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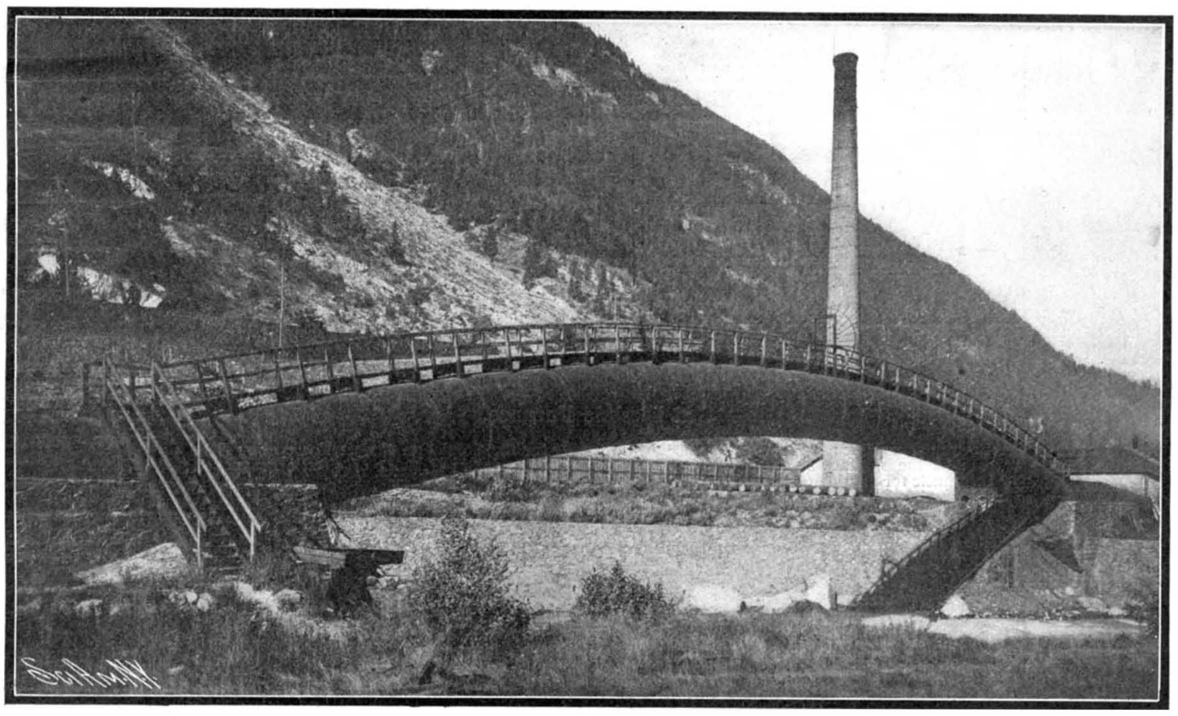
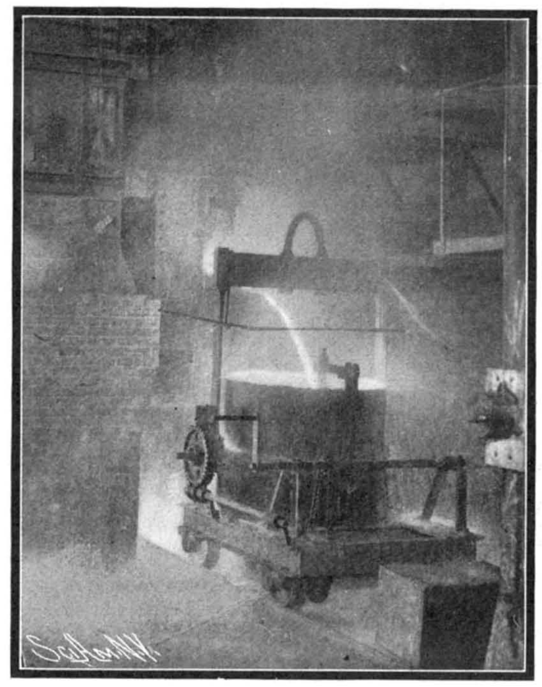
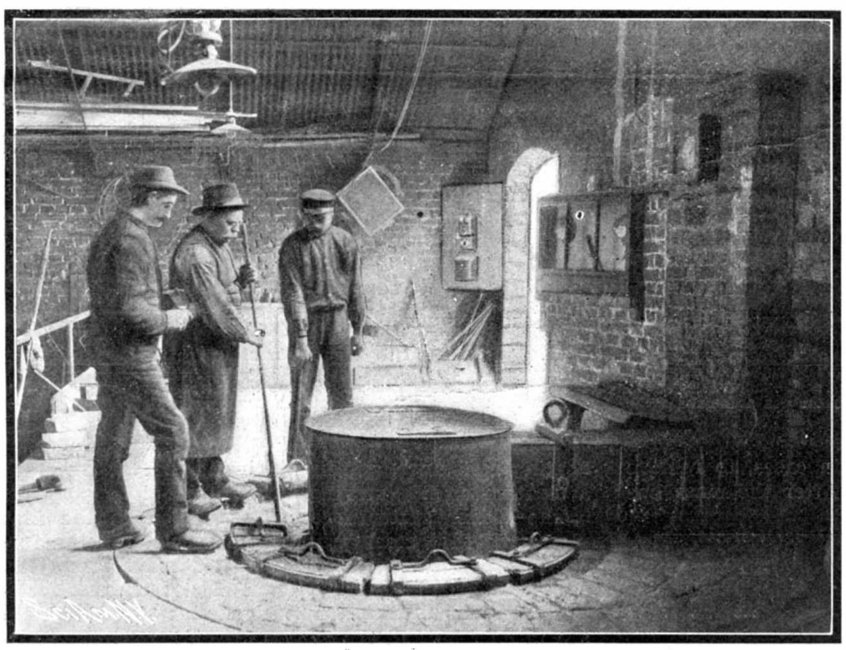


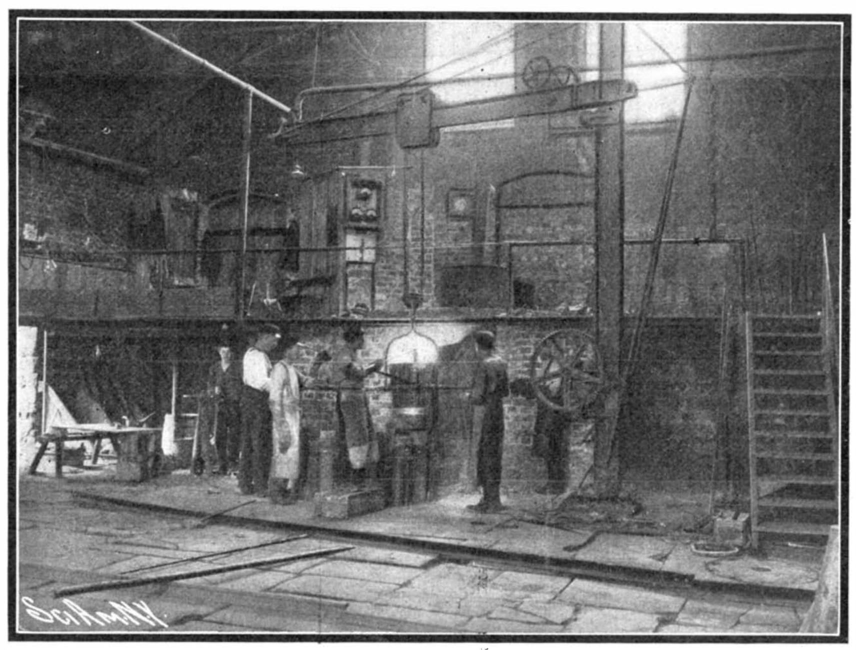
PIPE BRIDGE LEADING TO THE HERAULT ELECTRO-METALLURGICAL PLANT.
Diameter of pipe, 7 feet, 9 inches; span, 164 feet; water power conveyed, 10,000 horse-power.



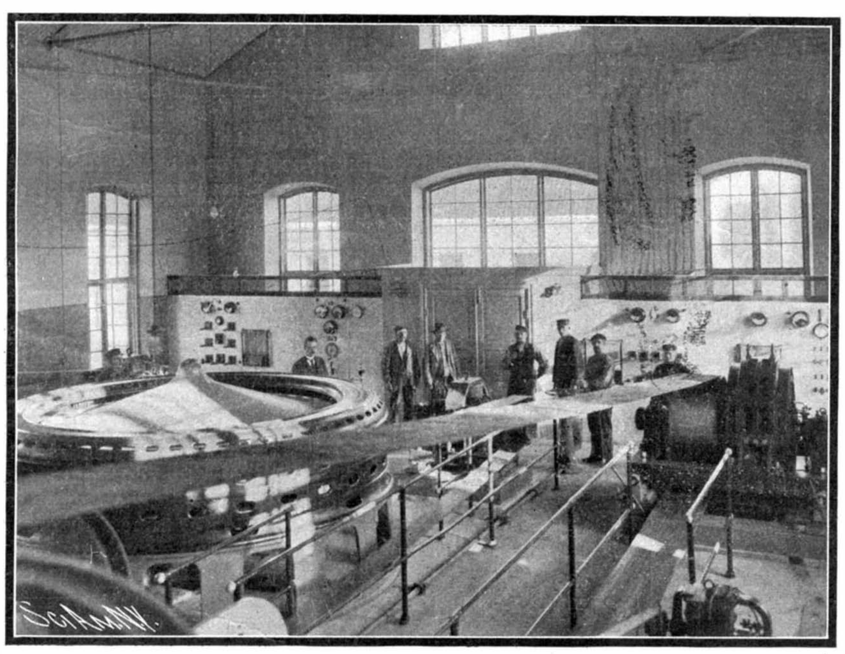
POURING THE METAL AT THE KELLER PLANT.



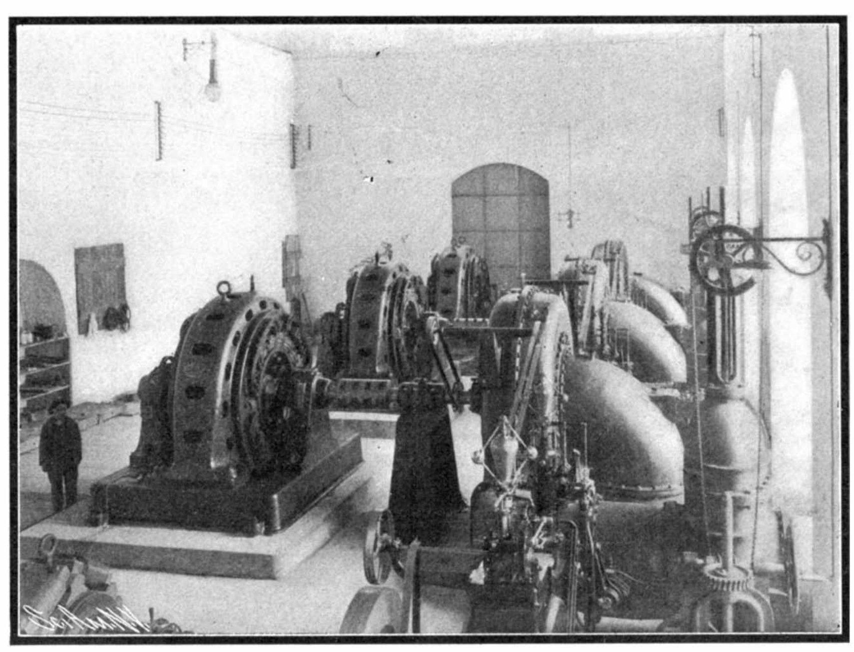
TOP OF KJELLIN IRON AND STEEL ELECTRIC FURNACE.



ELECTRIC IRON AND STEEL FURNACE AT THE KJELLIN PLANT.



THE 3,000-VOLT VERTICAL MONOPHASE GENERATOR OF THE KJELLIN PLANT.



GENERATOR ROOM OF THE KELLER ELECTRO-METALLURGICAL PLANT.

THE ELECTRO-METALLURGY OF IRON AND STEEL.

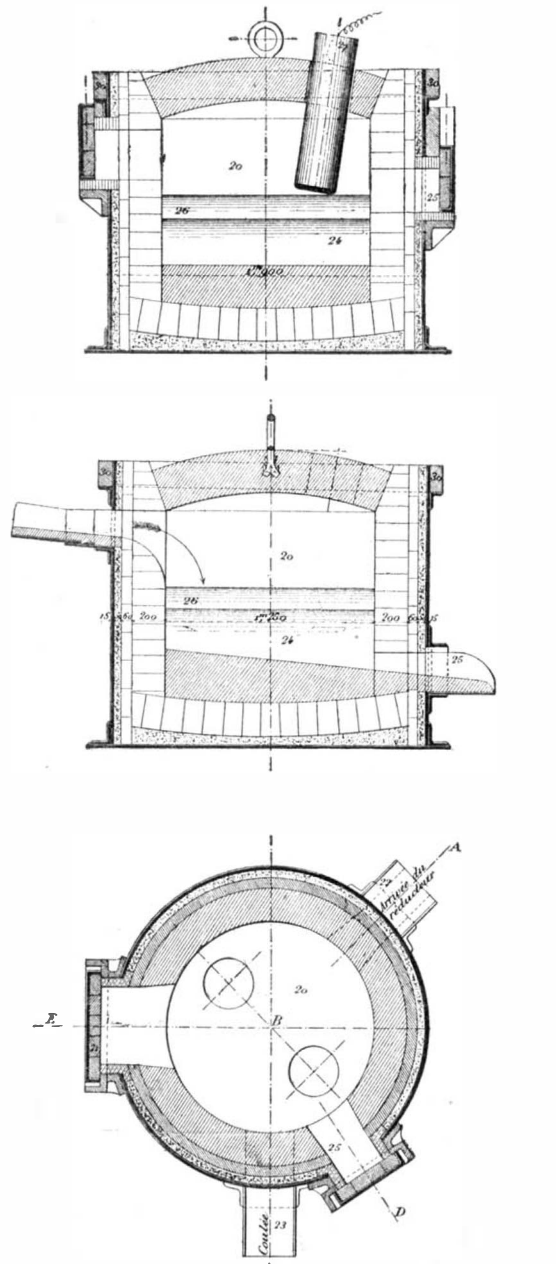
[Concluded from SUPPLEMENT No. 1492, page 23904.]

THE ELECTRO-METALLURGY OF IRON AND STEEL.*

By EMILE GUARINI.

RESISTANCE FURNACES.

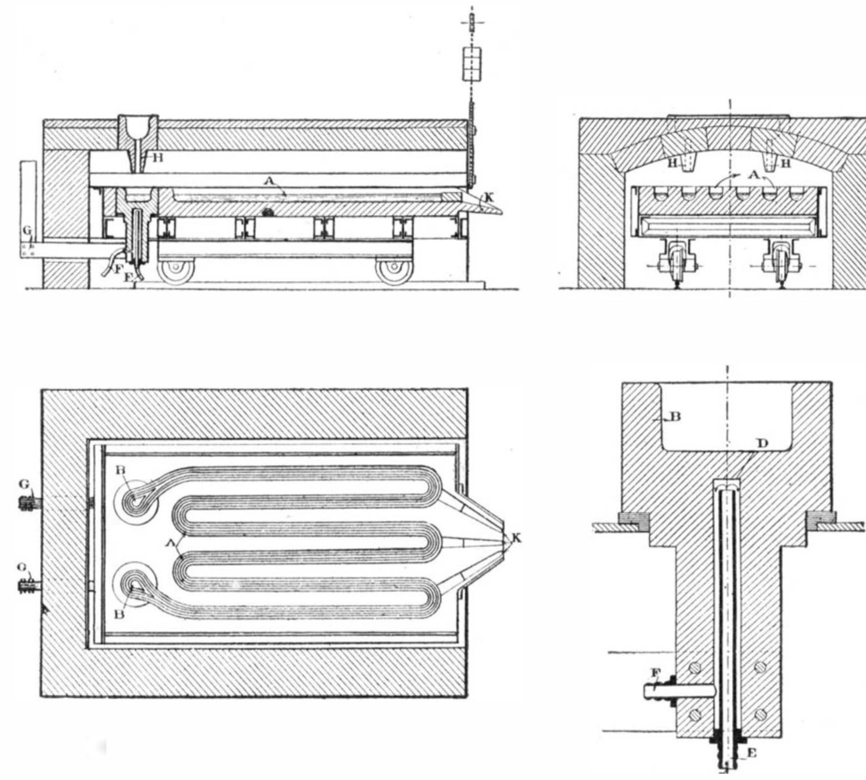
IN the Gui resistance furnace, the material serves as a resistance. The manufacture of steel is effected



First Harmet Type. Martin Electric Regulator or Furnace.

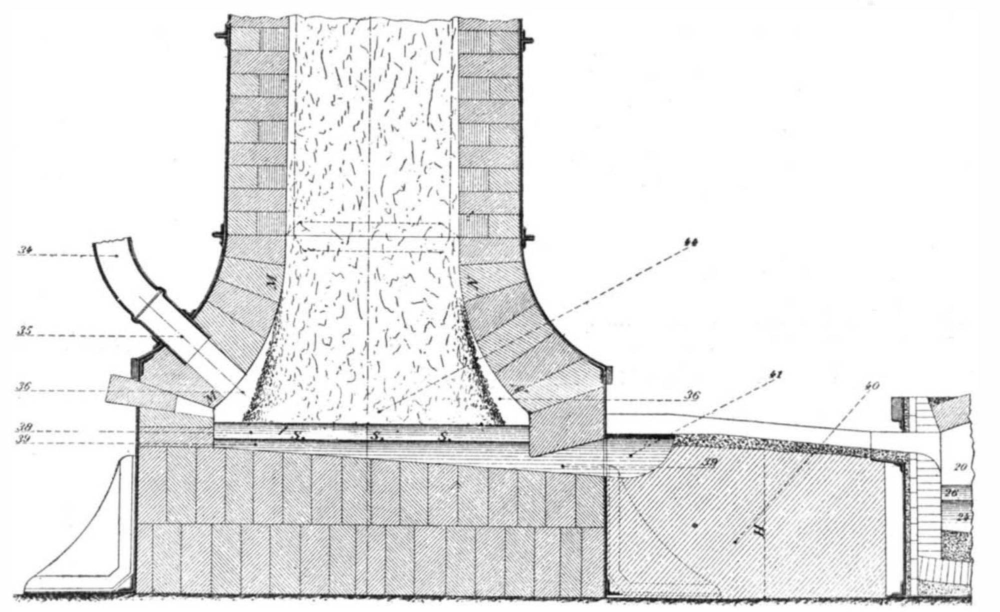
20, Circular chamber of the refining furnace; 21, charging door; 22, conduit for admission of the coarse metal; 23, tap hole for the coarse metal; 24, coarse metal; 25, aperture for outflow of slag; 26, slag; 27, carbon.

in two operations: purification by oxidation and dilution by the addition of scrap-iron. The furnace comprises two large hollow steel electrodes cooled by a current of water. When the surface of the molten mass is covered with small blue flames, a new charge of ore is added. During the refining it is necessary to employ basic reagents in order to eliminate the phosphorus and sulphur, and, in certain cases, to remove the slag by means of a scraper. After the mass has been sufficiently purified the scrap-iron is added. There should be mentioned in this class also, the Laval furnace, in which the metal is employed as an electric heating resistance, and in which the current traverses a stratum of slag serving as a bottom-plate.



Gui Electric Furnace.

A, Semi-orbicular crucible; *B B*, current collectors; *D*, cavity for the circulation of water for cooling *BB*; *E*, tube for the entrance of water at *D*; *F*, Outlet for cooling water; *G*, point of electric connection; *H H*, funnels for pouring off the molten metal; *K*, tap-hole.



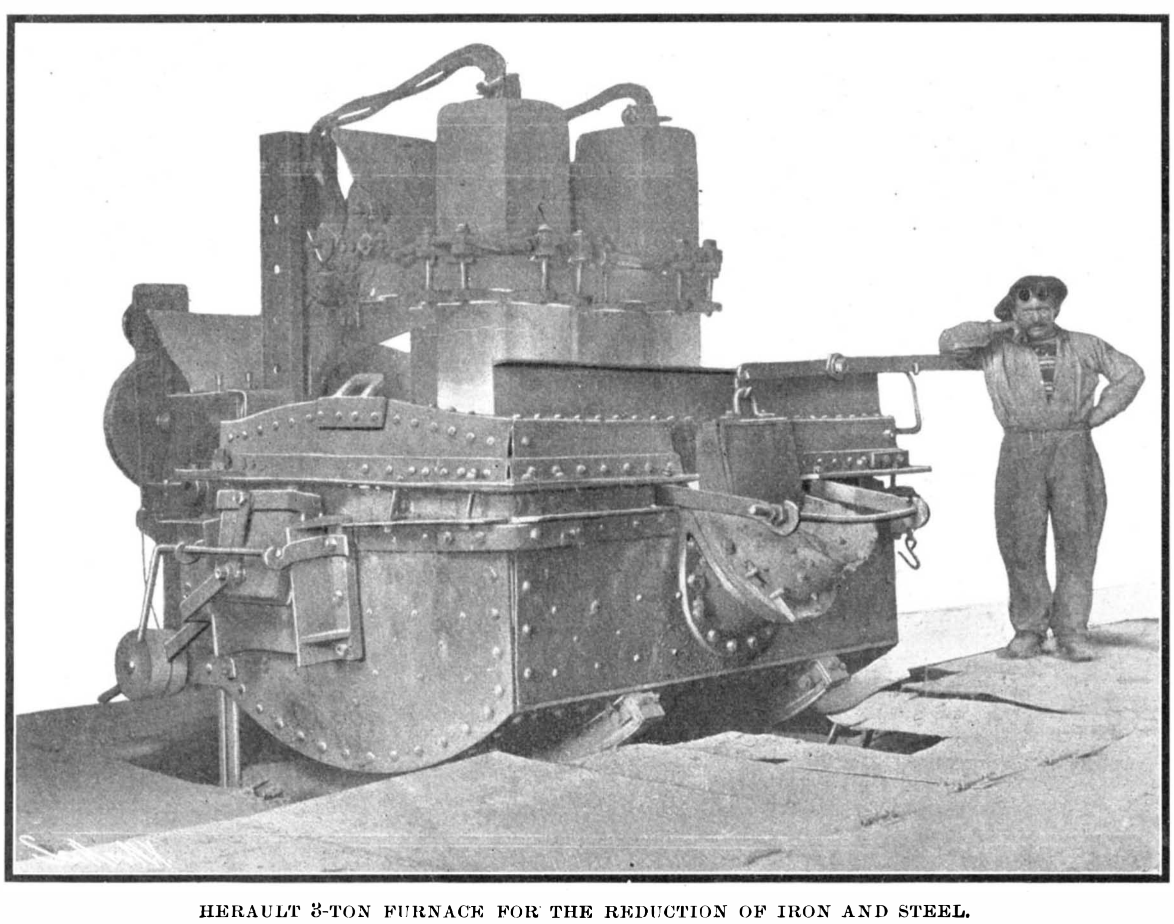
Harmet Electric Furnace, Second Type.

Vertical section through the axis of the reducer in the direction *X Y*. *H*, elevation of the channel through which the coarse metal is run off; *M* and *N*, curves of expansion of the shaft; *S S*, level of the metal in the crucible; 20, regulator; 24, metal; 26, slag; 34, conduit through which gas is forced into the crucible; 35, pipe for entrance of the gas; 36, space in which the gas accumulates; 38, slag; 39, metal; 40, sand surrounding the crucible 41; 41, crucible; 44, crucible.

The Keller system produces pig iron in the first place, and then steel or iron in a special refining furnace. The centrally charged blast furnace comprises, above the crucible, four vertical electrodes each forming a special furnace. The electrodes of each group are in parallel and the groups are in series. The carbonic oxide is burned beneath the base plate. The dead-plate of the reduction furnace comprises two movable parts on each side of a stationary arc. The current passes from one to the other through the material to be treated. The reaction is started by a stratum of conducting material. The electrodes are afterward raised and the furnace then begins to operate.

The Herault system is applied especially by the Société Electrometallurgique Française of Froges. A movable vertical electrode is placed in a chamber of refractory material, under which may be rolled a crucible mounted upon wheels and serving as a second electrode. The crucible, which is of carbon, is in the first place charged with a mixture of ore and coal and with iron and steel scrap or cast iron. The ore and coal are used in lumps. The slag is removed either continuously or at intervals. The fused metal being in the crucible, the excess of slag is removed, and then some oxide of iron, which gives an oxidizing bath on the surface, is added. The refining is effected through the reaction of the slag upon the carbureted metal, and this is accomplished very rapidly, owing to the very high temperature. For the dephosphorization, a basic slag is made by the addition of lime. In order to obtain special steels, the metals to be combined with the iron are added in proper proportions before the melting.

M. Harmet has invented two types of electric furnaces in which he purposes to furnish solely through electricity the heat units that would ordinarily be obtained by an excess of carbon and completely to utilize the carbon, so that the gases that escape from the blast furnace shall be no longer utilizable. The



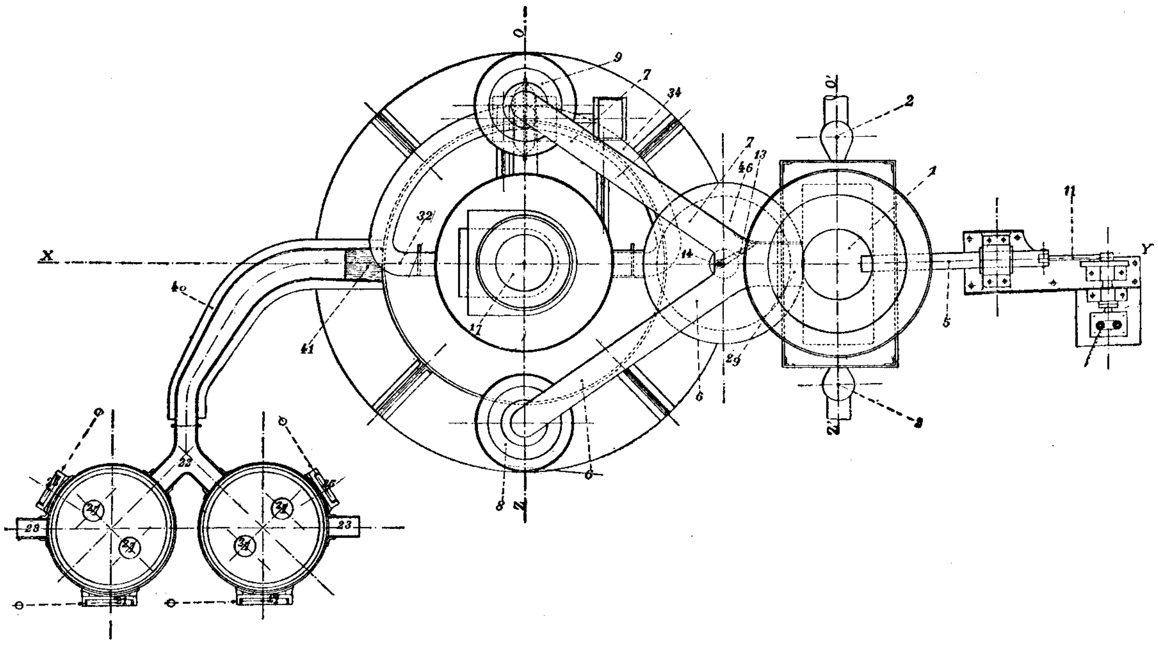
HERAULT 3-TON FURNACE FOR THE REDUCTION OF IRON AND STEEL.

THE ELECTRO-METALLURGY OF IRON AND STEEL.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT

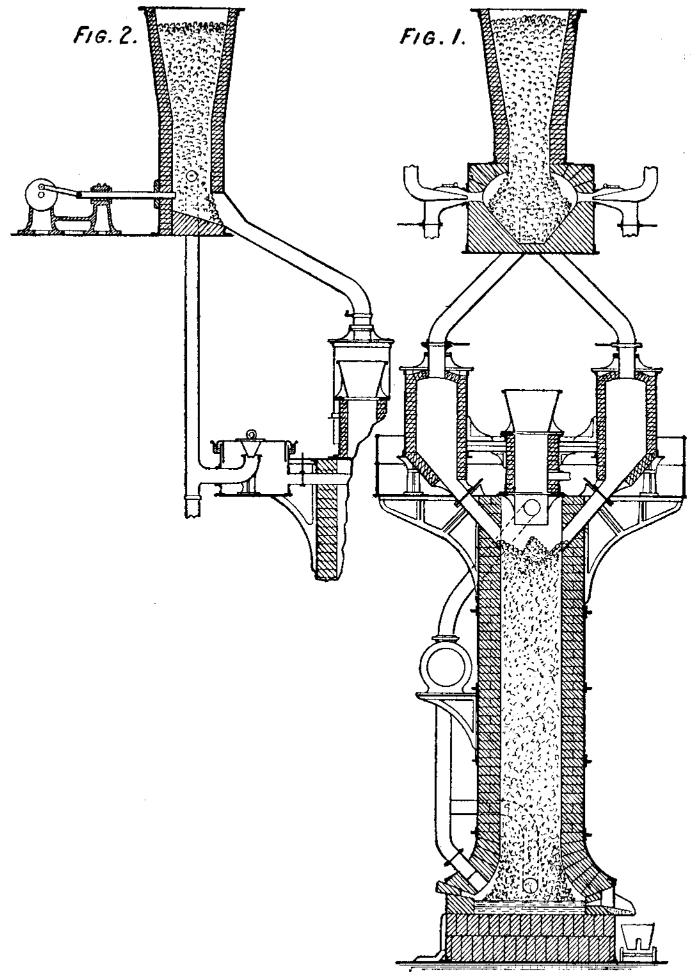
first system comprises three parts, viz., a melting furnace, a reducing furnace, and a refining arc. The first is charged with metallic oxide, which melts from the heat of combustion of the carbonic oxide derived from the second, in combination with the auxiliary heat units furnished by the electricity. The molten oxide passes into the second furnace, wherein it comes in contact with a column of coke. The reduction is accomplished by means of the combustion of the carbon and of the auxiliary heat furnished by the electricity. The raw iron then passes into the refining furnace, wherein sticks of carbon lead the current into contact with the molten metal. The refining is effected through the addition of the usual materials.

The second system differs from the first only in the arrangement of the two first furnaces. In the first, the materials are calcined through the effect of the

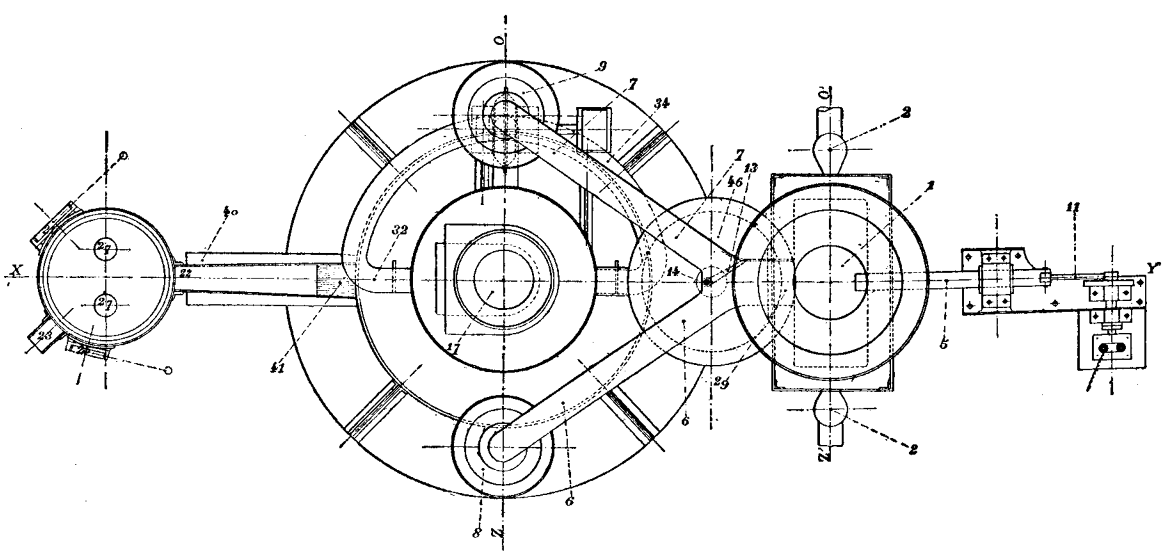


Harmet's Electric Furnace, Second Type.

1. Calcining receptacle ; 2, blowpipes : 5, follower for pushing the calcined material into the pipes 6 and 7 ; 6 and 7, feed pipes for hoppers 8 and 9 ; 11, crankshaft ; 13, manhole ; 17, stoker ; 21, charging door ; 22, channel for admission of molten metal ; 25, tap for metal ; 26, tap for slag ; 27, carbon ; 29, opening of feed passages ; 32, gas admission pipe ; 34, gas pipe leading to crucible ; 40, sand surrounding the crucible 41 ; 41, crucible ; 46, chest for the passage of gas.

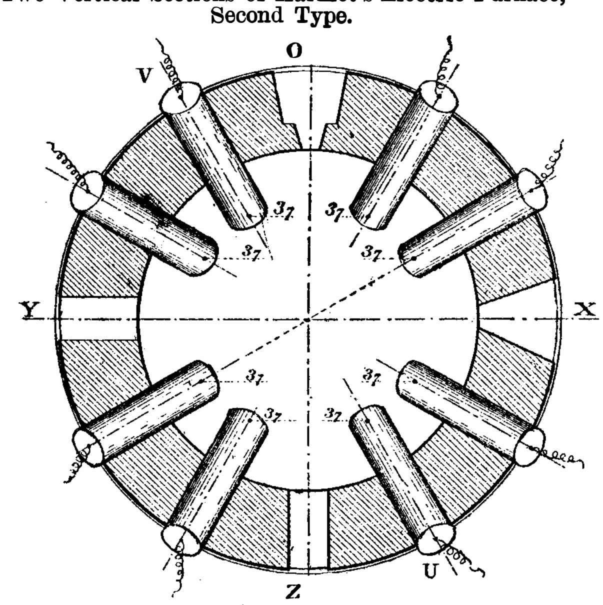


Two Vertical Sections of Harmet's Electric Furnace, Second Type.



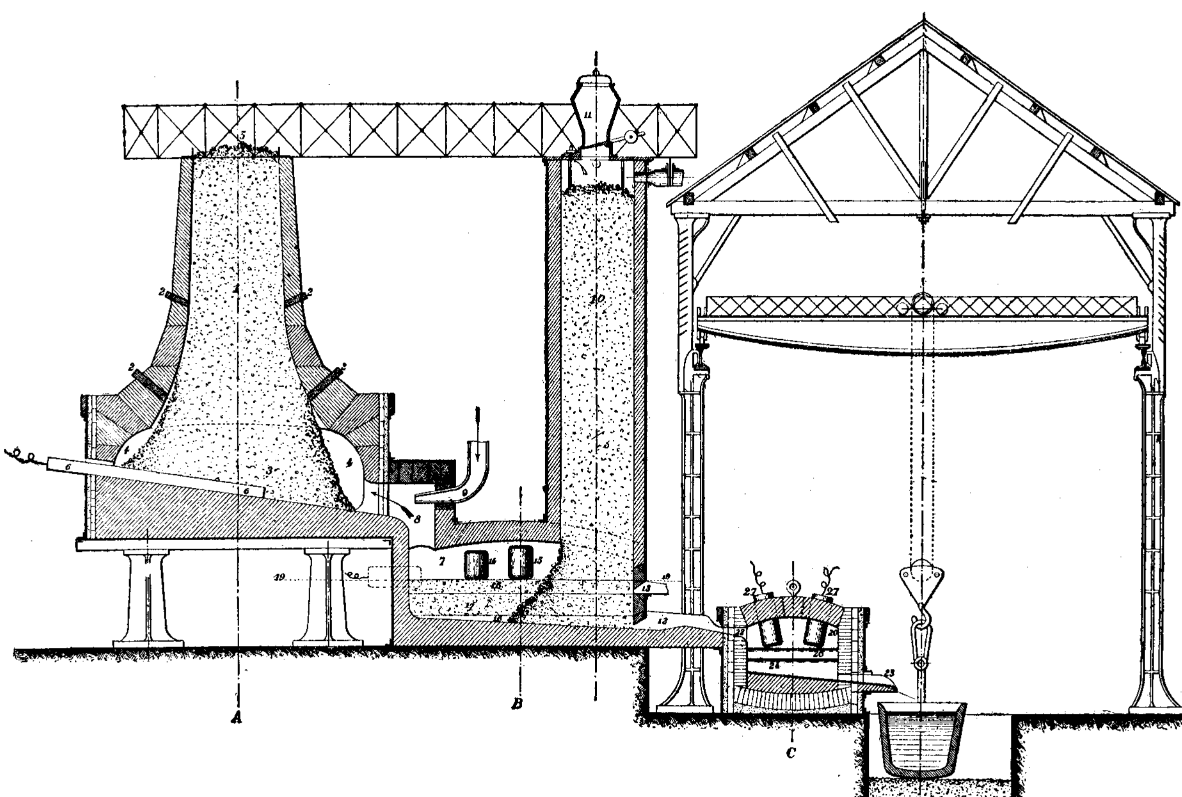
Harmet Electric Furnace, Second Type. (General Plan.)

O Z, axis ; X Y, axis ; 1, shaft of calcinator ; 2, blowpipes for furnishing heat ; 5, piston for forcing the calcined material ; 6, 7, conduits of the chargers 8 and 9 ; 11, crankshaft ; 13, trap ; 14, axis of trap ; 17, heater ; 21, charging door ; 22, conduit for admission of coarse metal ; 23, tap hole for coarse metal ; 25, aperture for outflow of slag ; 27, carbon ; 29, apertures of conduits for running off the metal ; 32, conduit through which the gas is drawn from the mouth ; 34, conduit for the flow of the gas from the mouth ; 40, sand surrounding the crucible 41 ; 46, chamber for the passage of the gas.



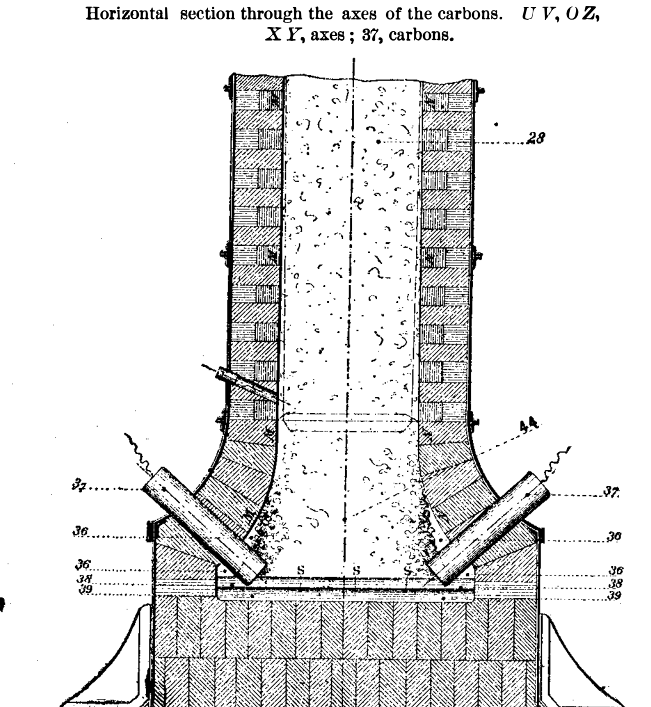
Harmet Electric Furnace, Second Type.

Horizontal section through the axes of the carbons. U V, O Z, X Y, axes ; 37, carbons.



First Type of Harmet Electric Furnace for the Electro-metallurgy of Iron. (General Section.)

A, Melting furnace ; B, reduction furnace ; C, refining furnace ; 1, oxide shaft ; 2, apertures for permitting of working the ore ; 3, melting furnace ; 4, annular space for the combustion of the gas ; 5, mouth ; 6, current carbons ; 7, reducer ; 8, conduit for escape of the gas from the reducer ; 9, tuyere ; 10, coke shaft ; 11, charging apparatus ; 12, aperture for the outflow of the coarse metal ; 13, aperture for the outflow of slag ; 14, 15, current carbons ; 16, stratum of coarse metal ; 17, stratum of fused oxide ; 18, stratum of slag ; 19, full portion of the crucible ; 20, circular chamber of the refining furnace ; 22, channel for the coarse metal ; 23, tap hole for the coarse metal ; 24, coarse metal ; 26, slag ; 27, carbons.



Harmet Electric Furnace, Second Type.

Vertical section on U V through the axes of the carbons. M N, Curves showing the form of the shaft; S S, level of the coarse metal ; 28, shaft ; 36, annular space for the accumulation of gas ; 37, carbons ; 38, slag ; 39, metal ; 40, crucible.

THE ELECTRO-METALLURGY OF IRON AND STEEL.

carbonic oxide derived from the second furnace. In the second, the fusion and reduction are accomplished together. The calcined ore, raised to a red heat, is mixed therein with a column of coke. The reduction is effected in the upper part of the furnace, and the fusion in the lower part through the effect of the electric heat. The reduction is facilitated by blowing in carbon monoxide taken from the furnace-top. This gas furnishes at the same time a supplement of heat units. We shall not dwell upon the American systems of Cowles and Cauley. The first comprises two hollow carbon electrodes. The material descends through the upper one, traverses the electric furnace, and makes its exit through the lower one. The second comprises resistances of graphite and clay in contact with which the material is heated. The furnace is vertical and has the form of an inverted truncated cone.

INDUCTION FURNACES.

Up to the present, there are but two systems of induction furnaces—that of Creusot, as to which we have no information, since the experiments with it are not finished, and that of Kjellin, which is in operation at Gysenge in Sweden. This furnace consists of an annular chamber in the center of which is housed a quadrangular core formed of fine insulated copper wire, prolonged at the exterior of the furnace, and, with the chamber, forming two links of a chain. A coil is connected with the two poles of an alternator. The current, in passing through the coil, excites a variable magnetic flux in the core, or cone, and the intensity of the current in the steel is then almost similar to the primary arc multiplied by the number of turns of wire in the primary coil. The tension is naturally reduced in proportion. There is therefore obtained a current of low voltage and great intensity.

The economic question is very interesting, and it may be stated that the cost is much less in furnaces as large as the ordinary ones. Following are some data based upon the experiments of different inventors. M. Stassano's experiments show that the electrometallurgy of iron will prove advantageous whenever three electric horse-power hours cost as much as, or less than, one kilogramme (2.2 lbs.) of coal. Such would be the case in countries well provided with hydraulic power, but poor in fuel, such as Switzerland and Italy. Upon employing metallurgic coke at 45 francs ($9) a ton for a 5,000-horse-power works and with an expenditure of 300 francs ($60) per horse-power installed, the cost of iron in ingots would be 94.4 francs ($18.90).

According to the researches of Gui, whose process is to be exploited at Plattenberg (Westphalia) by the Deutsche Elektrische Stahlwerke, which forms part of the Siemens & Halske establishment, the net cost may be determined as follows: Admitting that the electric furnace receives the product of the first fusion of the blast furnace, and calculating upon an annual production of 30,000 tons of steel, we reach a net cost of 80 francs ($16) per ton of finished steel. Keller calculates that in admitting a consumption of 2,800 kilowatt-hours per ton of finished steel, we may grant a net cost of from 90 to 100 francs ($18 to $20), or with a utilization of the by-products, of 45 francs ($9).

According to Conby, a ton of steel would cost 60 francs ($12) when made from the ore, and 140 ($28) when made from pig iron and scrap. Harmet, admitting a cost of .01 franc (1-5 cent) per 1,000 heat units, reaches the figure of 29.24 francs ($5.85) for the treatment of one ton of finished steel—a very low figure if we reflect that in the Siemens-Martin furnace we have to estimate 42.5 francs ($8.50) for the fuel solely.

According to Kjellin, a furnace of 736 kilowatts, say 1,000 electric horse-power, produces 10 tons of steel ingots per 24 hours, when charged with cold raw material. In this case, the consumption would be 2,400 horse-power-hours per ton. The power needed would be much reduced with hot raw materials, and especially with furnaces of much greater dimensions. Electric steel works are not as yet very numerous in Europe. Among those that do exist, that in Westphalia, which is exploiting the Guiqui system, is the most important.

The Stassano system, after having been tried at Darfo (Lake of Isee in Italy), has been installed in the Royal Foundry of Artillery at Turin, where it has given absolutely satisfactory results. M. Stassano is occupied in modifying and enlarging his installation, of which the regular operation is soon to begin again.

The Herault furnace is in operation in Sweden between Graubergsaal and Korffors, and in France at Froges and La Praz. Up to September, 1903, more than 300 tons of steel had been produced in Sweden. One of the furnaces established in France has a capacity of 400 tons of steel and produces 150 tons a day.

The Keller system is in operation at Livet (France) in the valley of the Romanche, and at Kerrousse upon the Blavat.

The Livet works has at its disposal a 196-foot head of water and an average discharge of 6,600 gallons per second. The groups of electric generators are of 1,200 horse-power, which is developed by Thury alternators capable of furnishing 30,000 amperes and actuated directly by Neyret-Brencier turbines. The electric blast furnaces are capable of producing about 8 tons of steel per 24 hours, or 25 tons in the same period if, instead of reducing the ore, scraps of iron and steel be melted.

The Gysinge works owns several furnaces and employs a high-tension alternating current. The last of the furnaces has a capacity of 1,800 kilogrammes (3,960 lbs.) of steel, from 1,000 to 1,100 kilogrammes (2,200 to 2,420 lbs.) being run off at every tapping. The furnace produces 4,100 kilogrammes (9,020 lbs.) of finished steel in 24 hours

As may be seen, the problem of the electro-metallurgy of iron and steel is sufficiently advanced and the results are sufficiently satisfactory to allow us to predict a brilliant future for it. It has unquestionable advantages over the ordinary process. Conditions being equal, it ought therefore to have the preference. Under special conditions of low cost of energy and high price of fuel, electro-metallurgy is even more economical. It would nevertheless be an error to believe that the electric process can be applied always and everywhere. Its success is rigidly connected with the primordial condition that the question shall be judiciously studied in every case and the local conditions be taken into strict account.

MODIFICATIONS OF THE PLAN OF THE NEW CROTON DAM.*

By WILLIAM R. HILL, M.Am.Soc.C.E.

THE responsibility of the engineer in charge of constructing dams and reservoirs is but vaguely appreciated by the public. In view of the many disastrous failures that have occurred, due to faulty plans and poor construction, it is made imperative for the engineer to exercise his best powers to insure proper and substantial structures. There is, perhaps, no other field of engineering that develops in the course of construction so many new conditions and unexpected obstacles, and when the engineer finds it necessary to make radical changes in the plans, even though involving heavy expenditures and subjecting himself to severe criticism, it is his bounden duty to make these changes.

The writer had the honor of being chief engineer of the Aqueduct Commission of the city of New York from January 1, 1900, to October 14, 1903. During his incumbency the new Croton Dam was under construction.

The purpose of this paper is to explain, as briefly as possible, the original plan of this structure, and the imperative necessity of its modification, and to answer a general demand made upon the writer that would seem to indicate a very widespread interest in these notable changes. Had the work continued under the original plan it might have resulted not only in the failure of the structure itself, but have been the cause of immeasurable loss to this great city of its supply of water, in addition to an appalling destruction of life and property.

The boroughs of Manhattan and Bronx, of an estimated population of 2,200,000 are dependent almost entirely upon the Croton River for their supply of water; in fact, they have no other supply, except the comparatively small quantity (20,000,000 gallons per day) from the Bronx and Byram rivers, small as compared with 290,000,000 gallons, the present daily consumption of these two boroughs.

The natural flow of Croton River in dry seasons was judged insufficient to supply the city as early as 1843, now more than sixty years ago, so Croton Lake, of a capacity of two billion gallons, was then created by building the old Croton Dam. Since then, from time to time, six other reservoirs, having an aggregate capacity of 40,000,000,000 gallons, have been built on the principal tributaries of the river, above the lake, for the purpose of collecting water in wet seasons, to be discharged into the lake as required for use. The city has no auxiliary supply, and no lakes or rivers that could be used as such in case of an emergency, hence an accident to a reservoir might result in so great a loss of water as to cause a water famine, truly styled one of the world's greatest disasters.

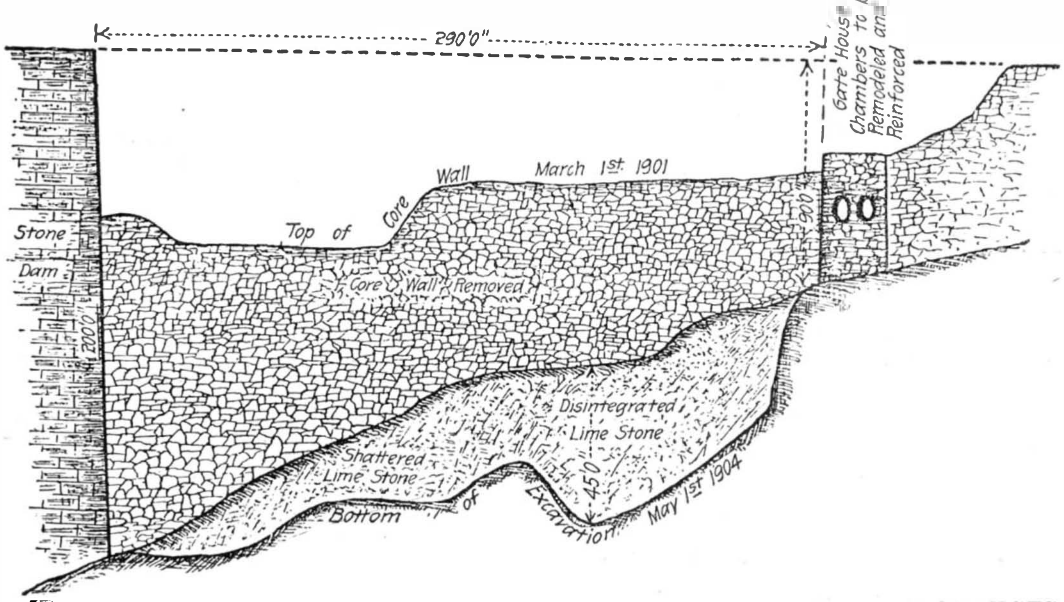
The new Croton Dam is located about 37 miles from the Central Park reservoirs. It is on the Croton River, about 2½ miles below the old Croton Dam. Its purpose is to enlarge Croton Lake, increasing its capacity from two to thirty-two billion gallons and its length from 5½ to 19¾ miles. The old dam will be submerged, as the flow line will be raised 36 feet.

The clearing of this great basin for the reservoir, 20 miles in length, was in itself an extraordinary undertaking, embracing the clearing of all timber, the removal of three villages, numberless buildings, farm houses and cemeteries, and the abandonment and reconstruction of railroad tracks, telegraph lines, highways, and bridges.

The work of constructing the new Croton Dam commenced October 1, 1892. It calls for a very large quantity of masonry; in fact, there will be no less than 800,000 cubic yards. In this connection it may be of interest to note that it will be the largest block of masonry in the world, excepting the Egyptian pyramids.

There are three distinct features of the dam—the spillway at the north end, the main stone dam crossing the valley, and the embankment at the south end. The spillway wall is built on the side of the valley, curving up stream from the stone dam; it is 1,000 feet long, 10 feet high at the end, and 150 feet high at its junction with the dam. It is rubble masonry, faced on the water side with cut stone in regular courses, and the lower side is in steps of large blocks of stone. A channel for the overflow is excavated in the rock back of the wall leading down to the river below the dam. The main stone dam, according to the original plan, was to be 600 feet long, extending from the spillway to the foot of the slope at the south side of the valley; thence an embankment and core wall 568 feet long was to continue to the end, making a structure 2,168 feet long.

The main stone dam is rubble masonry, faced on both sides, above the surface of the ground, with cut stone in regular courses. It is 297 feet high from the deepest point of the foundation, which is 131 feet below the bed of the river. Its greatest width at the base is 206 feet, and the width at the top is 20 feet. At the junction with the core wall according to the original plan it had a height of 230 feet. For the purpose of reaching a point where the core wall would have a lesser height, the Aqueduct Commissioners on September 16, 1896, on the recommendation of the former chief engineer, authorized him to extend the main stone dam 110 feet, in substitution of the embankment and core wall, but even at the point thus reached the core wall would have a height of 200 feet. This extension materially increased the cost of the structure.



LONGITUDINAL SECTION ON AXIS OF NEW CROTON DAM, SHOWING CHANGES MADE IN CONSTRUCTION.

The embankment was to be 30 feet wide at the top, with sides sloping in the ratio of 2 horizontal to 1 vertical. The lower portion of the inner slope to a height of 16 feet below the crest of the spillway, to be paved with stone, 18 inches thick, laid dry, upon 12 inches of broken stone, and on the upper part of the slope to a height of 12 feet above the crest of the spillway, the paving stone was to be 2 feet thick, upon 18 inches of broken stone. The core wall in the center of the embankment was to be 4 feet higher than the crest of the spillway, 6 feet wide at the top, and increasing to 18 feet at a depth of 136 feet, then same width to the base. The core wall was to be 200 feet high at the junction with the stone dam, and 90 feet high at a gate house that is built in the embankment, 290 feet from the stone dam. The high end of the core wall had been built in a wide pit, that was a necessary excavation for the end of the stone dam, which was 164 feet wide at the base, while the core wall was but 18 feet at its base. The slope of this pit extended southerly along the line of the wall for a distance of 150 feet, thus the core wall at its highest end was not built in a narrow trench below the surface of the ground, as is usual in ordinary cases.

The bed rock on the north side of the valley is gneiss, and the structure is founded upon it for a length of 1,200 feet. The character of the rock then changes abruptly from gneiss to limestone, and this extends southerly beyond the end of the structure. Although the contract drawings, upon which the contract was based, indicated "hard rock" at a depth of 75 feet below the bed of the river, yet it was found necessary to excavate the foundation pit to a depth of 131 feet before finding a firm foundation of hard rock. The character of the stone removed varied greatly; in places it was compact, then diversified by masses of

* Paper read before the American Water-Works Association at St. Louis, Mo., June 8, 1904.

stone broken up by open, eroded and mud-filled seams, and in places there were belts of disintegrated limestone. During the progress of the excavation, water flowed freely through the seams, and several open caves were found in the rock. In consequence of this great additional depth, it was also necessary greatly to increase the width of the base of the dam. Thus again the cost was materially increased because of the additional quantity of excavation and masonry.

Before the writer assumed the responsibility of this work, the foundation of the stone dam had been completed to the surface of the ground and the core wall had been completed, excepting the stretch between the stone dam and gatehouse, which lacked about 60 feet of its height.

In the spring of 1901, this core wall cracked in five places within a length of 100 feet. This caused the writer to believe that some serious disturbance had taken place, as in his opinion the cracks were too close together to be caused by contraction. After close study of the conditions, there was no conclusion to be arrived at except that there was a fundamental weakness here, and therefore it would be unsafe to proceed with the work. This close study brought to view objectionable features of the plans of the embankment and core wall, the most conspicuous of which were three. First the excessive height, narrow base, and unstable foundation of the embankment; second, the great height of the core wall, and, third, the double means afforded the water to reach the core wall.

To take up the first, the embankment: It was to be 150 feet high, and only 650 feet thick at the base. This section would be not only about 40 per cent higher than any heretofore built, but in comparison with other high embankments its base was narrow for its height. As an example, the Amawalk dam, which forms one of the upper Croton reservoirs, while only about half the height, 85 feet, has a base even wider than that of this embankment of unprecedented height. And further, this embankment was hazardous because of the unstable nature of its foundation. It was founded over a great refilled pit, which was 300 feet wide at the top, 170 feet at the base, and 70 feet deep; this pit was a necessary excavation for the foundation of the end of the stone dam, which was 164 feet wide at the base as before stated. It would be impossible to refill this pit as compactly as original ground, hence the safety of the reservoir was dependent not only on an embankment of a problematic section, but this problematic section rested upon an unstable foundation.

The second of the objections: The core wall of this embankment was 200 feet high and with no lateral protection or support from original ground whatsoever, as the artificially placed earth on each side of the wall had the height of the wall itself, 200 feet. Considering the height of the wall, and this in artificially placed earth, it could but be an experimental structure, inasmuch as it would be about twice the height of any heretofore built.

The third objection: The double means afforded the water to reach the core wall is another serious objection, as the water by starting at the end of the embankment in the reservoir and following between the face of the stone dam and the embankment would inevitably reach the core wall. It would be impossible to puddle or otherwise compact the embankment against the dam to prevent this, as settlement would surely follow in any embankment of this great height. This objectionable feature here exists because of the combination of a stone dam and an embankment, while it could not exist in either a continuous stone dam or, on the other hand, a continuous embankment and core wall. As to the second channel by which the water could reach the wall there is also little doubt, for it would be afforded freer access through the refilled material of the great pit, than it would have in ordinary cases, where the wall below the original surface of the ground is in a narrow trench and protected by original soil. It would be useless to consider any proposition to increase the width of the embankment, because the means afforded the water to reach the core wall along the face of the dam would always remain; this is a most dangerous feature, as the core wall would not have sufficient weight or strength to resist the pressure of the water that would come against it.

A fourth objection might here be stated, namely, the permeable and light character of the earth of which the embankment was made; but even with the best of material, an embankment so constructed would be insecure.

Thus it will be seen that the safety of this reservoir was dependent not only upon an embankment of a problematic section, resting upon an unstable foundation, but also upon a core wall of phenomenal height, unprotected and unsupported by original soil and attended with the greatest of all possible risks, that is the means afforded water to reach the center of the embankment against the core wall.

Such a structure cannot be regarded as anything but an experiment. It is abnormal and unpredecented in all its dangerous features. The engineer might apply in vain to science for aid in computing the efficiency of such a structure; he could get no light, for he could find not even the slightest guaranty of safety in a structure so built.

The failure of this embankment might not only create a devastating flood in the valley below, but also cause a current above of such irresistible velocity as would destroy the earthen part of the old Croton Dam, thus at once cutting off the supply of water to the city until the old dam could be repaired, and in addition, postponing indefinitely the time when the city would have the additional supply of water which the enlarged reservoir was to furnish.

Thus the writer was thoroughly convinced that a change in the plan of structure at this point was necessary. Thereupon he recommended to the Aqueduct Commissioners that this entire section of the embankment and core wall to the gatehouse be removed and the stone dam extended in its place. But while maintaining that the conditions allowed of no other conclusion, he recommended that a committee of three engineers be appointed to pass upon a question of so vital and widespread importance.

The commissioners, after personal investigation, agreed in this, and appointed a committee of expert engineers consisting of Messrs. J. J. R. Croes, past president of the American Society of Civil Engineers; Edwin F. Smith, chief engineer of the Schuylkill Navigation Company, and Elnathan Sweet, former engineer of the State of New York. The committee, after making an investigation, reported unanimously recommending this extension of the stone dam to the gatehouse.

The general public will no doubt feel that great weight has been added to these conclusions by the concurrence of the eminent engineers, Prof. William H. Burr, occupying the chair of engineering of Columbia University, and Mr. Nelson P. Lewis, chief engineer of the Board of Estimate and Apportionment of the city of New York, both of whom had been asked by Mayor Low to investigate and report thereon. On April 16, 1902, the Aqueduct Commissioners resolved to remove the embankment and core wall and to continue the main stone dam to the gatehouse.

The estimated cost to complete the embankment and core wall under the original plan was $145,233, while the preliminary estimate of the cost to remove the embankment and core wall and extend the main stone dam is $635,700, the difference, $490,467, being due to this modification; yet there will be a further increase because of the condition of the natural foundation of the core wall, as hereinafter described. In considering this estimate one should not lose sight of the fact that there has been a loss sustained of about $80,000, the cost of that part of the core wall that had to be thus abandoned.

In March, 1903, the core wall having been removed, it became apparent that the embankment and core wall would have been undermined and destroyed if completed under the original plan. The core wall was found to be resting upon limestone that in places was completely disintegrated to the form of loose sand and other portions in the process of disintegrating were more or less hard, the softer part being in such a condition that it could be easily crushed by the hand to the form of sand and would absorb water as freely as would a sponge. The hardest of this stone was full of eroded, open and mud-filled seams, the existence of mud being evidence that these seams had acted as passageways for water. Under date of April 1, 1903, Prof. Burr, who had concurred in the condemnation of the wall, reported to Mayor Low as to the foundation as follows:

"It is most fortunate that the core wall has been removed so as to disclose the actual situation and thus remove what would have been a source of gravest danger to the completed embankment structure as originally planned."

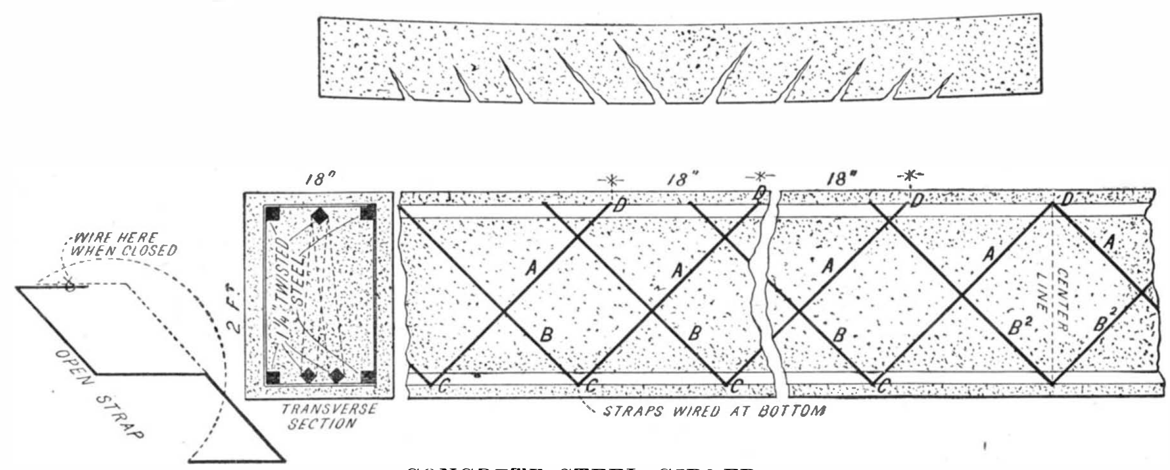
Prof. J. E. Kemp, of Columbia University, and Prof. J. J. Stevenson, of New York University, both geologists, were retained to investigate the locality affected. They reported that the conditions were deserving of very serious consideration, and that in certain locations the material was found to be so soft that, in their own words, it "runs with water like sand." Under their advice this loose and disintegrated rock has been removed to the depth of 75 feet below the base of the core wall, for it is only at this great depth that a suitable foundation for extending the dam has been found. The removal of this soft rock and replacing it with masonry has again materially increased the cost of the structure. The work of building this masonry is now in progress.

Another important change of plan is that of the gatehouse, above referred to. This gatehouse is located in the embankment outside of the core wall. It is well up on the slope of the valley, its base being about 100 feet higher than the bed of the river. The substructure of this gatehouse is described as follows: It has four water chambers, 74 feet deep and about 12 feet square. Two on the southerly side of the structure are to control the flow of the water in the old Croton aqueduct which passes through this gatehouse. The other two, on the northerly side, are to control the flow of water direct from the reservoir to the old aqueduct below the dam. These two chambers are connected with the reservoir by three brick inlets, 10 feet in diameter, and they are to hold water to a depth of 54 feet, yet the outer walls (which are inclosed in an artificial embankment) have a uniform thickness from the base to top of but 8 feet, while safe construction demands that they should be about four times that thickness at the base.

These walls, which had been built to a height of 50 feet, would not have sufficient strength to resist the water pressure that would come against them, and their destruction might result in a great loss of water from the reservoir and the demolition of the embankment, by the rush of water in falling a height of 150 feet to reach the valley below. On December 18, 1902, on the writer's recommendation, the Aqueduct Commissioners approved a plan providing for the reinforcement of these walls.

The preliminary estimate of the cost to construct the dam under the original plan was $4,150,573. This will be increased to about $6,400,000. The great increase in the cost of the work is due principally to the four above described additions and modifications, namely, the extra depth excavated under the main stone dam, the first extension of 110 feet of the main stone dam, the extension of the main stone dam necessitating the removal of the embankment and core wall, and lastly, the additional excavation necessary for the foundation of the last extension. Some idea of what these changes have necessitated may be gained from the consideration of but two items, that of the amount of earth excavation which will be trebled and that of the amount of masonry which will be increased from 550,000 to about 800,000 cubic yards. The value of the work done to March 1, 1904, is $5,363,000.

The most important of all structures to this great city, upon which its welfare would be almost wholly dependent, had to be mantled with all possible safeguards against its destruction. Thus, the writer being brought face to face with the one paramount necessity, that of the safety of this structure, was left no alternative but to modify the plan.



CONCRETE STEEL GIRDER.

NEW DESIGN OF REINFORCEMENT FOR CONCRETE STEEL GIRDERS.*

By E. A. S. Whitford.

From my study and observation of reinforced concrete girders, I notice that the line of rupture is almost invariably at an angle of 45 deg. upward from bottom of girder and near center of span and extending toward each end, as in Fig. 1. To overcome this is to give reinforcement in the direction needed. The need is proven by the rupture.

The general method now in use for reinforcing the body of a girder places the steel used in a line parallel with that to which the rupture develops. Reinforcement in this direction is of course necessary, but inadequate, as repeated demonstration has shown.

Realizing the need of a design of reinforcement which will retain all the present practical principles, and also add needed tensile strength at right angles to the line of rupture, I have designed the reinforcement which I herewith submit.

As will be seen, it is on the lines of a lattice truss, which is acknowledged to be the strongest truss made for the sectional inches of material used. In this design nothing is used but twisted square steel rods of different sizes, and annealed wire for wiring in place.

Unlike any other design I have ever seen, this does not depend on the direct adhesion of concrete to metal alone, in supporting the rods in bottom cord of girder, but all binding rods are used on the principle of "straps," which not only gets the adhesive strength of the concrete, but also the full tensile strength of the steel. By this method the longitudinal rods at the top and bottom cords of girder are rigidly bound together in a manner which will necessitate the stripping of the concrete from the "cord rods" before deflection can occur.

To accomplish this I extend the reinforcement as now used at line *B*, up and over the top "cord rods" in "strap" form, also adding extra "straps" at same angle (see *B*2).

Reinforcement "straps" *A*, which constitute the most

* Specially prepared for the Scientific American Supplement.

essential feature of this design, are placed at right angles to the line of rupture referred to. The result of this is not only to prevent (to a great extent) rupture, but to prevent deflection. Thus, deflection at *C* brings stress at *D* and meets resistance from compressional strength of concrete at that point and brings relief to the crushing tendency at said point *B*, thereby making use of the "compressional strength" of both the concrete and steel (at the top cord), which units of strength are greater, to increase the tensile strength (at the bottom cord), which units of strength are less, at a ratio of about 1:3.

By this construction the neutral axis is changed to a lower level, and the girder gets a greater benefit of a shearing strength, at the point where the "strap" rods cross; the gain in strength from this feature alone is considerable, and more than is at first apparent. I think it will be conceded that this design of reinforcement will easily give from 30 to 40 per cent more strength to a given size girder than is obtained by any other design now in use.

The "strap" rods are bent for convenience of application, as shown by sketch. When applying, twist as shown by dotted lines, and wire in place. Other "cord and strap" rods or ties may be added on the same angles and principle to any number desired. Quarter-inch square twisted steel ties may be used at right angles to cord and applied at interior section of girder (see dotted lines on sectional view) to great advantage, as it will give a maximum percentage of strength for a minimum amount of labor and material used.

This design and method of reinforcement is such as to distribute the load equally over the entire girder, bringing into use all the strength units, equalizing the stresses, and appropriating resistances, to a much greater degree of perfection than any other design which has come to my notice.

Changing in spacing of ties, together with different quantities and dimensions of steel used, make this principle of reinforcement equally applicable to a girder or beam of any span, width, or depth within the reasonable scope of concrete-steel construction.

[Continued from SUPPLEMENT No. 1492, page 23906.]

RESULTS OF BORAX EXPERIMENTS.*

By DR. H. W. WILEY.

SUMMARY OF RESULTS.

Ratio of Food Consumed to Body Weight.

OF interest in connection with the other purposes of this investigation is a study of the relation of the weight of food consumed to the body weight which was made in detail during the first series of observation. This study was made of each individual article of diet, and included a statement of the ratio of the weight of food, including the water consumed, and the ratio of the weight of dry matter in the food to the body weight. During the fore period, first series of observations, the average daily weight of the moist food, including water drunk, was 4.20 per cent of the total weight of the body; during the preservative period 4.22 per cent, and for the after period 4.21 per cent. That is, in about twenty-four days the average healthy young man would consume a quantity of moist food, including water drunk, equal to his own weight.

It is seen by the above that the administration of the preservative caused very little variation in the weight of food consumed compared with the weight of the body.

Reduced to water-free basis, the quantity of food consumed in relation to the weight of the body is as follows:

Fore period	0.96 per cent
Preservation period	0.99 per cent
After period	1.01 per cent

These data show that there is very little difference between the total quantity of dry matter in the food during the three periods. The total quantity of dry matter in the food consumed daily is in round numbers 1 per cent of the weight of the body. For a man weighing 150 pounds, therefore, the quantity of dry matter daily consumed in the food is about 1.5 pounds. It is also interesting to note that the daily ratio of the moist food, including the water drunk, is a little more than four times as great as that of the dry food.

Similar data for the other series of observations are recorded, but the further discussion of the problem is not deemed necessary.

Influence of the Preservative Upon the Weight of the Body.

In every series there was a marked tendency on the part of boric acid and borax to diminish slightly the weight of the body, although this tendency was in some instances checked during the after periods and a portion of the loss of weight was regained. In general, however, there was a tendency to continue the loss of weight during the after periods.

Excretion of the Added Preservatives.

The borax and boric acid taken into the stomach during the progress of these experiments were excreted almost entirely by the kidneys. In the first series of experiments 83.05 per cent were thus excreted, in the second series 82.85 per cent, in the third series 63.87 per cent, in the fourth series 82.96 per cent, and in the fifth series 75.17 per cent. During the course of observation 607.4 grammes of preservative were given, either in the form of boric acid or the equivalent in borax, of which 468.69 grammes were excreted in the urine, or 77.16 per cent of the whole. These numbers include the data for Series III., where the quantity of the preservative recovered in the urine appears to be abnormally low. In round numbers it may be said that 80 per cent of the boric acid and borax taken into the system in foods is excreted in the urine. It is probable that the rest is chiefly excreted with the perspiration. Only small quantities are found in the feces.

Effect of the Preservatives Upon the Composition of the Feces.

A careful study of the effect of the preservative administered upon the composition of the feces shows a slight tendency to increase the amount of water therein. There is, however, no tendency of any marked nature, even when the preservatives are given in large quantities, to excite diarrhea. The administration of the preservative produces a slight increase in the weight of dry matter in the feces.

Influence of the Preservative Upon the Metabolism of Nitrogen.

There is only a slight effect produced as a whole, as determined by the data of experiment, upon the excretion of nitrogen. The individual variations are somewhat marked, showing the danger of depending too positively upon data from only one or two persons. A slight tendency is shown, however, on the part of the preservative to decrease the excretion of nitrogen, which tendency becomes more marked after the withdrawal of the preservatives. For instance, the average nitrogen balance of the four series of observation (excluding Series II.), during the fore periods is 1.009, during the preservative periods 1.12, and during the after periods 1.74 grammes per day. Expressed as a percentage, the combined data show an excretion of 94.2 per cent of nitrogen taken in the food during the fore periods, 93.6 per cent in the preservative periods, and 90.1 in the after periods.

The general summary of all the experiments with borax and boric acid indicates the largest elimination of nitrogen in the fore periods, an intermediate amount in the preservative periods, and the smallest elimination in the after periods.

This relation is either produced by causes other than the administration of the preservative or the effect of the preservative continues after its administration has ceased and even after the preservative itself has ceased to be excreted from the body. It is not impossible that such an influence may be exerted. The retarding influence of the preservative probably increases with the length of the experiment, especially in those cases in which the amount of preservative administered is progressively increased. When the administration of the preservative is discontinued, the elimination of nitrogen is probably at the lowest point (if depressed by the preservative), and yet during the first days of the after period (or at least while the preservative is still in the system) the amount of nitrogen eliminated is probably as low as on the preceding days. There may be a tendency of the preservative in the large amounts in which it is administered to increase the formation of difficultly soluble compounds of nitrogen, and by that means, if no other, retard its elimination from the body.

The Effect of the Preservative Upon the Metabolism of Phosphoric Acid.

A study of the data relative to the influence of boric acid and borax upon the metabolism of phosphorus reveals many contradictory results. When, however, all the data are collected into one expression it is found that the influence of these bodies added to the food is distinctly marked on the metabolism of phosphorus and phosphoric acid. There is a distinct tendency shown by them to increase the quantity of phosphoric acid excreted during the period of the administration of the preservative. In the combined data of Series I., III., IV., and V. the average per cent of phosphoric acid, taken in the food, eliminated during the fore periods of observation is 97.3, during the preservative periods 103.1 per cent, and during the after periods 97.0 per cent.

Influence of the Preservative Upon the Elimination of Fat.

The influence of boric acid and borax upon the metabolism of fat is not very marked. There is a slight tendency shown to decrease the elimination of fat in the feces during the administration of the preservative, and a tendency to recover is shown during the after periods. The percentage of fat ingested in the food, eliminated during the fore periods is 4.1, during the preservative periods 4.0 per cent, and during the after periods 4.2 per cent. These data show that almost no disturbance in the metabolism of fat is caused by the administration of the preservative.

Influence of Boric Acid and Borax Upon the Oxidation of the Combustible Matter in the Food.

The collected data of all the series (except Series II.) show that 6.4 per cent of the combustible matter in the food is eliminated, unburned, during the fore periods, 6.6 per cent during the preservative periods, and 7.0 per cent during the after periods. These data show a slight tendency on the part of the preservative to interfere with the combustion of the food in the body, and this tendency is continued in even a more marked manner during the after periods.

Influence of the Preservative Upon the Solids Excreted.

The solids summary for all of the series (except Series II.) shows that the average quantity of solids in the food during the fore periods is 631.5 grammes, during preservative periods 627.6 grammes, and during the after periods 614.1 grammes. The average daily quantity of solids appearing in the feces in the fore periods is 25.6 grammes, in the preservative periods 28.6 grammes, and in the after periods 28.3 grammes. The average quantity appearing in the urine during the fore periods is 64.48 grammes, during the preservative periods 59.37 grammes, and in the after periods 56.20 grammes. The average balance of total solids during the fore periods is 544.701 grammes, during the preservative periods 539.875 grammes, and during the after periods 530.123 grammes. These data show a marked tendency on the part of the preservative to increase the total solids excreted in the feces and to decrease the total solids excreted by the urine. There is a distinct tendency manifested by the preservative to interfere with the processes of digestion and absorption. Inasmuch, however, as the total quantity of solids administered in the food varied slightly in the different periods, a fairer interpretation is obtained by comparing the percentages of the total solids exhibited in the food eliminated by the feces and urine respectively. In this comparison it is found that the total percentage of solids in the food eliminated in the feces during the fore periods is 4.1, during the preservative periods 4.6, and during the after periods 4.6. The percentage of solids in the food eliminated in the urine during the fore periods is 10.2, during the preservative periods 9.5, and during the after periods 9.1. These percentages indicate also very strongly the influence exerted by the preservative mentioned above. It must be remembered, also, in this connection, that practically 80 per cent of the preservative administered is recovered in the urine, increasing to that extent the total solids thus eliminated. In spite of this, however, there is a marked decrease in the total solids in the urine and a marked increase in the total solids in the feces.

Effect of Boric Acid and Borax Upon the Urine.

Elimination of Nitrogen.—The combined data of the four series (excluding Series II.) show that the percentage of nitrogen ingested in the food eliminated in the urine during the fore periods is 85.7, during the preservative periods 85.1, and during the after periods 81.1. This shows a tendency on the part of the preservative to diminish the percentage of nitrogen excreted in the urine, and this tendency is continued in a very marked manner in the after periods.

Reaction.—The data of Series II., III., and V. show a marked tendency on the part of boric acid to increase the acidity of the urine. In no case during the administration of boric acid was an alkaline reaction observed. In the case of the urine the marked acidity imparted to it by boric acid is continued in most cases throughout the after periods. The data of Series IV. and V., on the contrary, show a marked tendency on the part of borax to diminish the acidity of the urine and in several instances this substance imparted to the urine an alkaline reaction. These facts indicate that a large part of the borax and boric acid administered is excreted unchanged in chemical composition.

Quantity.—Very little effect is produced by these preservatives upon the volume of urine, although there is a slight tendency manifest to decrease the amount. There is a slight tendency also manifested during the administration of the preservatives to decrease the total solids in the urine. In this connection, however, it must be considered that the season of the year has a marked effect upon the amount of urine secreted, the tendency being to secrete larger quantities in cold weather than in warm. Combining the data of Series I., III., IV., and V. for those members completing the series we find that the average daily amount of urine secreted during the fore periods, per individual, is 969 c.c., during the preservative periods 960 c.c., and during the after periods 952 c.c. These data show almost no effect of the preservatives on the quantity of urine secreted, but there seems to be a slight tendency to decrease the amount secreted in the preservative and after periods.

Albumin.—In those few cases where there was normally a mere trace of albumin in the urine it is shown by the data that the general tendency of the preservative used is to increase the trace of albumin in the urine, and this increase is manifested also during the after periods.

Microscopic Bodies.—Microscopical examinations of the urine were made for the following substances:

"Uric acid crystals; urates; oxalate of lime; phosphates: (a) crystalline phosphates, (b) amorphous phosphates; epithelium cells of all kinds; leucocytes; red blood cells; casts: (a) hyaline, (b) finely granular, (c) coarsely granular, (d) epithelial, (e) other forms; mucous cylindroids; mucous strands."

The microscopic examinations were made at three periods during each series except in Series I., during which time the microscopic supervision of the urine had not been instituted. The examinations were made once during the fore period, once or more during the preservative period, and once near the close of the after period.

Reviewing the data as a whole in regard to the appearance of these microscopical bodies in the urine, the facts which appear prominently are the great variations in the number and character of these microchemical bodies. They occur constantly in some cases in very much greater abundance than in others. There are a few cases, in fact, quite a number, where the relative abundance of these bodies seems to be increased during the administration of the preservative. There is a smaller number of cases in which the contrary fact occurs. In the greater number of cases, however, the administration of the preservative appears to have had no influence upon the relative abundance of these bodies. The data, therefore, as a whole, cannot be regarded as conclusive respecting the influence of the preservative upon the number or kind of micro-chemical bodies occurring in the urine.

* Digest of Bulletin No. 84, giving the plan of work and conclusions as to effects of boric acid and borax on digestion and health.

The Effect of the Preservative Upon the Number of Corpuscles and Upon the Hemoglobin in the Blood.

There was no regular influence established relating to the effect of the preservative in increasing or decreasing the number of corpuscles in the blood. The data in individual cases are often contradictory and a general summary of them leads to no conclusive result. The final deduction can only be drawn that if the preservative affects the number of corpuscles and the amount of hemoglobin at all, it does so in very irregular manner, differing in different individuals and in a way which cannot be used as a basis of any definite conclusion.

CONCLUSIONS.

Necessity of Mineral Substances in the Blood.

In the consideration of the action of preservatives of a mineral nature, such as borax and boric acid, it must be remembered that the animal as well as the plant possesses a certain mineral hunger. In other words, mineral substances play a double rôle in animal and plant nutrition. First, they may serve as real foods, necessary to the formation and nutrition of the tissues. In the second place they are necessary to the functional activity of the various organs of the body, irrespective of any part they may take in direct nutrition.

The necessity of saline solutions in the blood is known to every physician and physiologist. If the blood were deprived of all of its saline constituents, the circulation would be impeded, restricted, or stopped, and death would result. In cases of collapse in disease saline injections in the blood are often used as a restorative measure. These salts in solution stimulate the heart's action and undoubtedly are active in the osmotic operations of the cells. This is one of the facts which show the intimate relation existing between physical chemistry and physiology.

Common salt is the most frequent and most abundant of the saline constituents of the blood, but the alkalinity of the blood is not due, of course, to common salt, which is a neutral substance. The existence of alkaline carbonates or other alkaline salts is necessary to the vital functions. While it is true that the digestion in the stomach takes place in an acid solution, it is likewise true that any excessive acid must be neutralized and enough of alkali added in the small intestine, in order that the further digestion of the food may properly take place. That saline bodies other than common salt or the alkaline carbonates may be useful, however, in the performance of the vital functions cannot be denied, though it might be difficult to demonstrate their absolute necessity. Hence, the introduction of saline bodies, which may or may not be of an antiseptic character, may, within certain limits, have a favorable influence upon health and digestion. At the same time it should not be forgotten that all excess of such bodies imposes upon the excretory organs an additional burden, which, while it might not impair their efficiency even for a number of years, might finally produce a condition of exhaustion which would be followed by serious consequences. Especially is this remark true of the kidneys, which appear to be a general clearing house for all the surplus of saline matters ingested in the foods.

Are Minimal Quantities of Preservatives Permissible?

It is admitted by all who have examined the subject in a critical way, even by the users of preservatives, that in certain maximum quantities the limit of toleration is reached in each individual and positive injury is done. But it is also well recognized that many, if not all, of the usual foods when used in large excess produce injurious results. The many cases of disease produced by overeating, or by eating improperly prepared or poorly cooked foods, or by eating at unusual times, are illustrations of this fact. Upon this basis and upon the further statement that when used in extremely small quantities the preservatives in question cannot be regarded as harmful, is founded the principal argument in favor of the use of the preservatives, aside from the fact that the foods themselves are kept in a better and more wholesome state.

It is only proper to give to this argument full consideration and not to brush it aside as illogical and irrelevant. It is evident that any attempt to determine experimentally the effect of extremely minute quantities of any preservative, even when used continuously, would not be likely to lead to any definite result. In the foregoing data we have illustrations of the fact that even large quantities of the preservative employed—larger by far than would probably ever be found in any food product—do not always act in such a way as to permit of definite interpretation. The claim, therefore, that the use of such preservatives is justified when the amount is extremely small, and when even these small amounts are used only at intervals and not continuously, is worthy of careful consideration.

An illustration which is pertinent may be taken from the particular preservatives with which the foregoing experiments have been made, namely, boric acid and borax. One of the food products to which these preservatives are very commonly added is butter. This statement should not be taken to imply that in butter prepared for domestic use in this country borax is found to any considerable extent. When butter, however, is to be transported over long distances, and necessarily kept a long while, the addition of borax is very frequently practiced.

The dietetic data which have been accumulated in the course of this experiment show that the quantity of butter consumed daily varies from 30 to 70 grammes. Suppose, as a maximum, we say that the quantity of butter consumed in any one case daily is 100 grammes, and that it contains 1 gramme of boric acid or an amount of borax equivalent thereto. The maximum quantity of boric acid used in a day in this case would be 1 gramme. In point of fact, however, it would rarely, if ever, reach this amount, but even in those cases where butter is eaten freely probably half a gramme would be about the maximum quantity consumed. Further than this, 1 per cent of boric acid, or its equivalent in borax, in butter is a very large quantity. Probably, as a rule, not more than one-half of 1 per cent is employed. In this case the quantity of boric acid likely to be consumed by any one individual in a day would be reduced to one-quarter of a gramme.

In the case of meats preserved by borax, although larger quantities are eaten than of butter, it is not likely that any larger quantities of borax would be consumed. Thus it appears that those who habitually eat butter and meat preserved with borax might be consuming a half a gramme or a little more of boric acid per day. But preserved meats are not regularly eaten, and hence the quality mentioned is likely to be overestimated. It would be unwise to affirm in a case of this kind, in the light of the data obtained by the experiments, that such a minimum consumption of borax, and especially when not a continuous one, would prove deleterious within any reasonable time of observation. The question then arises, Does the absence of such proof or the impracticability of obtaining it serve as a justifiable excuse for the use of this preservative?

This question ought not to be decided alone, because the principle of the decision must stand, not only for boric acid and borax, but for every preservative used in foods. In other words, whatever principle is established for judgment as to the use of boric acid in small portions must also be applied to the use of every other preservative used in foods. The principle must also be still further extended so that whatever may be established as regards butter or meat must be admitted in respect of every other substance used in food. Hence before admitting the full force of the argument based on minimal quantities the full significance of such an admission must be considered and the practically unlimited extent of its application acknowledged.

This leads to the discussion of the fact that in the majority of cases the labor of freeing the system from added preservatives falls principally upon the kidneys. In the method of life in vogue in this country the kidneys are already hard-worked organs. Americans probably eat more freely than the citizens of almost any other country, with the possible exception of England. Large quantities of nitrogenous foods are consumed. In the breaking down of the nitrogenous tissues the kidneys are the chief organs for the excretion of the debris. The addition of any further burden, therefore, no matter how minute, is to be deplored. If, however, the principle be admitted that injurious substances may be used in such small quantities as to be practically harmless, then we find the way open for loading upon the kidneys many different functions in addition to those which they now discharge. If they may be justly called upon to eliminate the small quantities of boric acid added in food they cannot logically be freed from the necessity of eliminating also minute quantities of salicylic acid, saccharin, sulphurous acids, and sulphites, together with the whole list of the remaining preservatives, which are eliminated principally through the kidneys. It would be useless to contend that the occasional consumption of small quantities of boric acid in a sausage, in butter, or in preserved meat would produce even upon delicate stomachs any continuing deleterious effect which could be detected by any of the means at our disposal, but naturally it seems that this admission does not in any way justify the indiscriminate use of this preservative in food products, implying, as it would, the equal right of all other preservatives of a like character to exist in food products without restriction.

It appears, therefore, that there is no convincing force in the argument for the use of small quantities unless it can be established that there is only a single preservative used in foods, that this preservative is used in only a few foods, that it will be consumed in extremely minute quantities, and that the foods in which it is found are consumed at irregular intervals and in small quantities. On the other hand, the logical conclusion which seems to follow from the data at our disposal is that boric acid and equivalent amounts of borax in certain quantities should be restricted to those cases where the necessity therefor is clearly manifest, and where it is demonstrable that other methods of food preservation are not applicable, and that without the use of such a preservative the deleterious effects produced by the foods themselves, by reason of decomposition, would be far greater than could possibly come from the use of the preservative in minimum quantities. In these cases it would also follow, apparently, as a matter of public information and especially for the protection of the young, the sick, and the debilitated, that each article of food should be plainly labeled and branded in regard to the character and quantity of the preservative employed.

Effect of Boric Acid and Borax Upon General Health.

The most interesting of the observations which were made during the progress of the experiments was in the study of the direct effect of boric acid and borax, when administered in food, upon the health and digestion. When boric acid, or its equivalent in borax, is taken into the food in small quantities, not exceeding half a gramme (7½ grains) a day, no notable effects are immediately produced. The medical symptoms of the cases in long-continued exhibitions of small doses or in large doses, extending over a shorter period, show in many instances a manifest tendency to diminish the appetite and to produce a feeling of fullness and uneasiness in the stomach, which in some cases results in nausea, with a very general tendency to produce a sense of fullness in the head, which is often manifested as a dull and persistent headache. In addition to the uneasiness produced in the region of the stomach, there appear in some instances sharp and well-located pains which, however, are not persistent. Although the depression in the weight of the body and some of the other symptoms produced persist in the after periods, there is a uniform tendency manifested after the withdrawal of the preservative toward the removal of the unpleasant sensations in the stomach and head above mentioned.

The administration of boric acid to the amount of 4 or 5 grammes per day, or borax equivalent thereto, continued for some time results in most cases in loss of appetite and inability to perform work of any kind. In many cases the person becomes ill and unfit for duty. Four grammes per day may be regarded then as the limit of exhibition beyond which the normal man may not go. The administration of 3 grammes per day produced the same symptoms in many cases, although it appeared that a majority of the men under observation were able to take 3 grammes a day for a somewhat protracted period and still perform their duties. They commonly felt injurious effects from the dose, however, and it is certain that the normal man could not long continue to receive 3 grammes per day.

In many cases the same results, though less marked, follow the administration of borax to the extent of 2 grammes and even of 1 gramme per day, although the illness following the administration of borax and boric acid in those proportions may be explained in some cases by other causes, chiefly grippe.

The administration of borax and boric acid to the extent of one-half gramme per day yielded results markedly different from those obtained with larger quantities of the preservatives. This experiment, Series V., conducted as it was for a period of fifty days, was a rather severe test, and it appeared that in some instances a somewhat unfavorable result attended its use. On the whole the results show that one-half gramme per day is too much for the normal man to receive regularly. On the other hand, it is evident that the normal man can receive one-half gramme per day of boric acid, or of borax expressed in terms of boric acid, for a limited period of time without much danger of impairment of health.

It is, of course, not to be denied that both borax and boric acid are recognized as valuable remedies in medicine. There are certain diseases in which these remedies are regularly prescribed, both for internal and external use. The value which they possess in these cases does not seem to have any relation to their use in the healthy organism except when properly prescribed as prophylactics. The fact that any remedy is useful in disease does not appear to logically warrant its use at any other time.

It appears, therefore, that both boric acid and borax, when continuously administered in small doses for a long period, or when given in large quantities for a short period, create disturbances of appetite, of digestion, and of health.

NEW METHOD OF PHOTOGRAPHING THE EFFECT OF THE N-RAYS.

By the Paris Correspondent of the SCIENTIFIC AMERICAN.

IN view of the fact that many experimenters have not been able to detect the presence of the N-rays, it will be of interest to describe the new method of photographing these effects which M. E. Rothé has communicated to the Académie des Sciences. In many of the researches the experimenters used the variations in brightness of a phosphorescent calcium sulphide screen when subjected to the rays. But other physicists have found it so difficult to perceive these changes that it becomes quite necessary to have some objective results, for it is only then that the conclusions will be absolutely certain. In using the photographic method, it is found that the phosphorescent screen, after insolation, diminishes rapidly in brightness. This has proved a drawback in the observation of the effects. In the present method M. Rothé takes these variations into account, and is easily able to detect the N-rays by a series of exposures on a photographic plate.

At a short distance from the plate (0.2 inch) he places a small circular screen of phosphorescent sulphide. After 5 seconds' exposure the negative shows a circular spot which is black at the center and diffused at the outer part, accompanied by a penumbra. The phosphorescence of the screen diminishes after a time and at the end of 20 seconds, for instance, he obtains a second negative which is less intense and smaller. By proceeding in this way, with equal exposures and equal intervals of time, he forms a series of black spots whose diameter is smaller as the phosphorescence decreases. The diminution of the brightness can be represented graphically by using the time intervals as abscissæ and the diameter of the spot as ordinate of a curve. The diameters can be easily measured to within 0.02 inch. The curves are very regular and there is no discontinuity. If the sulphide is now acted upon by an exterior source, heat or N-rays, the action of the latter is shown, as the curve ceases to be regular and has discontinuous portions. For instance, a beam of N-rays is let fall on the screen for 20 seconds. Impression No. 1 is produced on the photographic plate with an exposure of 5 seconds. Removing the plate and suppressing the N-rays, impression No. 2 is made on a second part of the plate after an interval of 20

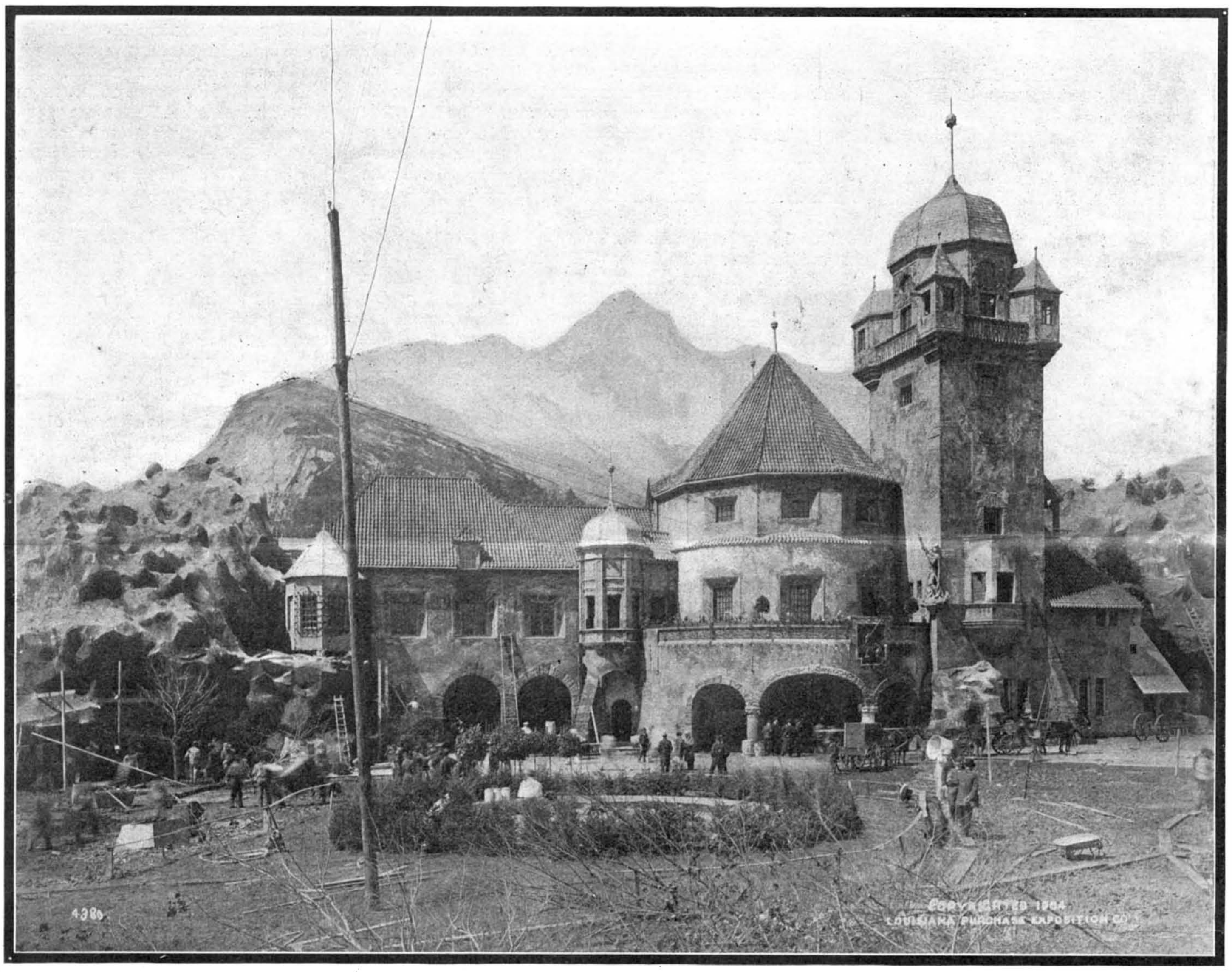
seconds, using the same time of exposure. These two operations are repeated 5 times, producing 10 spots on the same plate, say 4 by 5. For this purpose he constructed a special apparatus formed of two parallel sliding parts. The first slide is formed of a plate-holder carriage which moves up and down, and the plate can also be shifted horizontally. The second part is a screen of oxidized lead covered with wet paper which an assistant raises and lowers alternately every 25 seconds to cut off the N-rays from the sulphide. He expects to use a magnetic device which will allow one person to operate the whole.

It is clearly observed even without measurements that the spots on the plate decrease regularly in diameter, when working normally. In the contrary case, the continuity disappears, and for each pair the spots have about the same diameter. The second spot, which would have diminished, now holds up to about the same value, owing to the action of the N-rays. The curve thus inclines downward, but in a series of zigzags, clearly showing the effect of the rays. The curves are formed as follows: Numbering the spots from 1 to 10, curve No. 1 shows the gradual decrease when there is no outside action. The diameters of the spots are respectively 20.5, 17.5, 17, 16, 15, 14.5, 14, 13.5, 13, 12.5. Second, N-rays from a Nernst lamp are concentrated upon the sulphide screen at 20 inches distance by an aluminium lens. The uneven numbers (1, 3, 5, etc.) show the action of the N-rays, while the other exposures are normal. Curve II. gives 18.5, 17, 16.75, 15, 14.75, 13.75, 13.75, 12, 12, 12. As many as 40 curves like the above were made under different conditions. For the 25-second interval which is used, the N-rays, while they do not actually increase the brightness of the sulphide, at lease serve to diminish the speed with which it loses its phosphorescence. The above method is easy to operate and will no doubt prove of considerable value for detecting the rays.

THE TYROLEAN ALPS ON THE EXPOSITION "PIKE."

By the St. Louis Correspondent of the SCIENTIFIC AMERICAN.

EXPERIENCE with world's fairs, both in Europe and America, seems to have demonstrated that the "side show" element must be provided, if these fairs are to gather within their borders the millions of visitors who are necessary to save them from an absolute financial collapse. We do not stay to question the advisability of this form of entertainment, nor indeed is it strictly open to question; for the various side shows on a Midway Plaisance at Chicago or Buffalo, or upon the Pike at St. Louis, are many of them of such high order, and contain such faithful reproductions of the scenes and places that they represent, to say nothing of the actual natives brought over from a score of different localities throughout the world, that the Midway, or the Pike, is of necessity to a large degree educative in its influence. Engaged in the various side shows is a total of several thousand performers from foreign countries, and artisans from the remotest corners of the earth are to be seen, reproducing the life of twenty-five different peoples, while the services of 1,500 animals are required to lend reality to the various scenes. Two single shows together represent an outlay of $1,-400,000, while twenty of them are said to have cost not less than $100,000 apiece. While it is true that some of these entertainments have been given at other expositions, they have never been presented on the vast scale on which they are seen at the present Exposition. The majority are entirely new, and cover fields which have not hitherto been supposed to lend themselves to purposes of amusement. One of the largest and artistically most meritorious of these reproductions is that known as the Tyrolean Alps, in which a really very beautiful reproduction of the snow-capped masses of the Ortler, with the wild and rugged Zugspitze, cast their shadow over lower foothills that represent in wonderfully realistic manner the scenery of the Alps. With this mountain scenery to act as background, massive castles with lofty gray towers and embattled walls range themselves in close proximity to small Swiss houses with their arbors, gables, and towerlets, while near by is a Tyrolese Council hall built to full size. On the verandas and terraces are to be seen groups of peasants, singing their native songs as they pursue the tasks of their daily life. In the village street is a statue of Andreas Hofer, which stands beneath a little chapel that is cut apparently out of the solid rock. The cottages are all of them faithful reproductions of Tyrolese dwellings, taken from the hamlets of Bozen and Goss. On the ground floor of these cottages, Tyrolean girls in their native costumes offer for sale souvenirs and needle work wrought by their own hands. Concerts are given every night by orchestras of really first-class quality, and the general surroundings, sights, and sounds of the place, particularly in the evenings, when the colored fountains are playing, and the village is softly lighted, make it difficult to realize that one is seated in the midst of one of the largest and most bustling expositions ever gathered together. Perhaps the most meritorious feature of all is the remarkably realistic trip in cars through a mountain road, during which one is continually confronted with vistas which are perfect and really exquisite reproductions of famous Alpine scenery, the canvas for which was painted by Josef Rummelspacher. There is no evidence of that unblushing "fake" which has proved the ruin of many similar but less ambitious attempts; and it is to the credit of this feature of the St. Louis fair to say that there are at least half a dozen other features of the Pike that are only a little less meritorious than the one we have described.



THE CASTLE IN THE TYROLEAN ALPS, HEIGHTS OF ORTLER IN THE BACKGROUND—ST. LOUIS EXPOSITION.

CAPITALIZATION OF RAILWAY PROPERTY.

THE par value of the amount of railway capital outstanding on June 30, 1903, was $12,599,990,258, which represents a capitalization of $63,186 per mile for the railways in the United States. Of this capital, $6,-155,559,032 existed as stock, of which $4,876,961,012 was common, and $1,278,598,020 preferred, and the remaining part, $6,444,431,226 as funded debt, which consisted of mortgage bonds, $5,426,730,154; miscellaneous obligations, $640,704,135; income bonds, $234,016,821, and equipment trust obligations, $142,980,116. Current liabilities are not included in railway capital for the reason that this class of indebtedness has to do with the operation rather than with the construction and equipment of a road. Current liabilities for the year amounted to $864,552,960, or $42,211 per mile of line.

Of the total capital stock outstanding, $2,704,821,163, or 43.94 per cent, paid no dividends. The amount of dividends declared during the year was $196,728,176, being equivalent to 5.70 per cent on dividend-paying stock. For the year ending June 30, 1902, the amount of dividends declared was $185,391,655. Of the total amount of stock outstanding, $6,155,559,032, 6.59 per cent paid from 1 to 4 per cent; 13.51 per cent from 4 to 5 per cent; 10.34 per cent from 5 to 6 per cent; 11.39 per cent from 6 to 7 per cent, and 9.10 per cent from 7 to 8 per cent. The amount of funded debt (omitting equipment trust obligations) that paid no interest was $272,788,421, or 4.33 per cent. Of mortgage bonds, $194,295,524, or 3.58 per cent, of miscellaneous obligations, $7,377,925, or 1.15 per cent, and of income bonds, $71,114,972, or 30.39 per cent, paid no interest.

MONEY SYSTEM OF MANCHURIA.

THE following paper on money in Manchuria, prepared by Mr. Arthur Henckendorff, of the Russo-Chinese Bank at Niuchwang, was transmitted by the United States consul at that place under date of May 5, 1904:

I think it would not be possible to find a more intricate or complicated money system than that at present in vogue in Manchuria. This is owing, I should say, to the fact that they have not a fixed recognized standard of silver which can be taken as a basis for exchange operations.

Although China's currency is on a silver basis, yet there is no standard of silver common to all their provinces.

For instance, the silver of Niuchwang has a touch of 99.2, or, in other words, 8 ounces of alloy to 992 ounces of pure silver. The touch of the silver of Liaoyang, Mukden, Kirin, and Tieling is supposed to be the same as that of Yingkou, but it never is, Yingkou silver usually being finer by 1 or 2 ounces in the thousand. Kwangchingtsu silver has a touch of 99, which puts it below Yingkou silver, while, on the other hand, Harbin silver has a touch of 99.8, which puts it above that of Niuchwang. When we think that the touch is only one of the items which has to be taken into consideration in the every-day exchange operations which take place between the various Manchurian towns, we can understand that the negotiating of a rate between Chinese currency is not a simple matter. This constant practice in exchange of the Chinese banker accounts, I should say, for much of his quickness of perception.

The hard coin currency in Manchuria consists of the sycee, small coin, and, of late, the ruble; yet the bulk of the merchandise bought and sold is not bought or

sold against these hard effectives. All prices and rates quoted are against transfer money or mo-lu yingtzu—in other words, goods money, or huo yingtzu. This transfer or mo-lu yingtzu is a peculiar and muddled system. The arrival of the ruble and the establishment of a quick communication with Manchuria, thus enabling the rapid transportation of treasure to and from Manchuria, is in large part responsible for the muddling.

The transfer money is a purely nominal currency not substantiated in any way by an effective—in other words, it is a credit. We will say, for instance, that a merchant starts business in Niuchwang and that his capital is deposited in some bank in Shanghai. The first thing he will do will be to sell his draft on Shanghai in the market at the market rate. The purchaser will transfer to the credit of the merchant, at the place where he banks, the equivalent, in transfer money, of his draft, and with this credit he can purchase his goods or do his banking. This transfer money can at any time be sold for silver or ruble effectives.

The Chinese year has four settling days or mao-kou, when all transfer money which has been issued has to be released. The method of redeeming transfer money has undergone several changes during the last few years. The first system was that transfer money should be redeemed at full value in hard silver at the end of every three months. This system was continued until about two years after the Japanese war. During this period the effective currency was sycee and copper cash, small coin not having then made its appearance in large amounts.

Tiao notes were largely issued by bankers and merchants of good standing. Silver at that time was only purchasable with cash, not, as now, with transfer money. All other exchange quotations between Yingkou and the other provinces were in transfer. At this time hard sycee was subject to a premium of from 50 cents to 1 tael per shoe of taels, or, roughly, about 2 per cent—that is to say, 53.50 hard sycee taels were equivalent to 54 or 54.50 transfer taels. On the settling day, when the holder of transfer was paid full value in sycee—that is to say, in sycee at par with transfer—he actually received about 2 per cent more than the original amount; this 2 per cent represented the interest he received on his money. By this it may be seen that transfer money increased in value as it approached the settling day, owing to the fact that it was accruing interest.

After the Japanese war the Chinese government started to mint dollars in the various provinces; this had the effect of raising the price of silver and causing a scarcity in the silver market, as the government was buying large quantities. This scarcity of silver made it very inconvenient to have to settle up in ready silver, as the market was often very tight, and consequently the premium on silver would go up very high, thus causing a heavy loss to issuers of transfer; so it was arranged that transfer upon falling due should not be redeemed at par in silver, but should have a premium added to it. This premium was usually slightly smaller than the premium on sycee, and represented the accrued interest. This system had the effect of somewhat diminishing the demand for hard sycee.

During the Boxer trouble the transfer issued was not settled up for a period of nine months. The next settling day it was settled up by the issuers of transfer paying $81.50 for each shoe of transfer, the shoe then being worth about $79, the difference between these amounts standing for the interest. Since then settlements have been made both by paying small coin and by paying a premium.

I mentioned a little while ago that before the Japanese war there were tiao notes and copper cash in currency. These gradually disappeared after the appearance of the small-coin dollar, so that now even in the stalls in the streets you will hardly hear the word tiao mentioned, all business being done in small coin.

Of late the ruble has been a very important factor in the Manchurian currency. The ruble was brought into circulation by the Russian railway and the troops. The Chinese took to it readily, owing to the ease with which it could be carried backward and forward, thus saving the expense of shipping specie.

The currency of Liaoyang is slightly different from that of Niuchwang. The effectives there are the small coin, sycee, copper cash, and rubles. They have there also a system very much like the transfer of Niuchwang; that is, the tieh yingtzu, or note money. This consists of tiao notes issued on demand by bankers and merchants of good standing, payable upon presentation, not in copper cash, as would be expected, but in small coin, at the rate of the day. (The present exchange is about 11 tiaos to the dollar; the tiao there is the same as the tiao here, that is, 160 cash.) The present rate is about 15 tiaos to the tael. This quotation stands good merely for transfers of the tael and tiao against goods bought or sold; if ready silver is required, an extra premium of about 1 tiao, more or less, according to the market quotation, must be paid. For instance, if a person buys 100 pieces of goods the price of which is 1 tael a piece, and the market rate is 15 tiaos to the tael, he would have to pay 1,500 tiaos for these 100 pieces of goods; but if, on the other hand, he wants to buy 100 taels of hard sycee, he will have to pay 1,600 tiaos, that is, 1,500 tiaos plus the premium of 1 tiao (or whatever the market rate may be) on each tael, thus making it 100 tiaos more.

The money system of Mukden and Tieling is practically the same as that of Liaoyang.

The system in Kwangchingtsu and Kirin is quite different again. There they have a system of transfer money very much like the system in Niuchwang. The exchange there is chiefly between tiaos and silver. The tiao there is three times the value of the Yingkou Liaoyang, and Tieling tiao. It is valued at 480 copper cash. But in Kwangchingtsu and Kirin there is no cash to speak of, nor are many tiao notes issued, so that the tiao is more or less a nominal currency, used merely for business transfers, the actual settlements being made in sycee according to the rates quoted in the market.

The price of rubles is quoted in tiaos. The ruble has a fixed rate of 2 tiaos. The difference in rise or fall in exchange is made up by a premium on the ruble, which rises and falls as the value of the silver increases or decreases. In Chi-chi-har and Harbin all business is done in hard effectives, either sycee, rubles, or small coin.

CURTIS STEAM TURBINE IN THE ST. LOUIS MACHINERY BUILDING.

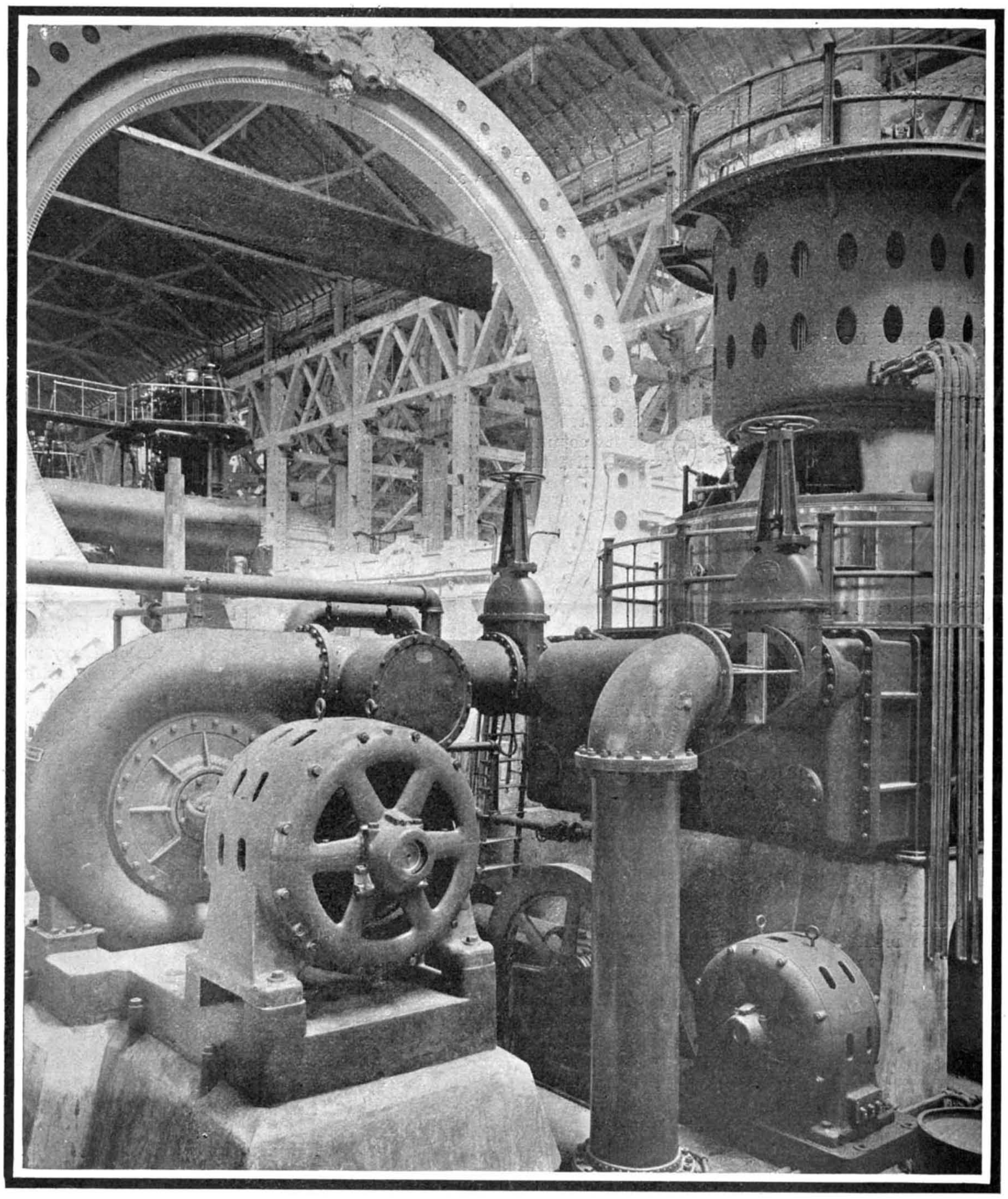
By the St. Louis Correspondent of the Scientific American.

An instructive and suggestive contrast between two types of steam engine can be witnessed by visitors to the Machinery Building of the St. Louis fair. We refer to the adjoining exhibits of the Westinghouse 2,000-horse-power reciprocating engine and the General Electric Curtis 2,000-horse-power steam turbine. They stand in adjoining spaces, separated by a huge plaster ring representing the field yoke of the large generators used in the Manhattan power station at New York. The one, bulky and imposing, represents the highest development of the reciprocating steam engine, which has held its sway practically without competition, ever since the days of James Watt; the other, relatively small and compact, represents the coming type of steam generator—the steam turbine. When one stands beneath the big plaster ring and looks from the one type to the other he realizes that he is standing at the parting of the ways.

The principle of the Curtis turbine differs from that of any other type in that it permits the use of moderate rotative speeds and very compact and simple mechanism.

The work is divided between several stages, each containing two or more revolving buckets supplied with steam from a set of expansion nozzles. In other types of turbines the steam finds its way either through a great number of successive rows of buckets without being carried through nozzles, or it is used in giving velocity in a single set of expansion nozzles, requiring either a large number of buckets or necessitating the use of very high velocities of rotation.

The turbine shown in the Machinery Building is a 2,000-kilowatt machine capable of 50 per cent overload. It is of the four-stage type with a condenser base. It runs under a pressure of 175 pounds to the square inch at a speed of 750 revolutions per minute. The height from the base-plate to the top is 22 feet, 4 inches. It contains four wheels, of a diameter of 8 feet 6 inches. There are two rows of buckets on each wheel, the buckets increasing in size as the pressure falls, the turbine working quadruple expansion. In the first stage the pressure falls from 175 to 60 pounds, in the second stage from 60 to 25 pounds, in the third stage from 25 pounds to atmospheric pressure, and in the fourth stage from atmospheric pressure to a full vacuum of 28 inches of mercury. One of the most valuable features of this turbine is the method of steam admission. There are two valve casings, one on each side of the turbine, with ten valves located in each. The admission is controlled by a centrifugal governor with a tension spring at the top of the shaft. The movement of the governor acts on hinged blocks, and this movement, acting through a center pin, causes a succession of contacts,



THE CURTIS STEAM TURBINE AT THE ST. LOUIS EXPOSITION.

twenty in all, each contact controlling one of the twenty admission valves through an electrical current. This provides a great delicacy of control, and the governor has given most admirable results in practice. Another interesting feature is the step-bearing, which carries the load on the vertical rotating shaft. The oil is forced in between two cast-iron bearing steps, and flows in a film, which is from two to three thousandths of an inch only in thickness, between the adjacent surfaces of the steps, up through the guides, and out. The whole weight of the moving parts is thus carried on a film of oil at a pressure of 600 pounds to the square inch. The bearing works with remarkable efficiency. On the 5,000-kilowatt machines which are being built in large numbers for different power plants, the moving parts that are attached to the shaft weigh altogether 70 tons, yet it is possible to turn this mass from a state of rest by taking hold of the balls of the governor which give only a 7-inch leverage to the center of the shaft. In a test of the step-bearing, made on one of these 5,000-kilowatt machines when it was running at a speed of 500 revolutions per minute, the two main steam valves were shut down tightly, the condenser was opened to the atmosphere, and the rapidly rotating mass of 70 tons was allowed to run down to a

state of rest. It was exactly two hours and 55 minutes before the turbine came to a full stop.

The remarkable rate at which the turbine is establishing itself as the coming prime mover is shown by the fact that the Curtis Company, which is only one of several that are engaged in turbine manufacture, has orders on hand for, or has built, within the past few years, no less than 160 turbines of a total of 283,100 kilowatts, and that they have now on hand eight 5,000-kilowatt turbo generators for the New York Central Railroad, six of the same size for another large railroad company, and nine for four other electric light and power companies.

In closing, it may be mentioned that one great advantage of this turbine, from the operative standpoint, is that it is capable of enormous overload and of very sudden and severe shock. On one occasion it is of record that an additional load of 2,000 kilowatts came in suddenly on a 5,000-kilowatt turbine without any trouble whatever being developed. On another occasion there was a sudden drop of 4,000 kilowatts, which resulted in a rise in the speed of revolution of only 34 per minute, and the control was so efficient that the machine had dropped back to its normal speed of 500 within two minutes' time.

THE CHEMISTRY OF COTTAGE CHEESE.*

F. H. HALL.

IN thousands of homes in New York State cottage, or Dutch, cheese is a familiar table dainty. Thousands of housewives and dairymaids, and hundreds of factory cheesemakers of the other sex, have repeatedly taken the steps necessary to transform the liquid food, milk, into the solid food, cottage cheese; yet it is doubtful if many of these producers could give more than a superficial account of what takes place in the process, and it is certain that, until within a very short time, no one could speak authoritatively as to the chemical changes which occur in making this form of cheese. Cottage cheese is, however, one of the simplest of our cheeses, as it is found to consist mainly of two substances, water and casein dilactate. The latter is one of the two chemical compounds, or salts, resulting from the union of casein in the milk with lactic acid formed by bacterial fermentation of milk sugar.

The white color, crumbly or semi-pasty consistency, and slightly acid flavor of cottage cheese are too well known to need description; and study of its composition and digestibility confirms the popular belief that it is well fitted for a place in our dietaries.

In the manufacture and ripening of cheddar cheese the biological factor—that is, the effect of living organisms—is large, and so far we know of no other agency that will produce the same result in later stages of ripening as do the bacteria in normal cheddar cheese. The true cheddar flavor appears to be lacking unless bacteria are allowed to develop; but in making cottage cheese, bacteria are useful mainly in producing the acid that curdles the milk, since no true "ripening" of cottage cheese takes place and the flavor is merely that of well-soured milk. The direct action of the bacteria may be dispensed with altogether by the use of small amounts of commercial acid to produce curdling and of a little sour milk or cream to give the flavor. By this substitution of commercial acid for the acid gradually produced by bacteria, the time of making cottage cheese may be greatly shortened and the amount of heating similarly diminished. Milk fresh from the separator may be made into good, palatable, and digestible cheese within half an hour.

The clue to the chemistry of milk-souring and cottage-cheese making was found in the series of tests and observations on cheddar cheese that are recorded in bulletins of the Station issued during the past three seasons. In this work it was ascertained that, as the milk sours, the casein first forms with the lactic acid produced by bacterial activity a distinct chemical compound, or salt, which has been called casein monolactate, and which has fixed physical and chemical properties. As additional acid is produced by the manipulation of the bacteria, the monolactate reacts with more acid to form a second compound, characterized by other equally definite qualities. This second salt has been called casein dilactate.

Since cottage cheese is usually made directly from the milk, without the addition of rennet, study of the changes taking place in the process is comparatively simple, and very satisfactory knowledge of the steps in the transformation has been reached in recent experiments.

The ordinary souring of milk is caused by certain ones of those minute, single-celled plants known as bacteria. The organisms of this group of bacteria, which includes several species, live upon the sugar contained in the milk and leave, as a result of their activity, a certain amount of lactic and other acids, the amount produced depending mainly upon the number of bacteria of the proper sort present and upon the temperature at which the milk is kept.

In the tests preliminary to making cottage cheese, it was found, that, at the ordinary room temperature, 65 deg. to 80 deg. F., the milk sugar was changed quite rapidly for about 32 hours, then slowly for 72 to 96 hours, when this form of bacterial activity ceased. It is characteristic of many forms of bacteria that their action is self-limited; that is, that their products, after a certain concentration of them is reached in the material in which the bacteria are, appear to poison the organisms so that their functions cease, even though plenty of food material remains. It is as though human beings were confined where the carbon dioxide breathed out would accumulate until it produced stupefaction. In the souring of milk in the tests, when about nine-tenths of one per cent of acid was formed in the milk, the production ceased although nearly three-fourths (72 per cent) of the milk sugar was still untouched. About two-thirds of the milk sugar which disappeared could be accounted for by the lactic acid produced, while various other products like carbon dioxide, formic acid, acetic acid, and alcohol were derived from the remaining 38 per cent of the milk sugar changed.

The milk began to curdle, however, long before the maximum of acid was formed, coagulation taking place in from 24 to 29½ hours in different samples of milk, at which time the acid in the milk had reached six-tenths or seven-tenths of one per cent.

The coagulation, as already stated, is the result of the union of the milk casein with the acid formed, the combination being at first in the form of casein monolactate, a compound not soluble in water but easily soluble in rather weak brine, this compound gradually changing to casein dilactate which is soluble in neither water nor weak brine. It is not until considerable of the dilactate is formed that the milk appears curdled. In the tests, from 13 to 14 per cent of the casein in the milk was in the monolactate form when coagulation was first noticeable, and 86 to 87 per cent in the dilactate form. With further formation of acid the casein all became casein dilactate, so that when the soured milk is ready for making cottage cheese, all the casein is in this relatively insoluble form.

Following these preliminary tests, cottage cheese was made under various conditions, to ascertain what relations exist between the quantity of milk and the amount of cheese, to study the composition of the cheese and the changes it passes through, and to learn the details of making by which a uniform product could be assured. Skim milk only should be used, since there is a considerable loss of fat in making cottage cheese from whole milk. The fat can be added later when the cheese is salted, in the form of thick cream, and the percentage easily varied to suit individual tastes.

It was found that the milk would produce from 17¼ to 22½ per cent of its weight of cheese, the amount depending largely upon the percentage of moisture the cheese contained. This water content varied from below 70 to over 80 per cent and was regulated largely by the temperature used in curdling the milk and in heating the curd to expel moisture, and also upon the length of time the curd was heated. To secure cheese of the best texture it should be so handled that it will contain from 70 to 75 per cent of moisture when finished, though some may prefer a drier and more crumbly cheese than this. The best success in making test cheeses by the ordinary method was reached when a good starter of sour milk was used (½ pound to 20 pounds of milk), and the temperature of souring and curdling was not allowed to rise much over 70 deg. nor that of the heating to expel the whey above 90 deg. Under these conditions the time necessary for good curdling was about 24 hours, a very convenient period, the whey drained off perfectly and rapidly, and the desired amount of water could be easiest secured. If the temperature of souring, curdling, and heating be too low, below 80 deg., the curd drains very slowly and the cheese is commonly too moist; while too high a temperature for souring is liable to give a soft, mushy curd. Within the limits given as favorable, the cheese can be made quite moist by raising to 90 deg. gradually, taking half an hour to reach that point, and holding at 90 deg. for 15 minutes. Holding longer at 90 deg. or raising the temperature above 90 deg. tends to diminish the amount of water in the cheese.

Since curdling in case of cottage cheese made without rennet is due merely to the action of acid, it was thought that such cheese could be made from freshly separated milk without allowing the bacteria time to produce acid, if the acid were supplied in another form. The experiment was tried in two ways, using lactic acid, which is the one naturally found in milk, and hydrochloric acid, which is a common commercial article. Chemically pure hydrochloric acid should be used, however, as that sold in the drug stores contains impurities which might be undesirable.

The acid used is diluted with from eight to ten times its bulk of water and added to the milk when the latter has been brought to the proper temperature, stirring it thoroughly through the milk. This stirring should be continued until the whey separates clear, and settles out in flakes. In this way the formation of lumps is prevented and the curd will be finely divided and will not require cutting.

With both acids good cheese was made, and the results, when the acid was properly proportioned to the milk and the temperature of the milk maintained at the suitable degree, were highly satisfactory as to texture and amount of product, and were secured in much less time than by the usual method. When sour cream was added to give the flavor, the cheese made with either acid was not to be easily distinguished by texture, taste or digestibility, from normally made cottage cheese.

At a temperature of 75 deg. when the acid was added, 0.6 per cent of lactic acid or 0.25 per cent of hydrochloric acid gave curd of good texture which separated rapidly and completely from the whey. The temperature of the milk when the acid is added has much to do with the rapidity of the curd separation. At 60 deg. it required 20 hours for the curd to drain, at 70 deg. one hour and at 80 deg. only 30 minutes. The percentage of moisture in the cheese was remarkably uniform, however, at any temperature.

Cheese made with the artificial acid differs slightly in chemical composition from normal cottage cheese, being considerably richer in sugar and slightly richer in casein. Bacteria do not have much time to work, in the milk, and little if any of the sugar is decomposed, hence more of it is carried by the curd.

The advantages from the use of acid in making cottage cheese lie in the saving of time and heat. Instead of waiting from 24 to 48 hours for curdling and some time for raising the temperature, the whey can be drawn off almost at once, and the curd drains quickly and is ready, without cutting, to be salted.

The whole process can be carried on at room temperature, also, instead of using additional heat as in normal making.

The disadvantages are the lack of sour milk flavor in cheese made from sweet milk, a disadvantage easily overcome by mixing in a little sour cream at salting, and the expense of the acid, a trifle of one-fourth of a cent for each pound of cheese, an outlay more than offset by the time and heat required for making in the old way.

Examination of cottage cheeses made from whole milk naturally soured, from skim milk pasteurized and unpasteurized, and with and without rennet, showed that there is no "ripening" of this cheese. It is usually eaten when freshly made, but even after three weeks, there had been only insignificant digestive or "breaking down" changes of the nitrogen compounds. In cheddar cheese, on the other hand, almost one-sixth of the nitrogen is contained in soluble forms at the end of three weeks.

From this lack of proteolytic, or breaking down, changes, the chemist would naturally infer that cottage cheese is less digestible than cheddar cheese; but common belief is to the contrary and is true. Cottage cheese proved, in artificial digestion tests at least, to be more readily digested than cheddar cheese. In this work, pepsin, which is the agent upon which digestion of nitrogenous materials in the stomach principally depends, was introduced into flasks containing cheddar or cottage cheese or some of the compounds formed during cheese making, and the material allowed to remain for some time under conditions which favor digestive action.

It was proved in this way that cottage cheese is more digestible than cheddar cheese, and for two reasons: First, because cottage cheese does not "mat" together as does cheddar cheese, consequently the digestive juices find readier access and can attack the fine particles of the cottage cheese rapidly and effectively; and second, casein dilactate, of which cottage cheese is mainly composed, is more digestible than paracasein monolactate which predominates in cheddar cheese. It was also found that cottage cheese made from whole milk was more readily digestible than that from skim milk, owing to the looser texture of the whole milk cheese. The fat does not impede digestion.

Good cottage cheese should have a soft, smooth texture, being neither mushy nor dry and sawdust-like. Such a texture will accompany a moisture content of from 70 to 75 per cent. The flavor should be that of mildly soured milk or well ripened cream, with an entire absence of bitter taste, flavor of stable, or other objectionable qualities. Such flavor may usually be secured by the use of a good starter; but if too much whey is retained the cheese may be sour. Flavor and texture are quite closely connected, at this point, for a slow draining curd is liable to result in poor textured and poor flavored cheese.

The various steps in making cottage cheese may be summarized as follows:

Use skim milk rather than whole milk, to avoid loss of fat. To secure proper flavor and speedy souring add a small amount of a good starter. This starter should be prepared from clean, fresh milk, separated from the cream and placed in a carefully cleaned receptacle, well covered, and brought to a temperature of 90 deg. and then allowed to stand from 20 to 24 hours at a temperature of 65 deg. to 70 deg. The upper portion of this should be discarded and the amount needed strained through a fine strainer or hair sieve and thoroughly mixed with the milk from which cheese is to be made the next day. A portion may also be used in preparing a starter for the next day, but as soon as any unfavorable effect is noticed a new starter should be prepared.

Several good and convenient commercial starters are on the market, for use of which directions accompany each package.

The milk is now kept at a temperature of 70 deg. to 75 deg. until well curdled, often in 24 hours, sometimes not until 48 hours. The curdled mass is broken up by hand or by a curd knife, raised gradually to 90 deg., taking 30 to 40 minutes in the process. The whey should then separate clear in 15 to 20 minutes, after which it is run from the curd, and the latter placed in muslin bags or on racks to drain. When whey ceases to come from the curd, salt is added to taste or at the rate of about a pound for 100 pounds of cheese, the curd formed into balls and wrapped in oiled paper that may be obtained from any dairy supply house. For the finest quality of cheese, thick cream, preferably ripened cream, should be added at the rate of about an ounce for one pound of cheese, before the cheese is made into balls.

* This is a brief review of Bulletin No. 245 of the N. Y. Agricultural Experiment Station, on Chemical Changes in the Souring of Milk and their Relations to Cottage Cheese, by L. L. Van Slyke and E. B. Hart.

If it is thought best to hasten the curdling, rennet extract may be added about eight hours after the starter has been introduced, using one ounce of rennet extract for 1,000 pounds of milk.

OIL FROM LIVERS OF SHARKS AND RELATED SPECIES.*

By Charles H. Stevenson.

The livers of various species of sharks and allied fish are suitable for oil production, giving rise in some localities to important fisheries. The principal species used are the sleeper shark, otherwise known as the nurse, ground, or gurry shark (*Somniosus*), taken in northern waters from the Arctic seas southward to Massachusetts, Oregon, and France; the basking or bone shark (*Cetorhinus*), formerly quite numerous, but now taken to a less extent, north of Europe and on the coast of Peru, Australia, California, etc.; the oil shark (*Galeorhinus*), on the Pacific coast, especially in California, and the dog-fish (*Squalus*), distributed throughout both hemispheres. In addition to these, nearly every species of shark yields livers suitable for oil-rendering.

The sleeper shark appears to be the most important species so far as oil-making is concerned. This is a large fish, individuals ranging in length from 12 to 25 feet. The livers yield from 12 to 50 gallons of oil each when taken in the autumn, but in the spring and summer they are almost worthless for oil purposes. On the New England coast this species is much less numerous than formerly, but it is reported in abundance on the Pacific coast of the United States.

During the autumn the taking of the sleeper shark is a somewhat important branch of the minor Icelandic fisheries, and is also taken by the Russians off the Kola Peninsula. The most important fishery, however, is off the coast of Norway, and especially between Lofoden Islands and Bear Island, in depths of from 150 to 200 fathoms of water. The Norwegians employ small vessels of 20 to 35 tons, carrying about six men each, the season beginning the first of October and ending in February. The fish are taken by means of large, strong hooks baited with fish or salted seal blubber.

The basking shark, probably the largest of all sea fishes, has been taken very extensively for the oil contained in the livers, but owing to decrease of the species the quantity now secured is much reduced. This fish attains an enormous size, the prevailing length of fully-grown individuals being 30 to 35 feet. The liver is proportionally large, yielding ordinarily from 80 to 200 gallons of oil and occasionally as much as 400 gallons. Indeed, a yield of 600 gallons has been reported from a single individual, but this has not been satisfactorily established. This species differs from other sharks in not being voracious. Therefore it must be taken with harpoons rather than with baited hooks. There is said to have been quite an extensive fishery for it on the Massachusetts coast about the middle of the eighteenth century. According to Captain Atwood, writing in 1880, "not more than half a dozen have been caught near Provincetown since 1810."

The basking shark is numerous on the coast of Peru and Ecuador, and its capture gives employment to a large number of small vessels, manned by six or eight men each. The American vessels fishing for humpback whales on that coast have occasionally engaged in its capture when whales were not in sight. Capt. George O. Baker, of New Bedford, reports that on one occasion in two days' fishing he secured 125 barrels of shark oil while on the lookout for humpback whales.

The method of taking this fish off the Peruvian coast, according to Captain Baker, is to approach it while it is lying motionless at the surface of the water and to fasten a harpoon in the top of the head forward of the eyes, so as to hold the head up and thus prevent the fish from going down or "sounding," and then the boat approaches and lances it until it is quite dead. It is taken alongside the vessel, a hole is cut in one side of the abdomen, a strap inserted on either side of the incision and the tail hoisted up so as to raise the body somewhat out of the water. A man then enters the abdominal cavity and with a knife cuts out the liver in pieces. These are passed up on deck, minced, as in the case of whale blubber, and placed in the try-pots. After a sufficient length of time the cooked liver pieces are removed from the pot, placed in a canvas or hempen bag, suspended from aloft, and permitted to drain. Nothing but the oil is saved. A considerable market for it exists in South America, where it is used principally as a body for paints for exterior surfaces. The price is usually 8 or 10 cents per gallon more than that of humpback oil.

The basking shark is taken occasionally on the California coast, the individual yield of oil there averaging about 125 gallons. The same species is also said to be taken in the waters of British India, being harpooned in great numbers by the fishermen of Karachi and other coastal districts.

The common dog-fish (*Squalus*) of the Atlantic coast and a similar species on the Pacific coast are the principal oil-yielding sharks in America. These fish range from 2 to 5 feet in length and from 5 to 15 pounds in weight. They are the great pest of fishermen, destroying nets, robbing fish from the trawls, and committing other depredations.

It does not appear that any important fisheries are organized especially for the capture of these fish, but many are taken incidentally in the shore and Georges cod fisheries, particularly during the spring, and the livers are extracted and thrown in the liver-butts along with those of other fish. The livers are generally of a bluish-gray color, shaped somewhat like those of cod or pollock, and are very brittle, breaking readily when lifted.

In Boston and Gloucester dog-fish livers are sold at the same rate as those of cod and related species, viz., 25 to 30 cents per bucket of 2½ gallons. The yield of oil during August, September, and October is about 6 quarts per bucket, but at other seasons it is much smaller.

Because of the small quantity secured, this oil is rarely kept separate from cod oil for currying purposes, and it sells for about the same price per gallon. A distinctive characteristic is its strong odor when warm, resembling that of ammonia; but this may be removed by proper refining. It is estimated that from 10,000 to 15,000 gallons of dog-fish oil are prepared on the New England coast annually, nearly all of which is combined with and sold as cod oil for currying purposes.

Captain Atwood writes:*

"When I first began to go fishing, in 1810 to 1820, the dog-fish fishery was considered one of the most valuable fisheries that we had around the shore. They appeared here in the spring and were very plenty, and would last a day or two and then all would be gone. Then you would not see a dog-fish again all summer, but about the 10th or middle of September they came to us again, returning south. They would stay into November, and during that time the fishermen would get—a man and a boy—all the way from 8, 10, to 15 barrels of oil. Twenty-five years ago we would occasionally see dog-fish in the summer. The last fifteen years they have been here all summer. During the war they were plenty all summer, and the livers sold for $1 a bucket, and now they are worth but 20 or 25 cents."

On the coast of Oregon, Washington, and British Columbia, large numbers of dog-fish are taken for conversion of the livers into oil, which finds a ready sale, owing to the high cost of other oils on that coast. These fish are reported especially abundant in the vicinity of Queen Charlotte Island, in British Columbia, where they are captured by the Indians. The livers of 100 dog-fish yield six or eight gallons of oil, and the rest of the carcass is utilized for fertilizer. Not only is there an abundance of this oil produced for local use, but also much for export. As long ago as 1876, about 60,000 gallons were exported from Victoria, at a valuation of 40 cents per gallon.† The present annual product is said to exceed 200,000 gallons. New York dealers have received some good samples which indicate a very low weather-test, but owing to the duty and freight rates little has come on the Eastern market.

Dog-fish oil has been used on the Pacific coast in competition with other oils with most favorable results, being "equal, if not superior, to oil supplied to Her Majesty's ships by the service, both for lubricating and lighting purposes."‡

Similar species of dog-fish are taken on the coasts of Norway, Chile, and elsewhere, the fisheries being confined to the summer months and the catch secured with nets as well as with hooks.

Along the Atlantic coast of the United States but little attention is given to the capture of sharks for economic purposes, notwithstanding the many species which occur there in comparatively large numbers. In several localities on the southern coast small fisheries are prosecuted during the winter months, for then the yield of oil is greatest. Among the species taken, other than those above mentioned, are the sand or yellow shark (*Carcharias littoralis*), which attains a length of 5 feet, and yields from 1 to 2 gallons of oil; the leopard or tiger shark, length from 10 to 25 feet, yielding 10 to 20 gallons of oil; the mackerel shark, also known as porbeagle or blue shark, measuring from eight to ten feet in length, and the liver yielding from two to seven gallons of oil; the dusky shark (*Carcharhinus obscurus*), which attains a length of ten feet; the hammer-headed shark (*Sphyrna zygæna*), of twelve or fifteen feet in length; the dog shark (*Mustelus canis*), two or three feet in length; and the thresher shark (*Alopias vulpes*). Some of the large sand and leopard sharks are difficult to secure and their capture gives considerable trouble. They are taken usually by means of harpoons or stout hooks and lines. When taken from a small boat at sea, immediately after the fish has been secured, it is lanced to death, the belly is ripped open with a knife, the boat canted, and the large, slippery liver pulled over the side into the boat, and then the carcass is discarded. Many of the smaller sharks are captured with menhaden, in purse seines, and are utilized at the menhaden factories. Owing to the damage which they do to the twine, the fishermen prefer not to set the seines around sharks, but it is difficult to avoid taking a few of them with the menhaden. It is estimated that from 7,000 to 10,000 sharks are captured annually by the menhaden steamers, all of which are converted into oil and fertilizer.

On the Pacific coast of the United States, especially in California, the oil shark (*Galeorhinus*) is utilized. It is four to six feet in length and weighs from 40 to 70 pounds, the yield of oil from the livers varying from two-thirds of a gallon to one gallon each. The fish are taken by means of hooks and lines when they enter the lagoons for reproductive purposes during the summer. The fins of this species are dried and sold for twelve or fifteen cents per pound, the Chinese using them in soup-making. Other species of shark utilized on the Pacific coast are the shovel-nose shark, thresher shark, and the man-eater or white shark. The shovel-nose shark was taken extensively along the coast of Humboldt County, Cal., from 1858 to 1868, from fifty to sixty men being employed at times in the fishery. It is harpooned in deep water and taken by means of hand lines in shallow water. This species measures from six to ten feet in length, and the liver of each individual yields three to seven gallons of oil.

There are several species of skates, rays, etc., occurring on the United States coasts which are utilized to some extent for oil-production. Principal among these are the common skate (*Raja erinacea*), the prickly skate (*R. eglanteria*), the smooth or barn-door skate (*R. lævis*), the sting ray (*Dasyatis centrura*), the cow-nose ray (*Rhinoptera bonasus*), etc. Many thousands of these are captured by the menhaden fishermen and utilized at the factories for conversion into oil and guano. Oil from the liver of the torpedo or cramp-fish (*Tetronarce occidentalis*), a large species, which at times attains a weight of 200 pounds, is said to be valued by the fishermen in the treatment of cramp and rheumatism.

Captain Atwood wrote in regard to the oil from the torpedo:

"I used to go and look for them for their livers—for the oil. The oil is one of the best lamp oils that I ever saw. It has been used sometimes beneficially in cases of cramp. I got a gallon of oil from one liver. I do not know but I have seen a cramp-fish big enough to make three gallons of oil."*

The liver of the saw-fish (*Pristis*), numerous on the South Atlantic and Gulf coasts of the United States, yields from six to eighteen gallons of oil. It is said that in British Guiana this oil is used for illumination and also for anointing the bodies of the inhabitants. The liver of the elephant-fish (*Chimæra*), which occurs in abundance on the California coast, is large and yields choice oil. This fish has a maximum length of two feet and weighs six or seven pounds.

It appears from the above that the yield of oil from individual shark livers ranges from much less than one pint in case of the dog-fish and others to the 400 gallons procured from the basking shark. Other than the livers, the carcasses of sharks are slightly oleaginous, and are rarely ever utilized in oil-rendering, but they are, of course, useful for conversion into fertilizer. The method of extracting the oil from the livers is much the same in all cases. If they are large, they should first be cut in small pieces or minced, as is done with whale blubber. The pieces are then subjected to heat until the cells are thoroughly broken, when the oil is extracted by pressure or it is permitted to drain therefrom. In case the oil is to be used for medicinal purposes, great cleanliness is observed, the livers being washed free from blood and the gall bladder removed. A quantity of water is placed in the kettle with the hepatic tissues and the whole boiled gently for an hour or two. On cooling, the oil floats on the surface and is dipped off and stored. It may be refined in precisely the same manner as cod oil.

According to Brannt, shark oils are distinguished as being the lightest of fixed oils, their specific gravities ranging from 0.870 to 0.880 at 59 deg. F., so that a mixture with blubber or other fish oils can at once be recognized by the higher specific gravity. They are pale yellow and clear, remain fluid at 21 deg. F., and contain very little stearin. They burn with a bright flame without carbonizing the wick. Brannt further states that they contain about the same constituents as cod-liver oil, but are richer in iodine. On account of their percentage of gall constituents the liver oils are readily distinguished from other fish oils.

Shark oils are largely used in tanneries, in steel tempering, and in various compounds where it is desired to impart a low specific gravity. They are also valuable as a body for paints for out-of-door objects, as walls, fences, etc. In some localities certain kinds are used by medical practitioners, who consider them quite equal to cod-liver oil. In the drug stores of this country shark oil is occasionally found with a label suggestive of an oriental origin and recommending its use as an embrocation in numerous diseases.

* From United States Fish Commission Report, 1902.

* Fishery Industries of the United States, Sec. I., p. 674.

† Report of the Commissioner of Fisheries of Canada for 1876, p. 346.

‡ Fourteenth Annual Report of the Department of Marine and Fisheries of Canada for the year 1881, p. 214 of supplement No. 2.

* Natural History of Aquatic Animals. p. 667.

Industrial Exchange in Germany.—For the past twelve months there has existed in Mannheim an industrial exchange formed on somewhat the same lines as a few similar organizations in other parts of Germany. The organization, especially in Southwest Germany, is composed of manufacturers and dealers in various classes of merchandise, and has its headquarters at Mannheim. The purpose of the association is to afford a convenient means of bringing together at stated intervals the manufacturer, whether large or small, and the buyer.

The membership of the local organization includes about 300 business firms, mainly from Baden, Rhenish Bavaria, and Hessen. Its meetings have been held at intervals of about two months and have generally been accompanied by an exhibit of samples of merchandise, printed matter, etc. The merchandise has covered a wide range of manufactures, including steel, bronze, and other castings, leather goods, chemical products, wooden ware, paper, tools, light machinery, desks and office furniture (the latter exhibited by a local dealer in American goods), etc. Conveniently displayed in dif-

ferent parts of the Stock Exchange Building, where the exhibit is made, are printed lists of the manufacturers in certain branches of industry, as, for example, the paper manufacturers, machine manufacturers, etc., connected with the exchange.

It is claimed the success of the project is assured, and there is now talk of a permanent exhibit of samples and of efforts to extend the work of the exchange in other directions.—H. W. Harris, Consul at Mannheim, Germany.

MAKING ATTAR OF ROSES IN BULGARIA.

THE oil of roses of the ancients, of which Dioscorides speaks in his Materia Medica, was produced by a mere maceration of the petals of the rose in olive oil. Perfumers employed it in this form during the entire Middle Ages, but the distillation of roses does not seem to date back beyond the eighth century. At this epoch, in fact, as we are told by the Arabian author Ibn Khaldun, the trade in rose water extended as far as to the Indies and China. Then, toward the twelfth century, the cultivation of roses extended to Persia, and the distillation became an important source of revenue to that country. It did not at first occur to the Oriental manufacturers, however, to separate from the rose water the small quantity of oily substance carried over with it by the aqueous vapor and floating in the receivers. This idea occurred only to Princess Nour-i-Djihan, who married the Emperor of Delhi, Djahangir, who died in 1627. The practice of distilling roses afterward became implanted in Arabia and the States of Barbary. It is generally asserted that the art of extracting the valuable essential oil was imported into Bulgaria by a Tunisian Turk. In this Balkan principality the cultivation of roses extends at present between the valleys of the Toundja and Strema, to the environs of Kazanlik, Novo Zagora, Tchirpan, Karlova, Novo Selo, Brezovo, and Pechtera. The altitude of these regions above the level of the sea is about 1,300 feet. The thermometer descends here in winter to 20 deg. C. below zero, and in summer sometimes reaches 35 deg. The mean temperature of these districts is therefore notably lower than at Nice and Grosse, the center of the French rose farms.

The majority of the Bulgarian distillers employ the damask rose (*Rosa damascena*), which blooms in May. The flowers, which are borne in bi- or tri-florous cymes to the number of from 7 to 13 per branch, exhale an exquisite odor. The plant is very delicate, and a white frost occurring at the season of blooming may destroy the entire crop. The plants are usually arranged, not isolatedly or in small scattered hedgerows, as in southern France, but in tall parallel thickets exceeding in height the stature of a man and spaced about seven feet apart. In order to reach such a result, four or five leafy branches of an old rose bush are, toward October, laid horizontally side by side in ditches 12 inches in width and depth, and then covered with earth that has been slightly manured. After eighteen months of attentive cultural care, the young shrubs produced by this process of layering come into flower. The crop becomes maximum at the fifth year, and properly pruned plants yield roses for twenty years.

The crop is gathered between May 20 and June 15, according to the year. As soon as it is daylight, the pickers pass through the alleys and pluck the flowers just in the act of blooming and with the buds ready to expand, since if the cutting of them were longer deferred, they would fully expand during the day, and by the next day their perfume would have been dissipated. An acre usually produces 3,300 pounds of roses, corresponding to nearly a pound of essential oil. As is shown in Fig. 1, made from a photograph taken by M. Christoff, of Kazaulik, the stills are arranged side by side under sheds. Each of these apparatus, which is of copper, is 5 feet in height and composed of three pieces, which are adjusted at the moment of using. These are a still in the form of a truncated cone, having a narrow neck and placed upon a primitive furnace of masonry; a flattened top part or cap; and a refrigerating tube that plays the part of a worm. This latter passes obliquely into the upper part of a large wooden tub (Fig. 2), is cooled by a current of water, and comes out of the tub at the bottom on the opposite side. Here it connects with the mouth of a flask in which the products of the distillation finally condense. Each still is charged with 22 pounds of flowers and 19 gallons of water, and then, after the different parts have been adjusted, the furnace is lighted. After the water has begun to boil, the temperature is progressively reduced. The operation lasts from an hour to an hour and a half, and is arrested after 12 quarts of liquid, or about two flaskfuls, have been collected. The flasks full of fresh rose water are afterward placed in a row, the stills are emptied of the exhausted petals and refilled with fresh ones, and the distillation is then begun again, the flowers treated being of the same day's gathering, since, after twenty-four hours, they lose all the delicate aroma that gives them their value.

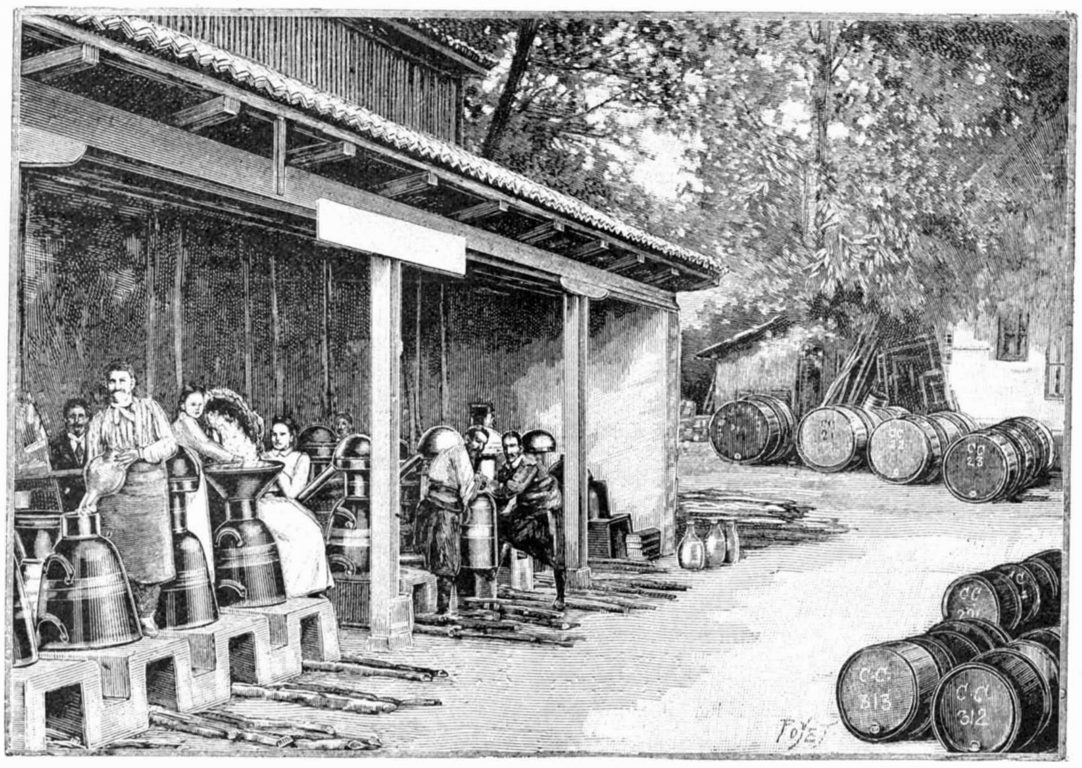


FIG. 1.—THE DISTILLATION OF ROSES IN BULGARIA. CHARGING THE STILLS AT THE CHRISTOFF ESTABLISHMENT.

In order to extract from the rose water the essential oil that it contains, a second distillation is made, certain special precautions being taken, into the details of which we cannot enter. Upon coming from the still, the pure oil of rose is of a pale yellow and consists of two ingredients—stearoptene (a white crystallizable hydrocarbide, having no odor) and an odorous liquid principle formed mainly of geraniol and cirtonellol mixed with some other bodies that have escaped the investigations of chemists. Moreover, dealers do not hesitate to complicate the task of testers by adulterating the valuable product with various essential oils, such as those of geranium, palma rosa, and sandal wood. The production of oil of rose in Bulgaria during the year 1903 was 13,770 pounds as against 8,580 in 1902 and 7,000 in 1901. In order to find so abundant a production as that of 1903, we shall have to go back thirty years. So the price of oil of rose, which in 1872 reached $128 a pound, did not, last October, exceed $60. —Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

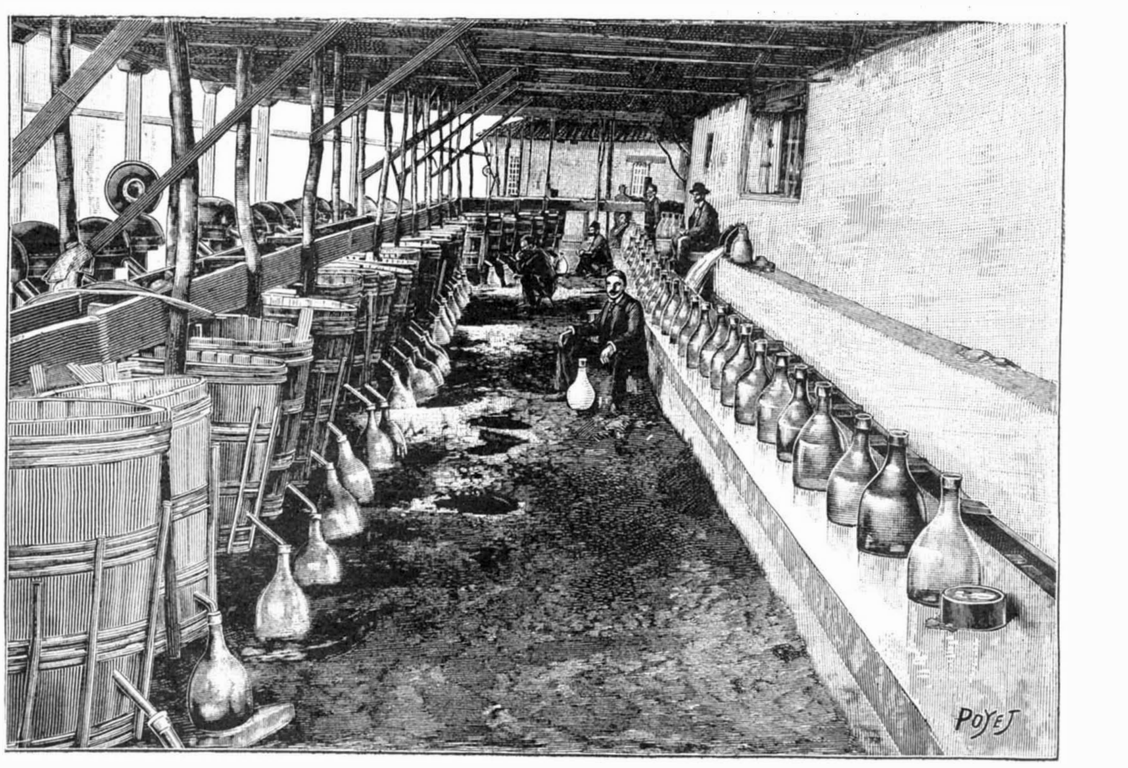


FIG. 2.—VIEW OF THE REFRIGERATING TUBS AND THE FLASKS THAT CATCH THE DISTILLATE.

DIRECT-VISION SPECTROSCOPES.

By T. H. BLAKESLEY, M.A.

THE formation of a spectrum, whether by a prism, a train of prisms, or a grating, involves the angular separation, one from another, of the various rays of different colors comprised in ordinary white light. This angular separation is called dispersion, and may conveniently be measured from any selected ray. Thus we read of spectroscopes of feeble power having a dispersion of 4 deg., and of those of stronger power with a dispersion of 12 deg., and so on. Each of these magnitudes refers to the angular distance between certain of the Fraunhofer lines in the spectrum produced by a particular instrument.

In many instruments, including some of the most powerful, dispersion cannot be produced without deflecting the whole of the rays from their original direction. Such an angular displacement is called deviation, and is quoted for some well-recognized ray. Viewed from this standpoint, dispersion between two rays is merely the difference between their deviations, and the essential difference between "direct-vision" spectroscopes and others is that in the former class the deviation of some central or selected ray has the value zero, whereas in the latter class the entire body of rays suffers angular displacement which is very large in comparison with the dispersion between the individual rays.

Thus in direct-vision spectroscopes the telescope, camera, or other appliance employed to utilize the spectrum may be pointed as if to receive the rays in their initial direction, and need only receive the small angular displacement from this position which is necessitated by the existence of dispersion. With instruments which are not of the "direct-vision" class, the proper position for the telescope or camera must differ widely from that for the direct reception of the original beam, on account of the large angle deviation.

It will thus be readily understood that direct-vision spectroscopes, provided they involve no other drawback, must be better suited than others for many operations; for instance, they can be more readily attached to astronomical telescopes.

But unfortunately they are not, as a rule, so powerful as those possessing deviation. A direct-vision spectroscope generally comprises prisms of two kinds of glass, arranged in a train with the refracting edge of each prism pointing in the direction opposite to that of the prism immediately preceding or following it. The prisms with refracting edges arranged on one side of the train are of one kind of glass, while the remaining prisms are made from another kind of glass. In this way the deviation of some given ray may be reduced to zero, while the dispersion remains finite. As the dispersion is the result of the differential action of the two sets of prisms, it will obviously be small unless many prisms are employed—an arrangement that would involve very great absorption of light.

There is another defect in direct-vision spectroscopes of this kind. They are liable to produce anomalous dispersion, which means that the angular order of the rays in the resulting spectrum may not be the order of increasing or diminishing wave-length. That prisms of certain substances naturally produce this disorder, is well known; but it is possible to produce it artificially by means of prisms of glass of different refractive indices.

To explain this, let us consider either of the arrangements indicated in Fig. 1, where prisms marked *A* are of one, and those marked *B* are of another kind of glass. It is evident that rays, for which both kinds of

glass have the same index, will pass through these symptoms without deviation, in a direction which may be called the axis of the instrument. Of the remaining rays, those for which the index of glass *A* is greater than glass *B* will be deflected toward one side of the axis, and those for which the index of *B* is the greater will be deflected toward the other side of the axis.

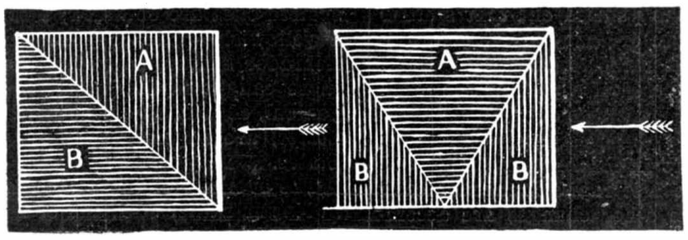


FIG. 1.

Now it is quite possible to obtain glasses with equal indices for rays at two different points of the spectrum. These two different rays will be brought into coincidence with the axis, and the spectrum will be folded back upon itself, producing anomalous dispersion. Even if this extreme condition is not reached, anomalous dispersion might exist in some part of the spectrum, on account of irregularity in the run of the dispersion in different glasses. In the simple cases cited, if μ is the index of a certain ray for one kind of glass, and ν is the index of the same ray for the second kind of glass, the condition $\mu = \nu$ is all that is necessary for that ray to suffer no deviation, and this condition may hold for more than one ray. In other cases the condition may not be so easily seen, but there is always some condition which can be formulated by means of an equation involving the coefficients of re-

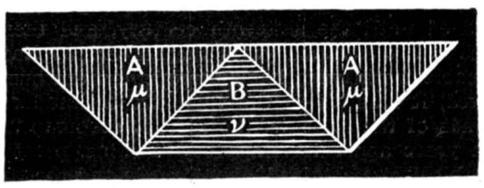


FIG. 2.

fraction of the two glasses and the angles of the prisms, under which the ray will suffer no deviation; and this condition may be satisfied by more than one pair of values for μ and ν.

As an instance, suppose three isosceles prisms having refracting angles α to be arranged as in the sketch, Fig. 2. The condition for no deviation in this case is:

$$\text{Cos } \alpha = \frac{\nu^2 - 2\mu^2 + 1}{2(\mu^2 + \nu)}$$

Now it is quite possible that this equation may be satisfied for more than one ray of the spectrum, and even if this is not the case, the rays of the spectrum may be unduly crowded together and even reversed in order locally. It follows that considerable care must be

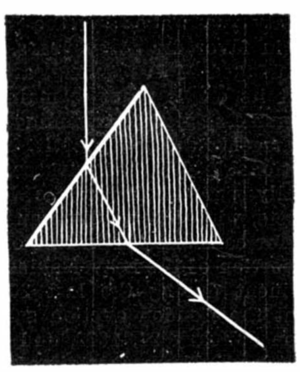


FIG. 4.

exercised in selecting glasses for such instruments as utilize two refracting materials.

In the case last considered suppose that α is made equal to 90 deg.; the equation of condition then becomes

$$\nu^2 + 1 = 2\mu^2$$

and the case may be readily illustrated by putting a cube of glass into the corner of a rectangular tank of water, of which the sides are plates of glass. Here μ refers to the water, ν to the glass cube. If the *D* line is to suffer no deviation, and μ for the *D* line is taken as equal to 1.3336, the solution of the equation of condition is

$$\nu = 1.59907,$$

and we must select a glass which has this value for the index of the *D* line.

Had the *F* line been selected we should have for the indices:

$$\mu = 1.3378 \qquad \nu = 1.60604$$

The difference of the indices of the glass for the two rays, or as it is called by Schott, the partial dispersion between *D* and *F*, would thus be 0.00697, a number not remote from what might be expected to occur in some sorts of glass whereof the index for *D* is 1.59907. There is little doubt that glass approximating to that here indicated would display anomalous or unduly irregular dispersion when employed with water as suggested above.

These are the scientific objections against employing two kinds of refracting materials in the way described, over and above those depending on the feeble dispersion and the high absorption of light. They might be overcome by employing, if it be possible, trains of prisms in which the deviation of one prism is not set against that of another.

A succession of prisms, of which the refracting edges all point across the general path of the rays in the same way, will produce a large dispersion and deviation in proportion to the number of prisms employed. If these are succeeded by a similar train of which the angles point across the rays in the opposite direction, the deviation and dispersion will both be annulled. But if, between these two trains, means can be found to reflect the whole beam so that rays which, before the reflection, were inclined to the right of the mean ray at certain angle, are after reflection inclined to the left of it at the same angle (Fig. 3), and *vice versa*, then the second train of prisms will increase the dispersion of the rays, while at the same time it diminishes the deviation of the beam generally. A simple reflecting plane mirror would have this effect, but would be subject to the defect that for the whole

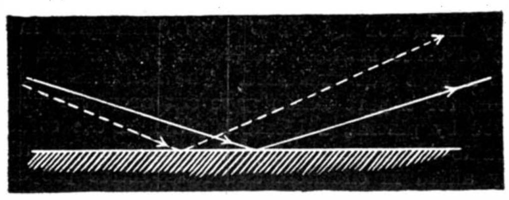


FIG. 3.

beam to be operated upon the mean ray would have to be incident at an angle considerably less than 90 deg. In other words, the mere reflection would create an extra deviation of the mean ray. To make up for this, the second train might be more or less numerous than the first. But it is unnecessary to resort to this plan, because an obtuse-angled isosceles prism may be employed as the reflector, the rays entering it by one of the equal sides being reflected internally by the base, and emerging at the second of the equal sides. If the mean ray is parallel to the base on entering the prism, it will also be parallel to it on leaving; and any other ray will make the same angle as before with the mean ray, but will now be on the opposite side of it. In the instrument about to be described this principle is employed, in conjunction with another which will now be explained.

When a ray of light passes symmetrically through a

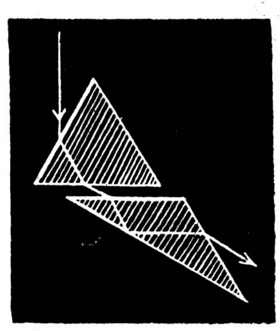


FIG. 5.

glass prism, it receives a deviation *D*, which is connected with the angle of the prism, *A*, and the index of refraction μ of the glass for the ray, by the equation:

$$\text{Sin } \frac{A + D}{2} = \mu \sin \frac{A}{2}$$

If the angle *A* is chosen so that the deviation shall be equal to it (i. e., if $D = A$), then the equation takes the following simple form:

$$\mu = 2 \cos \frac{A}{2}$$

Thus the glass being chosen, and the particular ray, which is to suffer no ultimate deviation, being selected, we are in possession of μ, and the angle of the prism *A* is fixed by this condition.

In this case it follows that the ray of light before incidence must be at right angles to the side from which it is to emerge (Fig. 4), and on emergence the ray is at right angles to the side upon which it was

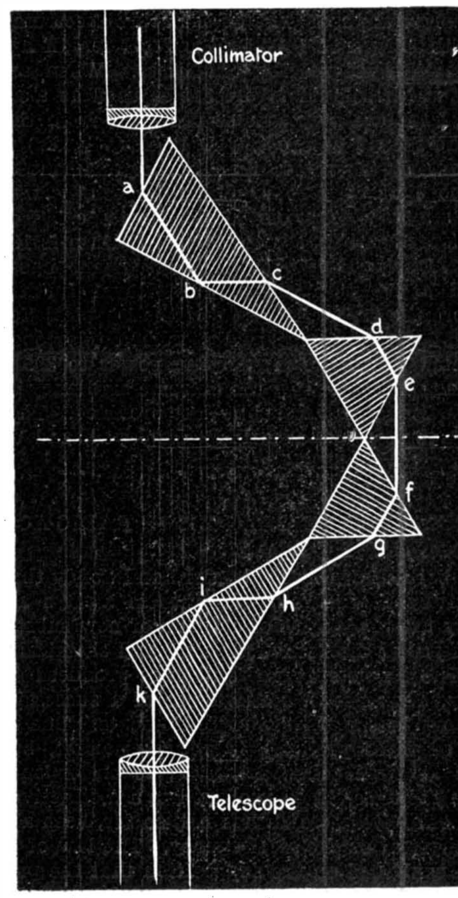


FIG. 6.

first incident. The reversibility of the path of the light, and the fact that the deviation is equal to the angle of the prism, require this to be the case.

On emergence from this prism, the ray is made to encounter one of the equal sides of an obtuse-angled isosceles prism (Fig. 5) for the purpose already described. The base of this prism must be parallel to the ray on emergence from the first prism. Thus, on emergence from this second prism the selected ray will be still parallel to its course between the prisms. We are free to make the base angles of the second prism of what value we please, so long as the light is internally reflected from the base at an angle exceeding the critical angle of the glass; but if we make them equal to $(90 - A)$, then the two prisms can be made to come together and form one right-angled prism (Fig. 5). The cavity between the two prisms, having parallel sides, may now be done away with, and the prisms merged into one. As the necessary reflection now occurs inside the right-angled prism, the next prism can be placed across the emergent beam in such a way as to annul the deviation of the selected ray while increasing the dispersion generally (Fig. 6).

The next two prisms, viz., the third and fourth, are images respectively of the second and first, with regard to an imaginary plane at right angles to the direction of the light from the collimator. Thus, after passing the fourth prism the selected ray is in the same straight line as when it left the collimator, and can be received by the telescope, camera, or other apparatus.

It will be noticed that the angle of incidence or emergence of the selected ray, at each of the surfaces through which it passes, is equal to the angle *A*.

The collimator and the first two prisms are rigidly connected together, and the last two prisms and the telescope (if that be the instrument employed) are also rigidly connected. These two systems are moved relatively one to the other round an axis which is near the two adjacent angles of the second and third prisms. The course of the selected ray between the second and third prisms is parallel to *ef* (Fig. 6), but any other ray in that space will traverse a path making some angle with *ef*. In that case, if the system composed of the two last prisms and the telescope is turned until the ray considered passes symmetrically between the second and third prisms, that ray will finally leave the

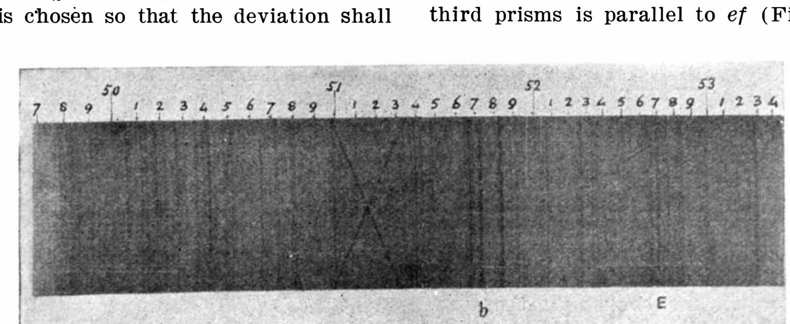


FIG. 7.—SOLAR SPECTRUM, SHOWING FRAUNHOFER LINES BETWEEN 497 $\mu\mu$ AND 534 $\mu\mu$.

fourth prism with an angle of emergence equal to *A*, and be parallel with the axis of the telescope. This symmetrical passage implies minimum deviation through the train of prisms, and thus any ray which is brought into the center of the field of the telescope has undergone minimum deviation through the train of prisms, and possesses the clearness of definition which that fact always implies.

The accompanying illustration (Fig. 7), reproduced from a photograph of part of the solar spectrum, was made with a lens of 14¾ inches focal length applied to a telescope magnifying ten times. When an arc lamp in which sodium is present is used as a source of light, then the spectrum of the light from the arc shows the second of the two *D* lines (viz., D_2) to be itself double. This seems an accomplishment for a spectroscope of only four prisms, especially with so small a magnifying power in the telescope.

The dispersion between the *A* and *G* lines is 18 deg. 20 min. During last year the instrument has been exhibited at Mercers' School, the Royal Institution, and before the Royal Society and the Physical Society of London. It is now provided with a telescope eyepiece which raises the magnifying power to 30. This step seemed warranted by the extreme brilliancy of the field with the lower powers at first provided. The line *A* and its region are admirably displayed, and the *H* lines are quite visible.—Technics.

THE SUCCESSION OF CHANGES IN RADIO-ACTIVE BODIES.*

It has been shown by Rutherford and Soddy that the radio-activity of the radio-elements is always accompanied by the production of a series of new substances possessing some distinctive physical and chemical properties. These new substances are not produced simultaneously, but arise in consequence of a succession of changes originating in the radio-elements. The radio-activity of these products is not permanent, but diminishes in most cases, according to an exponential law, with the time. Each product has a distinctive rate of decay of activity, which has not, so far, been altered by any physical or chemical agency. The law of decay has been explained on the supposition that the product undergoes change according to the same law as a monomolecular change in chemistry. The change occurs in consequence of the expulsion of an α or β particle, or both, and the activity of a product is thus a measure of its rate of change. While the products, like the emanations, and UrX, lose their activity according to an exponential law, the matter emanation X, which gives rise to the phenomena of excited activity, does not lose its activity according to a simple law. The experiments of Miss Brooks and the author, and of Curie and Danne, have shown that the decay of the excited activity of radium is very complicated, and depends upon the time of exposure to the exciting cause, viz., the emanation. The author has shown that the excited activity produced in a body by a short exposure in the presence of the thorium emanation increases at first for a few hours, passes through a maximum value, and then decays with the time according to an exponential law.

In the paper the curves of decay of excited activity of radium and thorium are given for both short and long exposures to the emanations, and it is shown that the law of change of activity with time can be completely explained on the theory that emanation X of thorium and radium is complex, and undergoes a series of successive changes.

The mathematical theory of successive changes is given in detail, and a comparison is made of the theoretical and experimental curves obtained for the variation with time of the excited activity. In the case of thorium, two changes are found to occur in emanation X. The first change is a "rayless" one, i. e., the transformation is not accompanied by the appearance of α, β, or γ rays. The second change gives rise to all three kinds of rays.

The decay of activity of emanation X of radium depends greatly on whether the α or β rays are used as a means of measurements. The curves obtained by the β rays are always identical with those obtained by the γ rays, showing that the γ and β rays always occur together and in the same proportion. The complicated decay curves obtained for the different types of rays, and for different times of exposure, can be completely explained on the supposition that there are three rapid successive changes in the matter deposited by the emanation, viz.:

(1) A rapid change, giving rise only to α rays, in which half the matter is transformed in about three minutes.

(2) A "rayless" change, in which half the matter is transformed in twenty-one minutes.

(3) A change giving rise to α, β, and γ rays together, in which half the matter is transformed in twenty-eight minutes.†

A similar rayless change is shown to occur in the "emanating substance" of Giesel.

The occurrence of a rayless change in the three radio-active bodies is of considerable interest. Since the change is not accompanied by rays, it can only be detected by its effect in the change or changes which follow. The matter of the rayless change is transformed according to the same law as the other changes. The rayless change may be supposed to consist either of rearrangement of the components of the atom or a disintegration of the atom, in which the products of the disintegration are not set in sufficiently rapid motion to ionize the gas or to affect a photographic plate. The significance of the rayless changes is discussed, and the possibility is pointed out that similar rayless changes may occur in ordinary matter; for the changes taking place in the radio-active bodies would probably not have been detected if a part of the atom had not been expelled with great velocity.

The radiations from the different active products have been examined, and it is shown that the β and γ rays appear only in the last rapid change of each of the radio-elements. The other changes are accompanied by the emission of α particles alone.

Evidence is given that the last rapid change in uranium, radium, and thorium, which gives rise to β and γ rays, is far more violent and explosive in character than the preceding changes. There is some evidence for supposing that, in addition to the expelled α and β particles, more than one substance is produced as a result of the disintegration.

After the three rapid changes have taken place in emanation X of radium, there remains another product, which loses its activity extremely slowly. Madame Curie showed that a body which had been exposed for some time in the presence of the radium emanation always manifested a residual activity which did not appreciably diminish in the course of six months. A similar result has been obtained by Giesel. Some experiments are described, in which the matter of slow decay, deposited on the walls of a glass tube containing the emanation, was dissolved in acid. The active matter was found to emit both α and β rays, and the latter were present in unusually large proportion. The activity measured by the β rays diminished in the course of three months, while the activity measured by the α rays was unaltered. The active matter was complex, for a part which gave out only α rays was removed by placing a bismuth plate in the solution. The radio-active matter deposited on the bismuth is closely allied in chemical and radio-active properties to the active constituent contained in the radio-tellurium of Marckwald. The evidence, as a whole, is strongly in support of the view that the active substance present in radio-tellurium is a disintegration product of the radium atom. Since the radium emanation is known to exist in the atmosphere, the active matter of slow dissipation produced from the emanation must be deposited on the surface of all bodies exposed to the open air. The radio-activity observed in ordinary materials is thus probably, in part, due to a thin surface film of radio-active matter deposited from the atmosphere.

A review is given of methods of calculation of the magnitude of the changes occurring in the radio-elements. It is shown that the amount of energy liberated in each radio-active change, which is accompanied by the emission of α particles, is about 100,000 times as great as the energy liberated by the union of hydrogen and oxygen to form an equal weight of water. This energy is, for the most part, carried off in the form of kinetic energy by the α particles.

A description is given of some experiments to see if the α rays carried a positive charge of electricity, with the view of determining experimentally the number of α particles projected from one gramme of radium per second. Not the slightest evidence was obtained that the α rays carried a charge at all, although it should readily have been detected. Since there is no doubt that the α rays are deflected in magnetic and electric fields as if they carried a positive charge, it seems probable that the particles must in some way gain a positive charge after their expulsion from the atom.

Since, on the disintegration theory, the average life of a given quantity of radium cannot be more than a few thousand years, it is necessary to suppose that radium is being continuously produced in the earth. The simplest hypothesis to make is that radium is a disintegration product of the slowly changing elements uranium, thorium, or actinium present in pitchblende. It was arranged that Mr. Soddy should examine whether radium is produced from uranium, but the results so far obtained have been negative.

I have taken solutions of thorium nitrate and the "emanating substance" of Giesel (probably identical with the actinium of Debierne) freed from radium by chemical treatment, and placed them in closed vessels. The amount of radium present is experimentally determined by drawing off the emanation at regular intervals into an electroscope. A sufficient interval of time has not yet elapsed to settle with certainty whether radium is being produced or not, but the indications so far obtained are of a promising character.—Nature.

* Bakerian lecture delivered at the Royal Society on May 19 by Prof. E. Rutherford, F.R.S.

† A statement of the nature of the three changes occuring in emanation X of radium was first given in a paper by Rutherford and Barne (Phil. Mag., February). A brief account of the theory from which the results were deduced has been given in my book "Radio-activity" (Cambridge University Press). Later, Curie and Danne (Comptes Rendus, March 14) arrived, in a similar way, at the same conclusions.

BEAVER FURS.*

By Charles H. Stevenson.

During the seventeenth and eighteenth centuries the beaver furnished the principal item in the fur trade of the world, but at present it is of somewhat minor commercial importance among the aquatic fur-bearing animals. The skins received by the wholesale dealers from various localities show different characteristics of pelage. In winter, the color on the back and sides is generally dark bay or brownish black, tipped with chestnut or russet, and seal-brown on the under parts, legs, and feet. The prevailing color ranges toward the south to a yellowish tinge upon brown, and in the north approaching a glossy blackish brown. In general, the beavers obtained in cold latitudes are darker than those secured in warmer climates, but those from the northwestern part of the United States are very light in color. A few black beavers and still fewer spotted ones are obtained; also, at very rare intervals, a yellowish white or pure white one is taken. The Labrador beaver, now somewhat scarce, is superior to those caught farther west, while those of Canada in general, as well as of the northern parts of the United States, are superior to those taken in the Southern States.

The overhair of the beaver is from 1¾ to 2½ inches in length, rather stiff, and of a dull color for two-thirds of its length from the base, and is terminated by shining points ranging in color from the most delicate brown to rich, glossy blackish-brown, giving the general color to the pelage. The underhair or fur is very thick, fine, and soft, from one-half to three-fourths of an inch long, and of a uniform bluish or brownish-gray color from the roots to the tips. It is denser and shorter on the underparts than on the back. The fur becomes prime in October in the latitude of the northern boundary of the United States, and continues in good condition until May, when it begins to deteriorate. The pelts are marketable, however, till about June 15, although they are somewhat thin, light in weight, and of less value.

THE MARKETS FOR BEAVER SKINS.

The economic use of beaver pelts antedates the discovery of America. As far back as the Middle Ages, at least, beaver skins were used as clothing by primitive people in Europe. Their principal use, however, was as furnishing material for fashionable hats for men. Beaver hats were worn as early as the twelfth century, but their popularity was not permanently established until the sixteenth century, and then for more than two hundred years the beaver supplied the fashionable world with hat material. As the business increased, it resulted in the slaughter of hundreds of thousands of the animals, the market consumption in certain years approximating 400,000 skins, practically all of which were obtained from Canada and the United States. So extensive and regular was the beaver trade that in the eighteenth and the early part of the nineteenth century the skins were accepted as currency throughout the western part of Canada and the United States, and were the standard for bartering with Indians.

It was not long before the market demands outran the resources of nature and the beaver was in danger of extermination. The price of the skins increased correspondingly, selling at times for $8 or $10 per pound, and the finished hat for $20 or more. At length the supply of the fur became so inadequate that other materials were necessarily substituted, resulting about 1839 in the general adoption of the silk hat by the fashionable world.

The demand from manufacturers of hats diminishing, the price of beaver pelts fell so low that the hunt proved unprofitable. Later a demand developed for the skins in the dressed-fur trade, and the price became steady at about $2 or $3 each. This fur became fashionable about twenty years ago, and the indications are that it will be in favor for many years. Small quantities, partly damaged in the curing, are yet used by the hatters, but its employment is mainly as dressed fur for caps, mufflers, gloves, trimmings, etc. Sometimes entire garments are made of it, but its weight makes it objectionable for that purpose. The darker pelts are usually purchased for the European and Canadian markets, while the medium and paler shades are worked up for consumption in this country.

The greater portion of the beaver skins taken on the American continent during the last 200 years have been handled at the London auction sales. The first sale occurred on January 24, 1672, and was an event of much importance. From that time to the present the total number of skins handled in London approximates 30,000,000, with a total valuation of $100,000,000. The average annual sales at present approximate 50,000 in number.

In addition to those handled in London, about 20,000 beaver skins are now marketed each year, being sold at Leipsic and at private sale in the United States and Canada. This makes a total of about 70,000 skins marketed annually in recent years, of which about 10,000 are obtained in the United States and 60,000 in the Dominion of Canada.

In the markets, beaver skins are classed not only according to the general localities whence they are obtained, but also according to their size and the quality of the fur. In assorting them four grades are recognized. Those of the first grade have a flesh-colored pelt, which appears fresh and sound, and with long heavy fur, which separates down to the membrane when blown into, and appears uniformly even, fine, and silky. The seconds are almost clear in the pelt, and the fur only slightly scant or poor. In the thirds the fur is thin, scant and poor, and the pelt dark. Fourths are of the poorest quality, with pelt almost black or bluish-green color, and the fur short and thin. Each of these grades is divided according to size, the large, medium, small, and kitts. The prices range from $1.25 for the poorest to $10, $12, and even $16 for those of choicest grade, averaging somewhat less than $6 per skin.

Fifteen years ago large quantities of beaver fur were used in this country, and as much as 65 per cent of

* From U. S. Fish Commission Report for 1902.

that sold in London was purchased for the United States trade. At that time long garments were fashionable, and plucked and dyed beaver was much in demand for trimmings. During recent years, however, beaver fur has been largely out of fashion in the United States and Canada, and consequently the consumption in these countries has not been extensive.

DRESSING AND FINISHING BEAVER SKINS.

On arrival in the markets beaver skins are rough and greasy, with the fine rich fur almost concealed by the coarse brownish hair. In the process of dressing, the skins are first soaked in water over night. The following day each one is placed, flesh side up, on a flat hardwood beam, and with a breaking knife a workman breaks up the grain of the pelt, thus softening it. The pelts are washed with warm water and soap, and then prepared for plucking. The water is removed by passing them through either an ordinary roller wringer or a centrifugal wringer, or, in some houses, by pressing them with the breaking knife. The hair side is dried and warmed by artificial heat, care being taken to keep the pelt side damp; chalk is sprinkled over the surface, and the hair removed. A small percentage of beaver skins, probably not more than 1 per cent, are left "in the hair"—that is, the overhair is not removed. Only a small demand exists for natural beaver, however, owing to its rough and coarse appearance.

Formerly it was customary to shear beaver skins, instead of plucking them, and many are yet prepared in that manner on the continent of Europe. In this case it is necessary to moisten the pelt preparatory to plucking; but, placing the skin, flesh side down, on a beam and using a comb and shears, a workman clips off the greater part of the long hairs in much the same way as a barber operates. Beaver thus prepared bears some resemblance to sea-otter fur, especially when very dark pelts are used, and sheared beaver is often used in imitation of that costly fur. The imitation is greatly enhanced when the overhairs are whitened by means of an acid.

After plucking, the pelt is shaved for the purpose of reducing its bulk preparatory to leathering. The pelt side is then dampened with cold salt water and allowed to so remain over night. The following morning it is stretched lengthways and crossways and partly dried. Butter or other animal grease is rubbed on the pelt side, and a number of skins placed in a fulling or tramping machine in which two hammers push or beat and turn them for eight or ten hours. The skins are then placed with a quantity of hardwood veneer sawdust in a large drum, over either a gentle charcoal fire or steam heat, and revolved for three or four hours. Next they are placed with sawdust in tubs, where they are tramped by barefooted workmen for about three hours, each tub containing about twenty skins.

On removal from the tramping tubs the pelts are thoroughly stretched by hand, and the leather side dampened over night preparatory to shaving on the following day. Shaving is the most difficult feature, and is intrusted only to skilled workmen. Each skin is placed, fur down, on a perfectly smooth hardwood beam, similar to that used in skiving, and by means of a skiving knife the operator shaves off the membrane of the pelt until the roots of the fur are almost made visible.

The skins are again stretched lengthways and crossways by hand, dried, and for the second time placed in the tramping tubs with hardwood sawdust for further softening and leathering. After two or three hours' tramping they are removed, straightened or stretched out, and returned for two or three hours further tramping. They are next thoroughly beaten with bamboo sticks to remove the sawdust, and then combed with a fine steel comb to lighten up the fur. The skins are then placed on a beam and by means of a large flat-bladed knife, sharp as a razor, a workman shaves over the top surface of the fur, removing all scattering hairs and impurities, thus completing the dressing process.

While it is not customary to dye beaver fur, many light skins are blended to a darker shade, and a few are dyed in much the same manner as fur seal. Some few skins are bleached golden brown, and a smaller number to a creamy white. Some are silvered by passing lightly over them a solution of sulphuric acid, and some are made a golden yellow by means of peroxide of hydrogen.

About twenty years ago many beaver skins were "pointed," the plain solid color being ornamented by inserting white hairs at irregular intervals, in imitation of the pelage of the sea otter or the silver fox. The hairs were generally sewed in the pelt by wig makers, but in some cases they were firmly fastened with cement. Badger hairs were most frequently employed, but white hairs of the gray fox, cony, and skunk were also used. On account of its varied white tips, the hair of the Egyptian ichneumon was also in great demand, being superior to the hair of the fox, or even the badger. Some skins were likewise ornamented with the white tips of small feathers taken from the breast of the grebe and less frequently the peacock. This ornamentation was quite fashionable from 1881 to 1884.

Beaver fur is especially serviceable for making hats because of its remarkable felting characteristics and its durability and glossiness. So strong are its felting properties that coats made from cloth of this material, manufactured solely by the felting process, have been known to wear for years, and it is claimed that in former times beaver fur was sometimes felted for hosiery purposes. While it is the most desirable of all furs for hat making, its high cost prevents its general use for that purpose. Practically the only beaver fur now received by the hatters is the blown fur obtained from the manufacturers' clippings and that cut from skins damaged in curing or otherwise. But even in using fur from these sources, a light hat made from beaver cannot be purchased for less than about $10, and the price is likely to be $15 or more.

TRADE NOTES AND RECIPES.

Note on Bronze Casting.—The composition of bronze must be effected immediately before the casting, for bronze cannot be kept in store ready prepared. In forming the alloy, the refractory compound, copper, is first melted separately, the other metals, tin, zinc, etc., previously heated, being then added; the whole is then stirred, and the casting carried out without loss of time. The process of forming the alloy must be effected quickly, so that there may be no loss of zinc, tin, or lead through oxidation, and also no interruption to the flow of metal, as metal added after an interval of time will not combine perfectly with the metal ready poured in. It is important therefore to ascertain the specific weights of the metals, for the heavier metal will naturally tend to sink to the bottom, and the lighter to collect at the top. Only in this way, and by vigorous stirring, can the complete blending of the two metals be secured. In adding the zinc, great care must be taken that the latter sinks at once to the level of the copper, otherwise a considerable portion will be volatilized before reaching the copper. When the castings are made, they must be cooled as quickly as possible, for the components of bronze have a tendency to form separate alloys of various composition, thus producing the so-called tin spots. This is much more likely to occur with a slow than with a sudden cooling of the mass.—Metallarbeiter.

Manufacture of Hollow Silver Articles by Means of Galvanization.—Rauscher's process for making hollow figures consists in covering models of the figures, made of a base or easily soluble metal, with a thin and uniform coating of a nobler metal, by means of the electric current in such a way that this coating takes approximately the shape of the model, the latter being then removed by dissolving it with acid. The model is cast from zinc in one or more pieces, a well-chased brass mold being used for this purpose, and the separate parts are then soldered together with an easily fusible solder. The figure is then covered with a galvanized coating of silver, copper, or other metal. Before receiving the coating of silver, the figure is first covered with a thin deposit of copper, the silver being added afterward in the required thickness. But in order that the deposit of silver may be of the same thickness throughout (this is essential if the figure is to keep the right shape), silver anodes, so constructed and arranged as to correspond as closely as possible to the outlines of the figure, should be suspended in the solution of silver and cyanide of potassium on both sides of the figure and at equal distances from it. As soon as the deposit is sufficiently thick, the figure is removed from the bath, washed, and put into a bath of dilute sulphuric or hydrochloric acid, where it is allowed to remain till the zinc core is dissolved. The decomposition of the zinc can be accelerated by adding a pin of copper. The figure now only requires boiling in soda and potassic tartrate to acquire a white color. If the figure is to be made of copper, the zinc model must be covered first with a thin layer of silver, then with the copper coating, and then once more with a thin layer of silver, so that while the zinc is being dissolved, the copper may be protected on either side by the silver. Similar precautions must be taken with other metals, regard being paid to their peculiar properties. Another method is to cast the figures, entire or in separate parts, out of some easily fusible alloy in chased metal molds. The separate portions are soldered with the same solder, and the figure is then provided with a coating of copper, silver, etc., by means of the galvanic current. It is then placed in boiling water or steam, and the inner alloys melted by the introduction of the water or steam through holes bored for this purpose.—Technische Rundschau.

Tempering Copper or Copper Alloys.—The process of tempering copper or its alloys described in the Zeitschrift für Werkzengmaschinen und Werkzeuge (Journal for Machine Tools and Tools) consists in heating the metals in question for a time at the requisite temperature, sprinkling them while in a heated condition with sulphur, and then plunging them hot into a bath of blue vitriol. It is advisable to reheat the metal before it has become quite cool. Numerous experiments have shown that the new tempering process is specially suitable for alloys of copper, and that remarkably good results can be obtained by treating an alloy of copper and tin by the process just described. Any of the various alloys of copper can, however, be used, the choice depending of course upon the nature of the article for which it is intended. The copper or alloy is usually put into the required shape (e. g., a wheel or tool) before tempering. The castings are then heated for a suitable time, say three minutes, over a fire, preferably a charcoal fire, at the proper temperature. The best results are obtained when the temperature is raised to the melting point of tin. The articles are placed on the fire and, together with the neighboring blocks of charcoal, sprinkled with powdered sulphur, till they are entirely covered by it, the sulphur-vapor thus being brought into contact with the castings. It is best to add the sulphur when the articles are thoroughly heated. After being covered with the sulphur the castings remain in the fire for a time; they are then plunged hot into a solution of blue vitriol, and allowed to remain in it for a short period. When the castings are taken from the vitriol, it is well to reheat them, and allow them to cool without the intervention of a cooling mixture. The new method of treating copper and its various alloys produces a remarkable hardness without impairing the ductility of the metal, thus rendering it specially useful for purposes for which a high degree of hardness and, at the same time malleability, ductility, and toughness are required.

ENGINEERING NOTES.

The results of some trials made by the French Automobile Club to ascertain the distances at which motor cars can be stopped when running at various speeds are likely to upset the popular impressions formed by many motorists that a car can be brought to a standstill in its own length from a speed of 30 miles an hour. The trials in question were conducted in the Bois de Boulogne, and while they show that motor cars can stop quicker than horses, yet they required a distance of 10 feet in which to come to rest when traveling at a speed of 7½ miles an hour. At a speed of 10 miles an hour they stopped in 13½ feet, and at 12½ miles, in 16¾ feet. At 16 miles an hour, 33 1-3 feet were required to stop in, and 60 feet at a speed of 25 miles an hour.

It is gratifying to learn that science has at length discovered the real cause of "caisson disease"—the terrible scourge which is the dread of engineers where submarine or tunneling operations have to be carried on under a pressure greatly exceeding that of the normal atmosphere. It has long been recognized that work done under such conditions is attended with much danger to those employed, and produced very distinct physiological effects, though these varied considerably with different individuals; while experience has taught that risk could be greatly mitigated by making the process of translation from one pressure to another—whether an increase or decrease—a gradual one combined with a free ventilation of the working chambers in which the men are engaged. Various hypothesis had been advanced by medical men to account for the different symptoms displayed by victims of the disease, and which in some cases would produce intense pains in the joints, in others some form of paralysis, and in others again, deafness, vertigo, loss of consciousness, etc.; but it has remained for Profs. Hill and Macleod to lay bare the whole pathology of the symptoms displayed, and by completely solving the problem of causation give engineers not only confidence in controlling and largely mitigating the evil results of working under pressure, but of extending the range of operations which have hitherto been regarded as possible for human endurance in diving and caisson work. The result of the careful and prolonged investigations which have been conducted by the two eminent scientists named were given in a recent communication to the Times, and though they do not in some ways teach anything new as regards the principle of the preventive measures needed to diminish the risks of injury, they demonstrate the scientific connection between cause and effect so clearly as to greatly accentuate the importance to be attached to them and thus to insure their more rigid observance. The investigations in question have shown that the various symptoms displayed by victims of caisson disease are produced by the effervescence of the blood in the small blood vessels consequent on the escape of the excess of air which exposure to pressure has forced into solution, and which subsequently effervesces like the gas in a freshly-opened bottle of sparkling wine. This escape of air from the blood vessels obstructs the circulation in the parts nearest them, and the nature of the bad symptoms displayed depends on the position of the blood vessels in which most air happens to be absorbed at the time, and in which effervescence is most readily effected. The gravity of the result depends on the intensity of the pressure, the length of exposure, and the rapidity with which the process of effervescence of the absorbed air is effected. A careful series of experiments on animals has shown that the occurrence of all these symptoms may be entirely prevented up to pressures of considerable amount, by the simple precaution of a very slow readjustment of pressure, under which the air in solution escapes from the blood gently and gradually, and no tendency to frothing occurs. The sole condition of safety appears to be the provision of a proper chamber in which this gradual escape of air from the blood may be carried out. This involves some degree of compulsion and curbing of the natural impatience which induces a workman, as soon as he has finished his shift, to escape as quickly as possible from his toil. Profs. Hill and Macleod are convinced as a result of their experiments that by the simple yet stringent insistence of the precautions suggested, caisson work may be carried on at pressures practically double those which are now considered the limit of human endurance, and which is roughly equivalent to about 70 feet or 100 feet head of water, or from 30 pounds to 45 pounds per square inch. Although divers do now occasionally descend as much as 120 feet beneath the surface, it is only exceptional constitutions that can stand such treatment, and even to such individuals the strain is severe. An extension of the practical range of pressure to a depth equal to 200 feet of water opens up possibilities in connection with pearl fishing, wreck salvage, and sinking operations as to make the discovery of the real nature of

caisson disease of considerable practical value, and incidentally illustrates how closely scientific inquiry and commercial utility are co-related.—Mechanical Engineer.

SCIENCE NOTES.

Prof. G. H. Darwin suggests in Nature that previous estimates of the sun's age will have to be modified, as the result of the discovery of a new source of energy in the disintegration of the atoms of radio-active substances. Lord Kelvin's well-known estimate of 100 million years was arrived at on the assumption that the energy emitted by the sun was derived from gravitation by the concentration of its mass. Prof. Darwin estimates that the energy derivable from this source is 2.7×10^7 M. calories. If the sun were made of a radio-active material of the same strength as radium, it would be capable of emitting 10^9 M. calories without reference to gravitation. This energy is nearly 40 times as much as the gravitational energy. He sees no reason for doubting the possibility of augmenting the estimate of solar heat as derived from the theory of gravitation by some such factor as 10 or 20. The geologist's estimate of the age of the earth has always been so much greater than that of the physicist, that they have generally been looked upon as irreconcilable. The multiplication of the physical estimate by 20 would bring it into very close agreement with the geological estimate. The presence of helium in the sun points to the existence of radium in its mass, so that there is much to be said in favor of Prof. Darwin's hypothesis.

It seems incredible that the cross surmounting the Pantheon in Paris could weigh six English tons, says a British contemporary. The Minister of Fine Arts stated in the Chamber that it weighed 6,000 kilos, which, reduced to English quantities, would be nearly six tons. Probably the minister includes in the weight a part of the lantern. What was said about the cost of a scaffolding to allow workmen to remove the cross being 22,000 francs is less questionable. It is strange that opposition to the cross should be so persistent when it is known to all that without the symbol the history of the temple would not be suggested. When Louis XV. laid the foundation stone in 1764 the building was intended to be a church in place of another dedicated to Saint Genevieve. In the early days of the Revolution it was declared to be a Pantheon which was to perpetuate the memory of illustrious men. Hence the inscription, "Aux Grands Hommes la Patrie Reconnaissante." In 1822 the building reverted to its original use and another inscription was engraved. From 1830 to 1851 it was treated as a secular building, and afterward as a church. When the decoration of the walls was undertaken the ecclesiastical history of France was to be illustrated, and the majority of the works have that object. Those desirous of the removal of the symbol should be consistent. A great many buildings in Paris are permitted to recall the Louis, Henris, and Napoleons, and fleurs-de-lis, bees, etc., are tolerated. No work of the demolisher can prevent citizens from knowing that Paris has had a tumultous history, and it seems no more than childishness to desire the substitution of a Gallic cock on the summit of an edifice which was so long recognized popularly and officially as a church.

Observations of the Alpine glaciers during a series of years have supplied proof that these great ice streams have long been in process of recession. Similar evidence with regard to the Greenland glaciers has not been collected over a wide area, though Dr. M. C. Engell, of Copenhagen, who visited the Jakobshavn glacier last summer, has made a collection of facts which seems to show conclusively that the glaciers of Greenland are also receding. Dr. Engell selected the Jakobshavn glacier for his studies because it is the only glacier of Greenland which has been observed by white visitors for a long period of time. At least nine visitors, several of them men of science, have examined these glaciers within the past fifty-three years. They did not all record the location of its front so clearly that Dr. Engell, in making his map, can be certain that he has correctly assigned the position of its face at the time each man saw it, but there seems to be little doubt that his map of the retreat of the Jakobshavn glacier just published in Petermann's Mitteilungen is approximately correct. Among the visitors to the glacier whose observations are shown on Dr. Engell's map were Rink, Nordenskjold, and other well-known Arctic students. The map shows approximately the position of the front of the great glacier in 1850, 1875, 1879; March, 1880; August, 1880; February, 1893; August, 1893, and 1902. The information given on the map indicates that in the past fifty-three years the face of the glacier has retreated about eight miles. Not only is it shorter than it formerly was, but its mass has otherwise been reduced to a very considerable extent. The surface of the glacier now lies from 20 to 30 feet below its former level and the precipitous walls of rock that hem it in bear the record of this change of level. It is found also that the other glaciers in that neighborhood are in process of retreat, and the evidence collected by Dr. Engell shows that this process has been going on for a long series of years. This evidence would seem to show that for the past half century the summer heat has been greater than it was for at least a considerable period before that time, with the result that on the whole the ice of south Greenland has been melting a little more rapidly than it has formed.

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