his clothing for ten months. He had lived a long time at a temperature inside the hut of from five to ten degrees above zero. He was nervous and irritable, at times almost irrational, and his eyes were wild and staring. He insisted on talking, craving news, and demanding food, but he complained of no pain.

His tongue was dry and cracked, and coated a brownish black. He was ravenously hungry. His pulse was 52, and soft or compressible. His skin was cold, clammy, shriveled, and sallow. His temperature under the tongue was 97.2 deg. There was great muscular waste, and he was unable to move or to stand without support. Before leaving Fort Conger in August, 1883, he weighed 168 pounds. He now weighed 120 pounds. He was carried aboard the Thetis about 11 P.M. on June 22, it being then broad daylight in that region, and his treatment from that hour until 8 o'clock the next morning was a teaspoonful of minced raw beef, alternated every half hour with a teaspoonful of milk punch. Strict quiet was enjoined.

On June 23 Surgeon Green was compelled to allow him to read some letters from home, after which he seemed less restless. He talked rationally, but showed a loss of memory in often repeating what he had previously said. He had not closed his eyes in sleep since his rescue. There was excessive constipation. The treatment was the same as during the night, except that finely cut raw onion was added to the minced beef, and half an ounce of milk punch was given every two hours.

On the next day, June 24, although he had yet had no sleep, and he showed a great desire to talk and read, there were signs of improvement. He was less persistent in demanding food, his tongue presented a moister appearance, he began to complain of soreness in his limbs, and his heart sounded stronger. Surgeon Green had him sponged with tepid water, and briskly rubbed with flannels. He gave him a small quantity of oatmeal thoroughly boiled, beef essence, and scraped beef and onion.

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On the next day, June 25, Lieut. Greely slept for the first time. He awoke after two or three hours, much refreshed. He talked without excitement, and his tongue and skin began to look more natural. His muscles felt sore, and his ankles were puffed.

On the next day, June 26, his mind was tranquil, but there was a loss of memory of words. He was allowed to sit up in bed and read a little. He slept six hours. For the first time since his rescue medicine was given him—some muriate of iron.

On the next morning he got eight ounces of broiled steak and on the following day, June 28, he dressed himself and sat up for two hours. His food was now gradually increased from day to day, and he continued steadily to improve. On July 1 he was well bundled up, and allowed to sit on deck for an hour in the sunshine. On July 17, the Thetis arrived at St. Johns.

Lieut. Greely's muscles were now filling out rapidly, and he was allowed to go on shore and take exercise. Here, Surgeon Green says, the lieutenant committed an error in diet at the American Consul's table, and suffered for two days with a slight attack of intestinal indigestion. On July 25, for the first time, he was allowed to eat three square meals. Six weeks after his rescue he had gained 49 pounds. He gained 91/2 pounds the first week, 15 pounds the second week, 8 pounds the third week, 7 pounds the fourth week, 51/2 pounds the fifth week, and 4 pounds the sixth week. Surgeon Green adds, under the head of "remarks":

"Vital depression, as exhibited by the temperature, not marked; digestion fairly good all the time; nervous system soon calmed. Microscopic examination of blood disappointing; exhibiting no unhealthy character of red blood globules. Liver not secreting. Large gain in weight, due to rapid assimilation of food, owing to a great muscular waste."

* * * * *

THE CAY MONUMENT AT UXMAL.

DISCOVERED BY DR. LE PLONGEON ON JUNE 1, 1881.

In 1881, we went for the second time to the ancient ruined city of Uxmal, Yucatan, and lived there four months, making moulds of every ornament and inscription, from which moulds perfect facsimiles of those grand old palaces can be produced in plaster, and placed in any exposition or museum.

During our stay there, on June 1, Dr. Le Plongeon had the great satisfaction of discovering a monument, a splendid work of art in all its pristine beauty, fresh as when the artist put the finishing touch to it, without blemish, unharmed by time, and not even looked upon by man since it was concealed, ages ago, where Dr. Le Plongeon discovered it through his interpretations of certain inscriptions. It was probably hidden to save it from destruction, between the sixth and seventh centuries of the Christian era, when the Naualts invaded and overran the country, demolishing many art treasures of the Mayas.

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[Illustration]

The monument represents a mastodon head, with various ornaments above and below it, the whole measuring 3.50 m. (11 feet 41/2 inches) in height, and in width 1.25 m. (4 feet 1 inch). Above the mastodon head there is a chain, nearly 10 inches deep; the stones forming the links are sculptured and fitted into each other just like the rattles of a rattlesnake; and yet higher another row of stones resembling knots. The uppermost part is composed of stones that incline outward from above; they are flat, measuring 0.55 by 0.45 centimeters (21 inches by 17 inches), and are covered with various signs pertaining to certain mysteries.

On the sides of the mastodon's trunk are these signs

[Illustration: (an "x" and a "circle with a dot in the middle")]

which read *Tza*, and means *that which is necessary*. Beneath the trunk and the upper jaw is what is meant to represent the distended jaws of a serpent; on it is inscribed the family name, | | | |, *Can*, the mouth (*chi*) of the serpent giving the second part of the name. *Canchi* means "serpent's mouth," and was the name of the royal family that ruled over the Mayas when their civilization was at its height.

Within the serpent's jaws is the greatest gem of American sculpture yet discovered. It is a head and throat, sculptured in the round, of Cay Canchi, the high priest and elder brother of the warrior Chaacmol, whose statue we exhumed from 8 meters below the soil in Chichen Itza, during the year 1876; which statue was afterward robbed from us by the Mexican government, and is now in the museum at Mexico city. The stone out of which the beautiful head is cut is not polished, but wrought so finely as to almost imitate the texture of the skin. It is decidedly a good looking face. The nostrils are most delicately chiseled, and the cartilage pierced; the eyes are open, and clearly marked. On the right cheek is his totem, a fish traced in exceedingly small cross bars. The forehead is well formed, not retreating, and incircled by a diadem composed of small disks, from the front of which projects a perfect fish's head. The hair is short in front, and hangs like a fringe on the upper part of the forehead, but is longer at the sides, hanging in straight locks.

On the wall against which this monument is built, feathers are sculptured, forming a canopy. Such a superb *chef d'oeuvre* proves beyond doubt that the Maya artists were in no way inferior to those of Assyria and Egypt.

Having been so unjustly deprived of Chaacmol without any remuneration for our time, labor, and expenditure, we decided to save the Cay monument from destruction at any cost, for should any ignorant persons attempt to move it, they would break it in so doing; so, after making a mould of it, we guarded it most securely, as we considered best, afterward inclosing it with planks, then built it up and left it as we had found it.

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Sr. Don Romero Ancona, then Governor of Yucatan, was very much provoked because we would not reveal the whereabouts of our find, but gained nothing by it, and the beautiful monument is still safe.

ALICE D. LE PLONGEON.

* * * * *

Rolled gold is made by casting an ingot of brass, and while this is still hot pouring upon it a thin layer of gold alloy. The ingot when cold is forced between steel rollers until a long, thin ribbon is produced, of which the proportion of gold and brass is the same as of the ingot. The percentage of gold is reduced as low as two and three per cent. This rolled gold is used in making cheap bracelets and watch chains. It wears from one to ten years.

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