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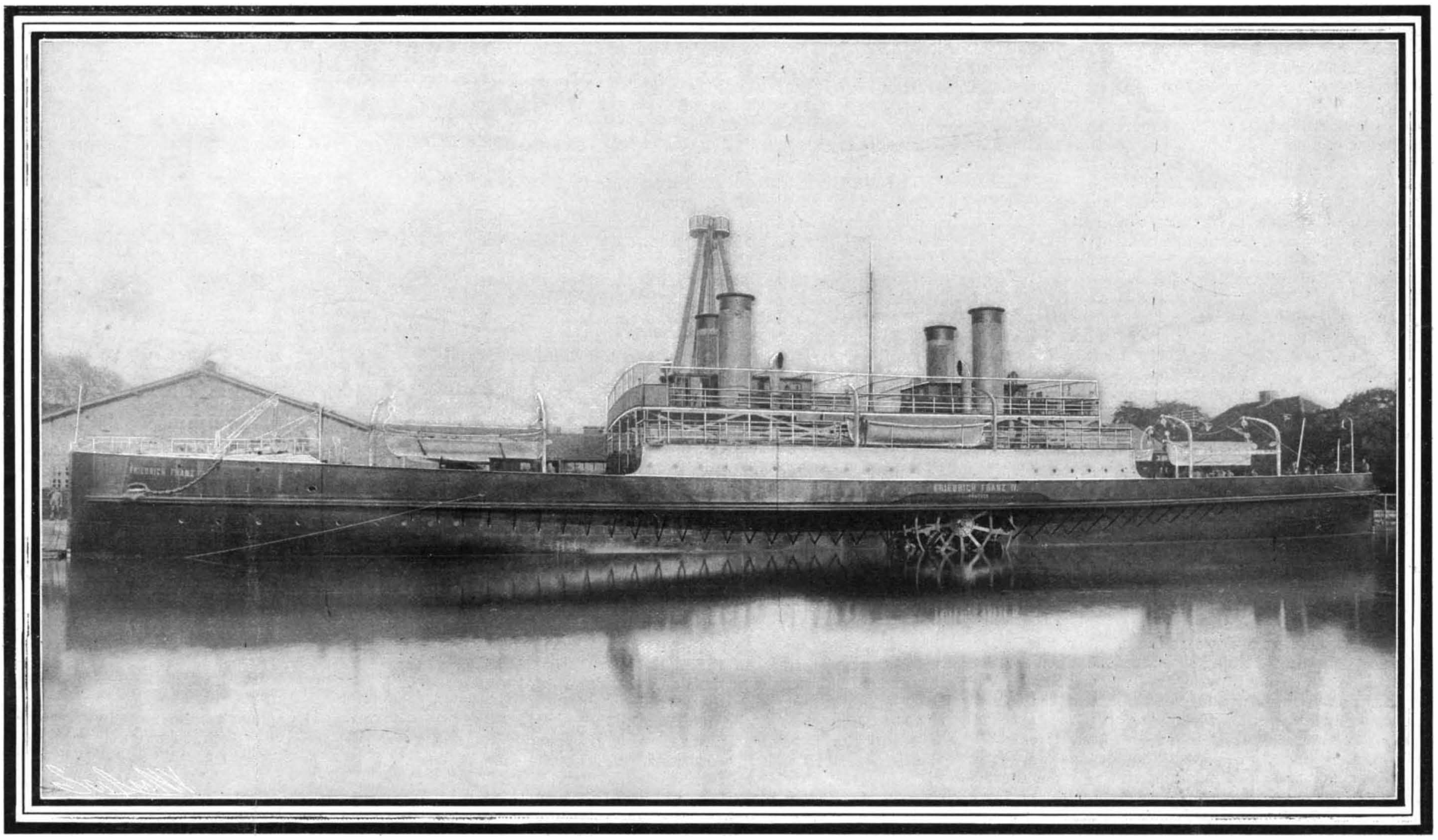
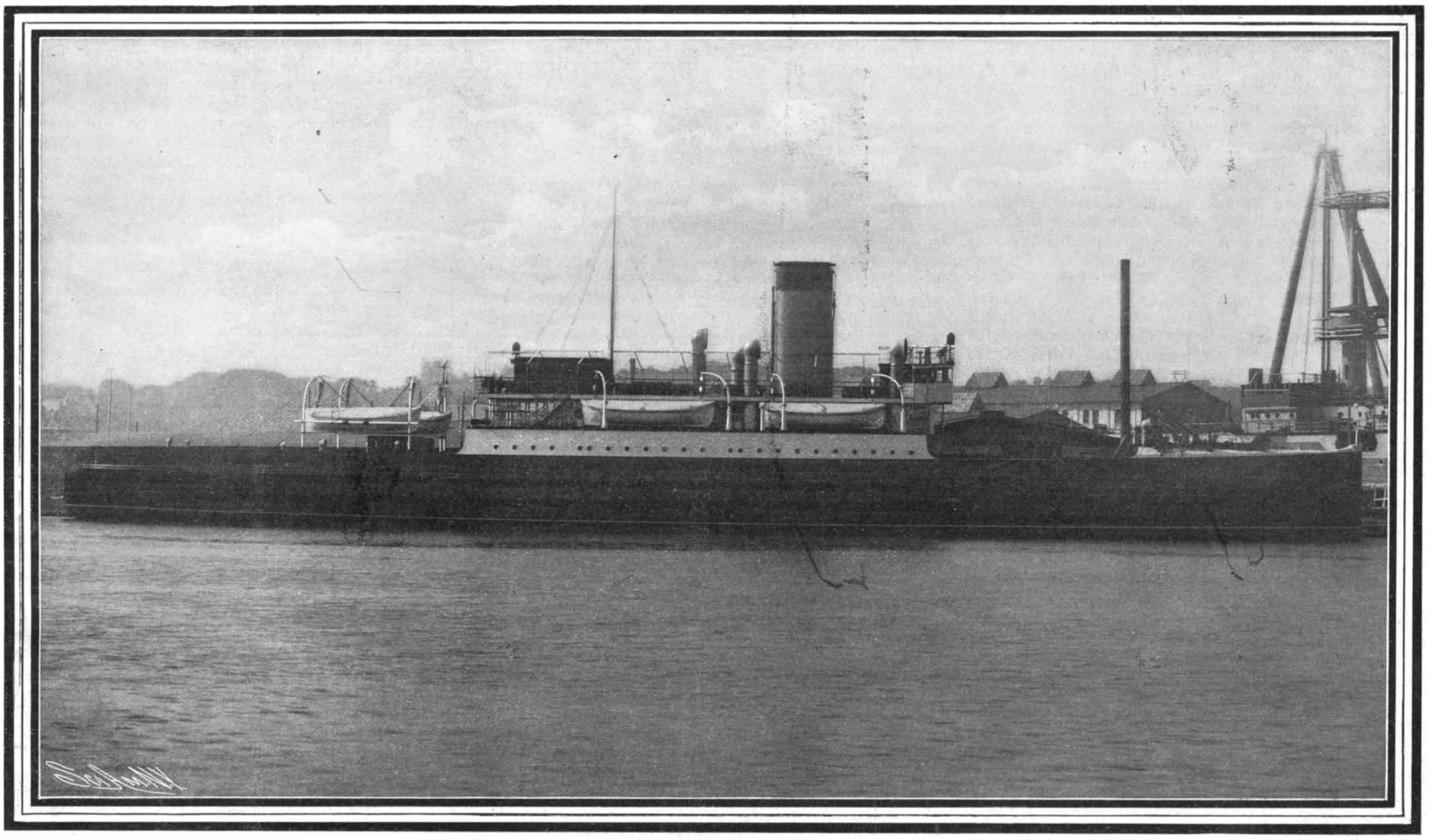


THE RAILWAY FERRY STEAMER "FRIEDRICH FRANZ IV."



THE RAILWAY FERRY STEAMER "MECKLENBURG."

STEAM RAILROAD FERRY BETWEEN GJEDSER AND WARNEMUENDE.*

MANY will remember the time when the traveler desiring to go to Copenhagen from Berlin had to take the railway route *via* Friedericia through Holstein, and the steamer from Kiel to Korsör, unless he felt courageous enough to intrust himself to the small steamer leaving Stettin. Many will also recall the pleasure with which the news was received that a company was building a railway line from New Strelitz to Rostock and Warnemuende, which would materially shorten the trip to Denmark. The road was completed and was eminently successful. Traffic to Denmark assumed undreamt-of proportions, and the Mecklenburg government promptly absorbed the young enterprise, thus acquiring a fresh source of income. The absorption of the railway by the state secured various advantages for it, thus increasing its usefulness. Nevertheless, it was a serious and keenly-felt drawback, especially with the quickest night trains, that the passengers were compelled to leave their warm beds at Warnemuende and Gjedser, and to brave wind and weather during a two-hour sea trip. Aside from the inconvenience, this sudden change was liable to cause serious colds. Both the Mecklenburg and the Danish governments have long endeavored to remedy this evil, but technical difficulties were in the way. A short time ago, however, the firm of Schichau, shipbuilders at Elbing, succeeded, on the order of both governments, in producing two giant steam ferries, upon which the passenger trains and freight trains can be run without trouble, and which discharge them upon the foreign track upon reaching their place of destination. The passengers no longer have to leave the car, but may safely tuck themselves away in the sleeper at Berlin and wake up again in Copenhagen, or *vice versa.*

There are now two large ferry boats running between the places mentioned, both belonging to the Mecklenburg government, and named the "Mecklenburg," and the "Friedrich Franz IV." The chief measurements of the former are: Length between perpendiculars, 282 feet; width over frames, 45.93 feet; width over base, 58 feet; lateral height amidships, 22.96 feet. The mean draft of the completely equipped and laden vessel is 13.51 feet. The twin-screw boat is built of best Siemens-Martin steel, according to the highest class of the Germanic Lloyd for large coast service, with ice reinforcement. For the greater safety of passengers, seven watertight and specially reinforced transverse bulkheads, reaching to the upper deck, have been provided.

On the upper deck are two railway tracks, which are united, fore and aft, into a switch, and destined for the reception of the railroad cars to be transported. Between the two tracks are disposed, amidships, the machine and boiler shafts, while laterally, at starboard and port, two deck houses extend over about one-half the length of the vessel, containing on the starboard side the smoking saloon for the first and the second class, the kitchen, office, and staterooms for the customhouse officers, and on the port side the staterooms for the captain and officers, as well as the mail and parcel rooms. On the upper deck strong iron ring-bolts are fixed for securing the wagons, and at the end of the track collapsible buffers. At the bow the upper or main deck is closed by the forecastle, which is fitted with a mechanically-opening gateway to allow the railroad cars to pass through. In the lateral houses below the forecastle are the anchor, windlasses, and the gangways leading to the crew's apartments.

Over the upper deck runs, to the length of the middle side houses, a boat deck, and above that the promenade deck, upon which is situated the elegantly appointed saloon for princes, which is, however, used as saloon for ladies and non-smokers traveling first and second class. At the forward extremity of the promenade deck are the chart house and the navigation house, as well as the commander's bridge, over which runs another bridge to the height of the chart house. On each side of the boat deck are two lifeboats; two more lifeboats can be found, suspended in high davits, on the after upper deck. From the latter the way leads through elegant deck houses to the dining saloon, the ladies' parlor, and the passengers' staterooms of the first class and second class, which are handsomely furnished and decorated. There are sleeping facilities for thirty-six passengers traveling first and second class, while the spacious dining saloon accommodates fifty-five persons. Below the forward upper deck is a saloon for passengers traveling third class, a ladies' saloon of the same class, and the rooms for the crew.

The vessel has two engines with triple expansion, possessing a total capacity of 2,400 horse power, which give the boat a speed of 13½ knots. The necessary steam is furnished by two double-end boilers.

In the way of machinery the vessel carries two steam "gang spills" (anchor windlasses), one steam steering gear, one forecastle lifting engine, two steam towing capstans, also machines for the electric lighting and for the two searchlights. The electric inside and outside lighting of the vessel is perfect; two searchlights serve to illuminate the course at night or in a fog, so that even with unfavorable weather conditions the vessel can satisfy modern demands upon means of conveyance. Owing to the limited size or unfavorable condition of the Gjedser harbor, the vessel is compelled to leave the harbor astern, as she cannot turn inside the same. For this reason she has been provided, outside of the one at the stern, with a helm at the bow, so that the vessel can be steered when going astern just as safely as when going ahead. In order to be able to maintain this ferry service in winter, the "Mecklenburg" has been constructed as an ice-breaker. The hull has a breakhead, such as is usually only carried by ice-breakers, and other important reinforcements.

The "Friedrich Franz IV.," built by the same firm, differs but little from her sister ship. The measurements are: Length, 280 feet; width, 61.51 feet; mean depth, 12.13 feet. She has ten watertight bulkheads. The strengthening of these bulkheads conforms to the requirements of the Marine Board. There are six lifeboats. Her engine has a capacity of 3,000 horse power, which makes her speed about 15 knots. She has four boilers.

The Danish government has ordered two similar vessels from the same firm.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

EARLY ATTEMPTS AT SUBMARINE NAVIGATION.

IN a recent interesting American work on the subject of "submarine navigation," Alan H. Burgoyne gives some particulars of the early attempts by inventors in this field of engineering, which, in view of the increasing importance which it has recently assumed in consequence of our progress in scientific knowledge, are worth noting, and from which the following notes are abstracted:

Diving bells, as the author remarks, have long been known. They were used with some degree of success (according to Aristotle) by Alexander the Great, at the siege of Tyre, B. C. 332. The credit of building the first actual submarine boat, however, belongs to Cornelius van Drebel, a Dutch physician, whose first successful attempt at submarine navigation was made in 1620. Two other boats were afterward constructed by him on the same plans, and in one of them James I. of England, who was an intimate friend of Van Drebel, made a long trip. These early craft were built of wood, and rendered watertight by greased leather stretched all over the hull. According to a nearly contemporary description of the largest of these submarine boats, she carried 12 rowers besides passengers, and made a journey of several hours, at a depth of from 12 feet to 15 feet. The holes for the oars were made watertight by leather joints. The success which attended Van Drebel's attempts is wonderful indeed, if we bear in mind the limited resources of the period.

In April, 1632, one Richard Norwood took out a patent for a submarine invention in which he proposed "making and using engines or instruments for diving and for raising or bringing out of the sea and other deep water any goods lost or cast away by shipwreck or otherwise." He was the first to patent an idea relative to submarine navigation. In the records of the English Patent Office there is also, under the date of 1691, a reference to one John Holland, who patented an engine for submarine navigation.

With Bushnell's "Turtle" begins, in 1773, the long list of metallic-hulled submarine boats. David Bushnell, to whom belongs the honor of having invented the first submarine craft which really navigated under serious conditions, and gave incontestably valuable results, was an American engineer. His little boat, which took four years to make, had the form of a turtle. The shape, though not, of course, conducive to great speed, favored stability. The "Turtle" could hold only one man, with a sufficient supply of air for half an hour's submersion. At the lower extremity of the hull was placed the safety weight, a mass of lead, which also acted as ballast. The mode of propulsion employed has been the subject of some dispute, apparently because Bushnell is credited with providing two methods. According to one design, propulsion was obtained by oars fixed in the sides of the boat by watertight joints. Steering was effected by a rudder, or rather paddle, at the back, the operator sitting on a seat. The conning tower was just large enough for the head of the occupant, and was fitted with lookout windows. In this design the "Turtle" is equipped with a bomb, or detachable charge of powder, with which it was intended to blow in the bottom of an enemy's ship. The fact is recalled that in 1776 David Bushnell obtained the permission of Gen. Parsons to make use of his submarine against the English fleet, then anchored to the north of Staten Island. He instructed Sergeant Ezra Lee in the working of his little craft. After several trial trips, the sergeant tried one calm night to attack one of the blockading ships, a 64-ton frigate. He was towed as close to the ship as possible by two rowboats, and he maneuvered so as to sink just under his enemy. He could not fix his torpedo, however, as the English ship was sheathed with copper, and his boat did not offer enough resistance for him to pierce a hole in her hull. Carried along by the current, the sergeant soon lost sight of his adversary, while the torpedo floated about on the surface of the water, blowing up an hour later with a terrific explosion, to the great terror of the English, to whom this kind of warfare was then unknown.

In 1780, seven years after Bushnell's first experiments, a Frenchman named Sillon de Valmer proposed to the French government to construct a vessel which could navigate the surface of the sea safely, and which could also sink below the surface and move about freely. De Valmer's boat was to be barrel-shaped, terminated at each end by a pointed cone. For this reason Mr. Burgoyne accords him the credit of first suggesting the shape now so common in submarine vessels; but we should be inclined to assign this credit to the priest Mersenne, of whom mention is made above. De Valmer's plans were detailed, sound, and mechanically practicable; and it is probably for this reason that Mr. Burgoyne gives him the credit, in preference to Mersenne, whose ideas appear to have been far more hazy and indefinite. In March, 1795, M. Armand-Mazière placed before the French Committee of Public Safety the plans of a submarine vessel which was to be propelled by oars actuated by a steam engine, the steam being generated in a strongly-bound wooden boiler, heated by a stove. It is worthy of note that he contemplated the use of separate oars to aid in submerging the vessel, and that it was nearly a century before inventors again proposed to provide their vessels with separate motors for this purpose.

The American engineer, Robert Fulton, so well known in connection with the early history of steam navigation, was also greatly attracted by the possibilities of submarine navigation. He submitted his plans to the French government in 1797, and a commission appointed to examine them made a favorable report. The Minister of Marine, however, was inflexibly opposed to the innovation. Fulton then made a model of his submarine, which again was received with favor by the commission chosen to report upon it. Nevertheless, Fulton's proposal was again rejected, and the same ill-luck awaited him at the hands of the Dutch government. Undiscouraged by these rebuffs, he applied in 1800 to Bonaparte, then First Consul, who, after due consideration, appointed three eminent men, Laplace, Monge, and Volney, to examine Fulton's plans, and also gave the inventor 10,000 francs to carry out experiments. By May, 1801, Fulton had completed a submarine boat, which he called the "Nautilus." A first trial took place in the Seine, opposite the Invalides. We should note that the "Nautilus" was a cigar-shaped boat, about 21 feet 7 inches long and 7 feet in diameter. The hull, as in the case of the "Turtle," was of copper, but supported by iron ribs. The steering was effected by a rudder, and the propulsion, when the boat was submerged, by a wheel fixed in the center of the elliptically-shaped stern. This wheel was rotated by a hand-winch. On the first trial of the "Nautilus," Fulton and one sailor formed the crew, and with nothing but a candle to light the interior they remained submerged twenty minutes. Having made some alterations in his boat, the inventor, accompanied by three other persons, descended on June 3, 1801, at Brest, whither the submarine had been conveyed. At a depth of 25 feet he accomplished various evolutions, remaining submerged for over an hour. On June 26 he succeeded in blowing up an old hulk, placed at his disposal by the French government. On August 7, having introduced air at high pressure into the "Nautilus," Fulton stayed under water five hours without suffering the slightest inconvenience. Just as his efforts, however, were crowned with all the success he had hoped for, the French authorities ceased to take much interest in his project, and declined to adopt it. All that Fulton asked was a reward for each vessel that he destroyed; the reimbursement of the cost of his boat, that is to say $8,000, one-quarter of which had been advanced by the Minister of the Marine; and, lastly, a patent, giving himself and his crew the quality of belligerents, so that, if they were captured, they would not be hanged as pirates. Curiously enough, it was the question of a patent that raised the most difficulty. In a letter of the Minister of the Marine, the opinion was expressed that it was impossible to issue a commission for belligerency to men who should employ such a method of destroying the fleets of the enemy. Caffarelli, Maritime Préfet at Brest, took the same ground. Whatever the cause, Fulton was definitely rebuffed, and an invention that might have rendered possible an invasion of England by Bonaparte was brushed aside. Even after his return to the United States, Fulton did not entirely renounce the study of submarine boats, but in 1814 produced the "Mute," a huge vessel, capable of holding 100 men. The "Mute" was 80 feet 6 inches long, 21 feet wide, and 14 feet deep. This submarine was armored on the top with iron cleats, beneath which was a good lining almost a foot in thickness. The name "Mute" was given to the vessel on account of the silent engine which propelled it. The trials of the craft were not completed when Fulton died.

Germans have the right to boast that their country bred the man who did more toward effecting a solution of submarine navigation than any other. This was Wilhelm Bauer, who, in 1850, built his first submarine at Kiel. He was unfortunately persuaded to alter certain details in the construction of his vessel by one Dr. G. Karsten, a professor of science at Kiel. The boat proved a failure, and sank in Kiel harbor in 1851. After an unsuccessful attempt to induce the Austrian government to accept the plan of an improved submarine, Bauer went to London, where a vessel was built, nominally after his plans. As a matter of fact, however, modifications were introduced by Lord Palmerston, Pausmore, and Scott-Russell, with disastrous results, for the boat sank at one of its trials, drowning a large number of persons. After an ineffectual attempt to persuade the American government to adopt his invention, Bauer, as a last resource, went to Russia. A boat was built after his designs at the Leuchtemberg Works, St. Petersburg, in 1855, and was accepted by the Russian government in November of that year. This boat had a length of 52 feet, a beam of 12 feet, and a depth of 11 feet, and was called "Le Diable Marin" ("The Marine Devil"). It was provided with a propeller, actuated by means of four wheels, which were worked on the principle of the

treadmill. In May, 1856, the boat began its trials at Kronstadt, and at the coronation of Alexander II., on September 6, 1856, Bauer remained submerged for four hours with a band of four musicians, who, when the first gun of the imperial salute was fired, played the Russian imperial hymn. No fewer than 134 experiments in submarine navigation were made by Bauer in Russia. On the last occasion he had the ill luck to lose his vessel by allowing it to go too near the bottom, the result being that the propeller was caught in a mass of seaweed and could not be freed. He escaped, and managed to refloat the vessel after four weeks' work, but it was again lost off Ochda, and there it remains to this day. Bauer left Russia in 1858, after which he was obliged to abandon his experiments, for the reason that he had reached the end of his resources. He unquestionably pushed forward the science of submarine navigation many steps, and conclusively proved that to live under water in comfort is not impossible. His splendid energy and dogged determination should never be overlooked in the history of the evolution of the submarine boat.

Mention may be made of one or two trials of submarine boats that were made during our own civil war. On February 17, 1864, the "Housatonic," a fine, newly-built ship of the Union navy, was destroyed under the following circumstances while anchored off the harbor of Charleston. About a quarter before nine o'clock in the evening the officer of the watch descried a suspicious object making for the ship. The object resembled a flat plank moving on the water. In two minutes from the time when it was first sighted it had reached the ship's side. The submarine boat, to which the name "David" had been given, hit the "Housatonic" a little forward of the mainmast in close proximity to the magazine. When the commander of the "David" fired, the "Housatonic" leaped violently in the air, after which it began at once to settle down by the stern. The ship quickly sank, and only a part of the crew were saved. Not a trace could anywhere be found of the assailants, and it was generally supposed that they had escaped during the confusion. When, however, about three years later, divers were sent down to the "Housatonic," the truth was discovered. Fixed in the hole that it had itself created, and into which it had been sucked by the tremendous inrush of water, was the ill-fated submarine, its crew of nine men having all been drowned like rats. Between 1860 and 1864 several so-called "submersible monitors" were constructed in northern shipyards. Of these the most curious was undoubtedly the "Keokuk," which on April 7, 1863, was ordered, in conjunction with other ironclads, to attack Fort Sumter. She was struck by a storm of projectiles, was riddled like a sieve, and had to be withdrawn.

MODERN ENGINEERING.

THE present time is indeed the age of the engineer; at no other period has the technically educated and trained man been in such demand. The influence of the services of such men in industrial affairs has long been a matter for comment in the technical press; and during the past few months the English journals have urged the importance of this subject upon their manufacturers. To keep pace with ever-changing conditions engineers need such suggestions as are contained in the able addresses delivered at the formal opening of Williams Hall at Lehigh University. We refer to the remarks made by Dr. Rossiter W. Raymond, secretary of the American Institute of Mining Engineers, and by Prof. Edward H. Williams, Jr., of the Departments of Mining and Geology of Lehigh University. In the address on the "Dynamics and Ethics of Modern Engineering," which treats of the influence of the engineer on events and his relation to industrial affairs, Dr. Raymond gives expression to his views on these matters, of such interest at this time, in so clear and forceful a style that we wish to give them prominence. He ascribes to engineering a controlling prominence in the world's affairs and defines it as "the control of nature by man." The powers of physical nature are to be appropriated, annexed, and absorbed into human nature; and in the execution of this primal command, the use of machinery has been the factor and measure of progress. It will always be the nation which is foremost in the utilization of some natural power—whether coal or water power—that will be also foremost in every branch of human progress. Coupled with the definition of machinery, as being "any means by which man's individual powers are re-enforced for the conquest of nature," is the thought that men must be brought together, must re-enforce one another, must combine, so that thousands are made to act as one. Attention is called to changing conditions in human affairs, in which the unfit go to the wall. He said: "And first, as to the conditions themselves, so wonderfully changed by modern engineering. What has it done, what is it doing, to transform the civilized world?" To illustrate this idea he notes the effect of the Suez Canal upon the history of the world. As soon as the canal was finished a vast fleet of sailing vessels was rendered almost entirely worthless. Some five years later, the steamers which had superseded them were in turn superseded, because the enlargement of the canal permitted the transit of larger vessels, carrying relatively more freight. Finally, and within some fifteen years after the opening of the canal, the introduction of the triple-expansion compound marine steam engine, saving much coal, gave so much additional room for freight that the second fleet of steamers was superseded. Thus a vast merchant navy of sailing vessels, and two navies of steamers were discarded within fifteen years on account of the disturbing effect of modern engineering.

Continuing in this line, he said that railroads and telegraphs have facilitated and accelerated the destruction of "middlemen," and permitted the direct relations of producers to consumers. Also that more generally and deeply, perhaps, than any other one cause has been the progressive adoption by mechanical engineers of the American system of uniform patterns and replaceable parts for all machines. These and similar causes have led to the concentration of capital and labor in fewer and larger units. By way of illustration, a striking instance is furnished by the statistics of the American iron manufacture. We are making now ten times as much iron as we made thirty years ago; and yet we have a smaller number of blast furnaces in operation than we had then.

Dr. Raymond emphasized three general conclusions of fact: "(1) The progress effected by modern engineering has destroyed, within the last forty years, more than half the 'fixed capital' of the world. That is, more than half the capital invested in buildings, machinery, and other forms of investment which could not be turned to new uses, has been simply 'wiped out.' (2) The same progress has dislocated perhaps 50 per cent of the skilled labor of the civilized world. (3) Most remarkable of all, this period of revolutionary industrial change has not been generally disastrous to either capital or labor. For there has been, in the civilized countries thus affected, no famine; the number of workmen in the trades affected is larger than before; a great number of new occupations has been added to the old list; wages are higher, and the cost of living, as compared with wages, is lower. On the other hand, the small capitalists, who seemed to have been crushed out of existence, are now represented by a much larger number, who, as stockholders in strong companies, draw larger profits from their capital than before."

So much for the dynamics of modern engineering. Now as to its ethics.

The new age is peculiarly an age of moral and intellectual requirements. In the first place, with regard to the qualifications of workmen of all kinds, the emphasis has been taken from skill, and put upon intelligence, fidelity, and loyalty. Thirty years ago the manufacturer of iron was looking for experienced men who could tell by the look of things how to handle a blast furnace. Now that sort of skill is not wanted, but rather intelligence and loyalty in executing orders. The chemist in the laboratory determines the requisite mixtures of ore, flux, and fuel. What is wanted is to have the orders given by those who have all the conditions before them understood and obeyed. The glamor of so-called "skill," which used to surround many handicrafts, has been dissipated by science. The reason of the overwhelming importance of our technical schools was stated to be that they produce the men who know how, and can be trusted. Dr. Raymond in concluding said: "But to possess knowledge and trustworthy character is not enough to secure success in this new age. Success in life, whether measured by gain, or fame, or usefulness, is ever and always a function of influence over men. This is pre-eminently an age of the power of language. And this art, for its highest effectiveness, must be enriched by a generous culture."—Mines and Minerals.

INTERNATIONAL VIEW OF THE SIMPLON TUNNEL.

IT has been officially stated that, at the end of last June, 10 miles 1 furlong of the total length of the Simplon Tunnel, amounting to 12¼ miles, had been completed. Since the piercing of the tunnel was commenced, in August, 1898, it may be fairly concluded, assuming the same rate of progress to be maintained, that it will be ready for traffic about the middle of the year 1905. It will, therefore, not be premature to draw the attention of our readers to the very important results that are likely to attend the opening of the new route. It might not unreasonably be supposed that the part it will play in linking up and developing existing continental main railways, and in causing the construction of smaller branches and feeders, would be restricted to certainly a large, but still to a readily ascertained and definable sphere of action and influence. It will be subsequently seen that no such limited conditions obtain in the present instance. The range and scope of the passage beneath the Lepontine Alps will produce effects which will be felt by trade and commerce in many countries of the world. Thirty years ago, before the Saint Gothard Tunnel was made, the construction of one *via* the Simplon was mooted. It was at that time considered the only site along the whole Alpine chain, from Mont Cenis to the Tyrol, where a tunnel could be bored at the bottom of a mountain without exceeding the practicable limit of length. Another advantage of the Simplon road is that transport between Bâle and Italy will be more cheaply carried by it than by the Saint Gothard. The former, moreover, is far better adapted to the wants of the northwestern nations of Europe. It will afford excellent means of communication between France and Italy, and at the same time will greatly facilitate the commercial relations of Germany with the other continental countries.

Of all the neighboring nations, France is the one most concerned with the future of the new tunnel, and it is a little singular why she at first held back and took little or no interest—though she must have felt some—in the great undertaking. The success of the Saint Gothard enterprise no doubt opened her eyes to the competition that was likely to arise between some of her own ports and some of those belonging to Italy, and it was estimated that the probable return of the Saint Gothard Tunnel would be at the rate of £3,000 per mile, which in 1894 amounted to £3,840 per mile. Without entering further into financial details, it may be stated that in 1883, a year after the line was opened, 469,711 tons of merchandise passed over it, which increased in 1893 to 805,000 tons, and to 1,005,000 tons six years afterward. Between the same dates the passenger traffic rose from one million to one and a half millions. These statistics, which were valuable and instructive, admitted of no doubt of their accuracy, and created a very serious impression in France. The progress of the Saint Gothard route was at once connected with that which had taken place at Genoa, and at other ports in Belgium and Holland.

It must be admitted that the Simplon will be a powerful competitor with the other great sub-Alpine highways. It affords the shortest road from Paris to Milan, and in several other respects possesses a marked superiority over other routes. Consequently, the French government is gravely concerned about a project for uniting its own system of railways with the main line of the new tunnel, by the shortest and least expensive plan. Three courses are open for selection, of which that *via* La Faucille presents many advantages over its rivals which will be subsequently alluded to. There is no question that France regards with a certain degree of anxiety the subject of the Alpine tunnels, and the attacks both threatened and made upon her by their construction. It is for the commerce and trade of her great maritime city, Marseilles—her Liverpool—that she is so apprehensive. For a long time Marseilles had a monopoly of nearly the whole of the traffic of western Europe, which now passes to some extent through Italy and a part of central Europe. In Switzerland, Marseilles has to reckon with the competition of Antwerp, of Rotterdam, of Hamburg, and not only with that of Genoa. At present Antwerp abstracts from Marseilles a considerable amount of goods traffic, which, coming from the Rhine valley, is consigned to the Far East. A large quantity of freight has left the ports of the Mediterranean, because it is cheaper to send it through the Straits of Gibraltar than across the Alps by railway. If we regard only the future competition of Genoa, and the French ports of the Mediterranean, it is evident that the opening of the Simplon route will damage the interests of our continental neighbor, by extending the sphere of activity of the Italian port at the expense of both Marseilles and Cette. There is not the slightest doubt, observes our contemporary Le Genie Civil, that the traffic of the Saint Gothard and the Mont Cenis lines will be shared with that of the Simplon in the same manner as that of the Brenner and Cenis was with the Saint Gothard.

The opening of the Simplon route will place Geneva, within five miles, at the same distance from both the Italian and French ports. This is unfortunate for the latter, since nearly all the traffic from Marseilles to all parts of Switzerland passes through Geneva, and will thus feel more than ever the competition of its rival. Both France and Italy have open water transit with India, America, and Australia. The question may well be asked, How does it happen that the former country, with its Atlantic ports, and in spite of all its efforts to outvie the Saint Gothard—to which will be shortly added the Simplon—sees its commerce pass largely into the German, Dutch, and Belgian ports? The answer, admitted by the people themselves, is that their whole mercantile maritime service, fleet, naval installations, mechanical appliances and plant, are altogether insufficient, and below the standard of modern requirements. In addition, the internal navigation of the country is exceedingly inadequate and tedious. Traffic by boat from Poitiers to Marseilles frequently occupies twenty days, or at the rate of a mile per hour. At the present time large works are in course of construction for improving the water communication in the interior of the country. In the investigation of the relative advantages of water and land traffic, an important point to be considered is the kind of goods to be carried. Some description of goods, such as those which form part of the Italian exports to England, must be sent as far as practicable per rail—the quickest, the safest, but the dearest mode of transport. The last objection is not always so forcible as might appear, because there are certain high classes of goods which can afford to pay comparatively dearly for safe and speedy transit.

The scope of the future international route will not be restricted to the countries of Switzerland, Italy, and France. Nor must its relations with the last be regarded as wholly inimical to her interests. If, on the other hand, Italy avails herself of French railways to export her merchandise to Great Britain, and also to America, on the other, France will, although to an admittedly smaller extent, dispatch her goods over the Italian line to Austria and Hungary. It is more than possible that ultimately the new line will connect up with the Balkan States, although the present is not a very hopeful occasion to indulge in optimistic forecasts. It should be stated that the Italian government have allotted £2,800,000 to the construction of approach and subsidiary lines to the Simplon, over which will be conveyed merchandise from the shores of the Adriatic to the French seaports of the Atlantic. It may be mentioned that various projects are proposed

for improving the internal navigation, both in Italy and France, as aids to the fuller development of the new system, which may be subsequently referred to when they are in a more advanced stage. The Faucilles, beneath which the new French railway is to pass, is a range of hills in France, in the shape of a sickle (*faucille*), separating the basins of the Meuse and the Moselle from that of the Saône.—Engineer.

[Continued from SUPPLEMENT No. 1461, page 23417.]

STABILITY TESTS FOR NITROCELLULOSE AND NITROCELLULOSE POWDERS.*

By ALBERT P. SY, M.S., Assistant Chemist, Ordnance Department, U. S. Army, Frankford Arsenal.

THE THOMAS TEST.†

THE sample is heated in a glass-stoppered tube, in an oil bath, for eight hours daily. A good nitroglycerin powder should stand four days' heating at 94 to 96 deg. C., without developing brown fumes (N_2O_4); a good nitrocellulose and nitrocellulose powder should not show fumes before three days, at a temperature of 99 to 101 deg. C.

These temperatures are too low to produce a decomposition which may be accurately observed by the appearance of brown fumes; it is difficult sometimes to say just when brown fumes appear. Moisture and volatiles in the sample affect the result. Aspinwall‡ objects to the length of time (sometimes over twenty days) required to obtain results.

THE 135 DEG. C. GERMAN TEST.

2.5 grammes of the sample to be tested are placed in a strong test tube; a piece of blue litmus paper is put into the tube about one-half inch above the explosive. The tube is lightly corked and placed into a bath at 135 deg. C.

Three observations are made: (1) reddening (complete) of the litmus paper, (2) appearance of brown fumes (N_2O_4), and (3) explosion of the sample. Stable explosives should stand the test as follows:

	Litmus red	N_2O_4	No explo.
Nitrocellulose	:30	:45	5:00
Nitrocellulose powder...	1:15	2:00	5:00
Nitroglycerin powder...	:30	:45	5:00

To make the results of this test as valuable as possible, all three observations must be carefully studied and compared with those obtained from known good powders.

The temperature of 135 deg. is usually considered too high for stability testing, as it may cause decomposition not always dependent upon the stability of the explosive. Sometimes it is impossible to say just when the litmus paper is red, or when brown fumes are present, and two operators may vary thirty minutes in their observations. Different makes of litmus papers give widely varying results. The test papers used by the Ordnance Department are made by Eimer & Amend, according to specifications, of as nearly uniform quality and sensitiveness as possible.

By keeping all conditions as nearly uniform as possible and observing precautions mentioned, this test is one of the best of its kind.

THE VIEILLE TEST (110 DEG. C.)

Ten grammes of the explosive are placed in a strong glass tube, a piece of blue litmus paper is placed above the sample and the tube closed air-tight; the tube is then heated in an air bath* at 110 deg. C. until the litmus paper is completely reddened. The time required for this reddening is noted, the bottle removed and opened; this operation is repeated daily, using a clean bottle and fresh test paper, until the time required to redden the paper is one hour or less. These

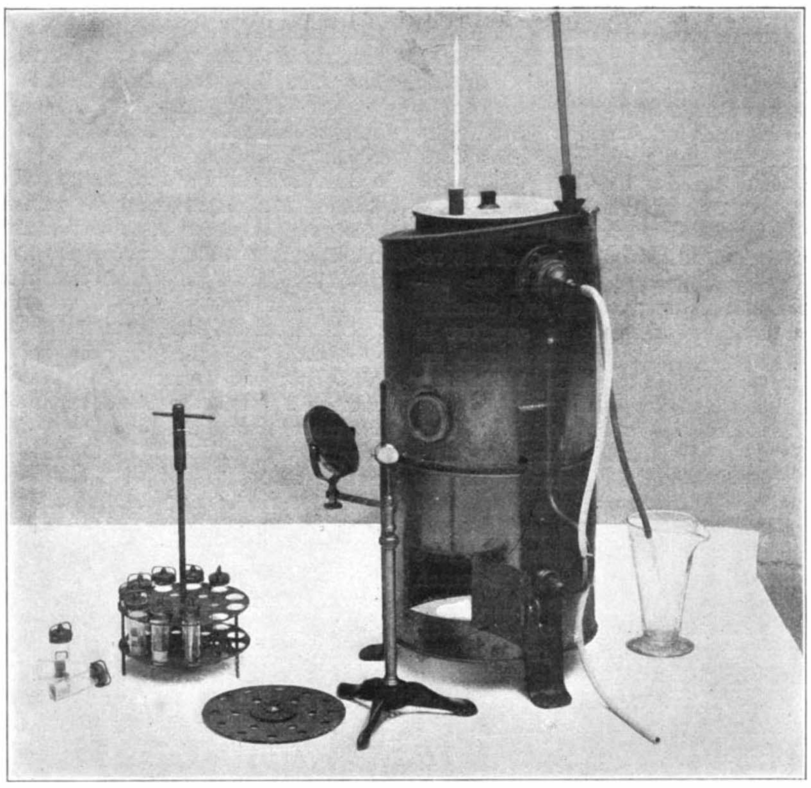


FIG. 4.—APPARATUS FOR VIEILLE TEST.

* A special air bath is used to heat the samples to 110° C.; for description and illustration see Sy: Jour. Franklin Inst., March, 1903.

* From Journal of the United States Artillery.
† Zeitschr. f. Angew. Chem., 1898, p. 1027.
‡ Jour. Soc. Ch. Ind., May 31, 1902.

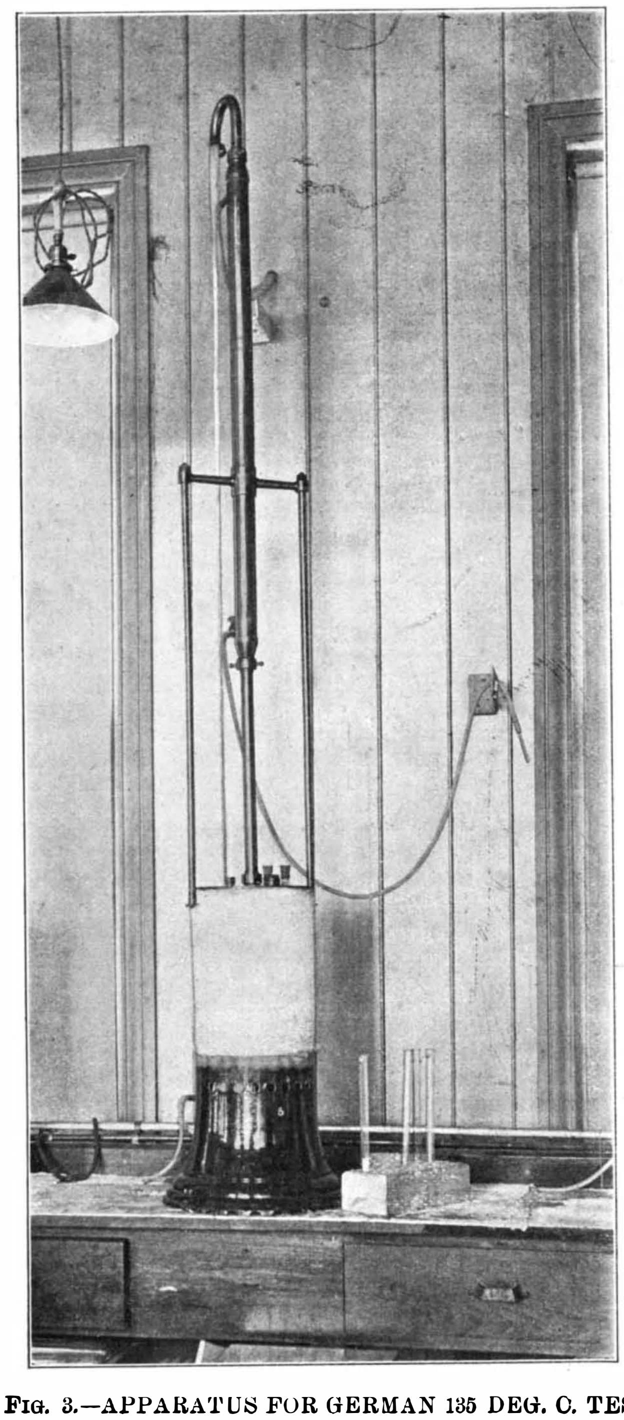


FIG. 3.—APPARATUS FOR GERMAN 135 DEG. C. TEST.

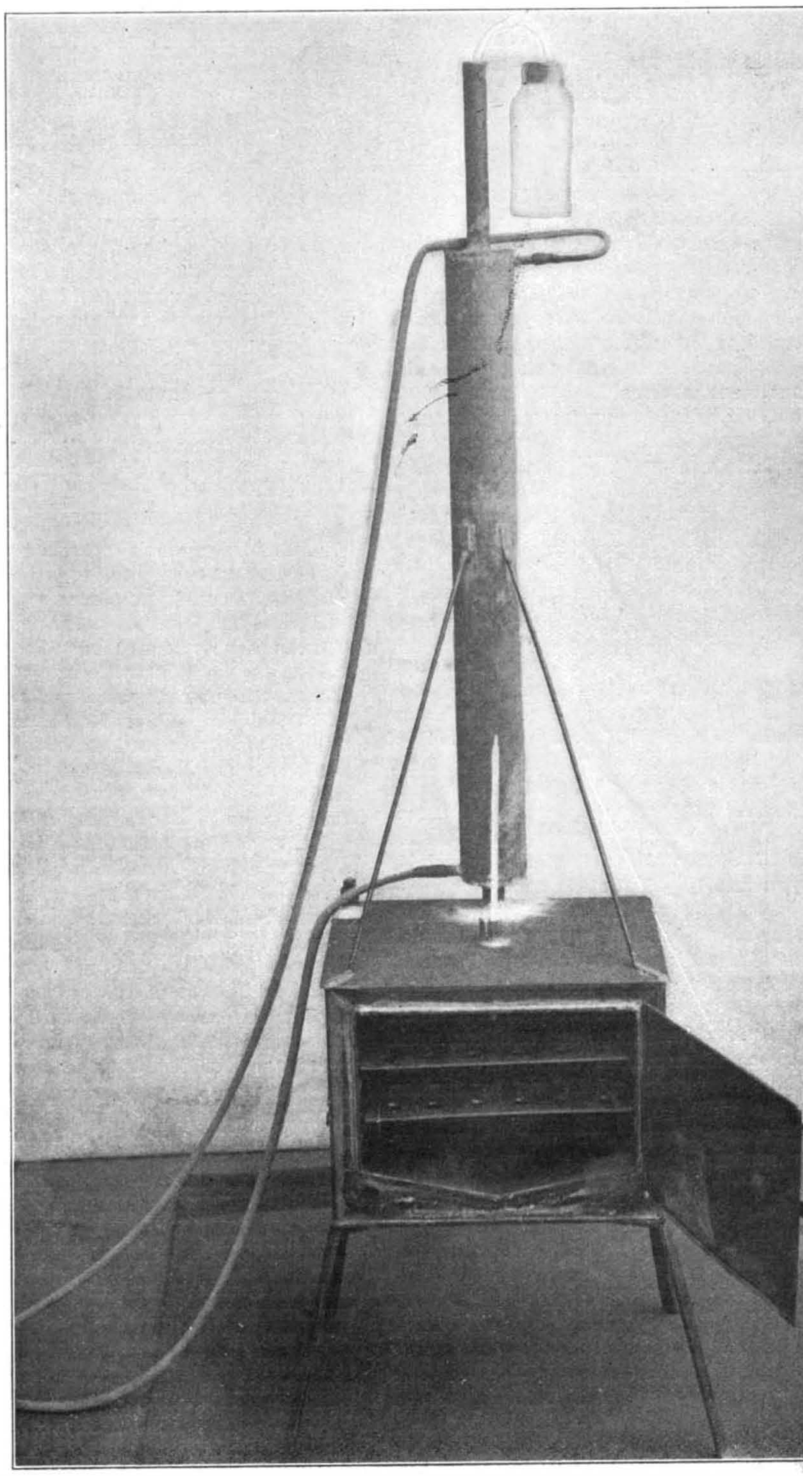


FIG. 5.—OVEN FOR NEW 115 DEGREE TEST.

daily times are added and the total (accumulated time) should not be less than

30 hours for large grain powders,
20 hours for small grain powders (5 inch or less),
10 hours for nitrocellulose.

This test is not applicable to nitroglycerin powders. In common with all other heat tests where blue litmus paper is used, it shows only acid products of decomposition. It is practically impossible to get all the bottles equally tightly closed, and on this account there are variations in time, since pressure is an important factor in decomposition—the greater the pressure the less the stability time. The personal equation of the observer in reading the reddening of the paper, and different makes of test paper give rise to variations. At this laboratory (Ordnance Department, U. S. Army) the test papers used are the same as those described under the "135 deg. C. Test."

THE WILL TEST.*

Nitrocellulose is decomposed by heating to 135 deg. C., and by means of a current of CO_2 the products of decomposition are carried into a reduction tube containing a heated spiral of copper gauze; here the nitrogen compounds are reduced to nitrogen gas which is measured over sodium hydrate solution. The nitrogen is measured at regular intervals, and the rate of evolution is taken as an index of the decomposition. A nitrocellulose which by this test gives off equal quantities of nitrogen in equal intervals of time is considered by Will to be in "the limit state of purification," and therefore as stable as possible. An unstable nitrocellulose—one not in the "limit state" (Grenzzustand) —suffers, at first, an accelerated decomposition, which sooner or later becomes uniform.

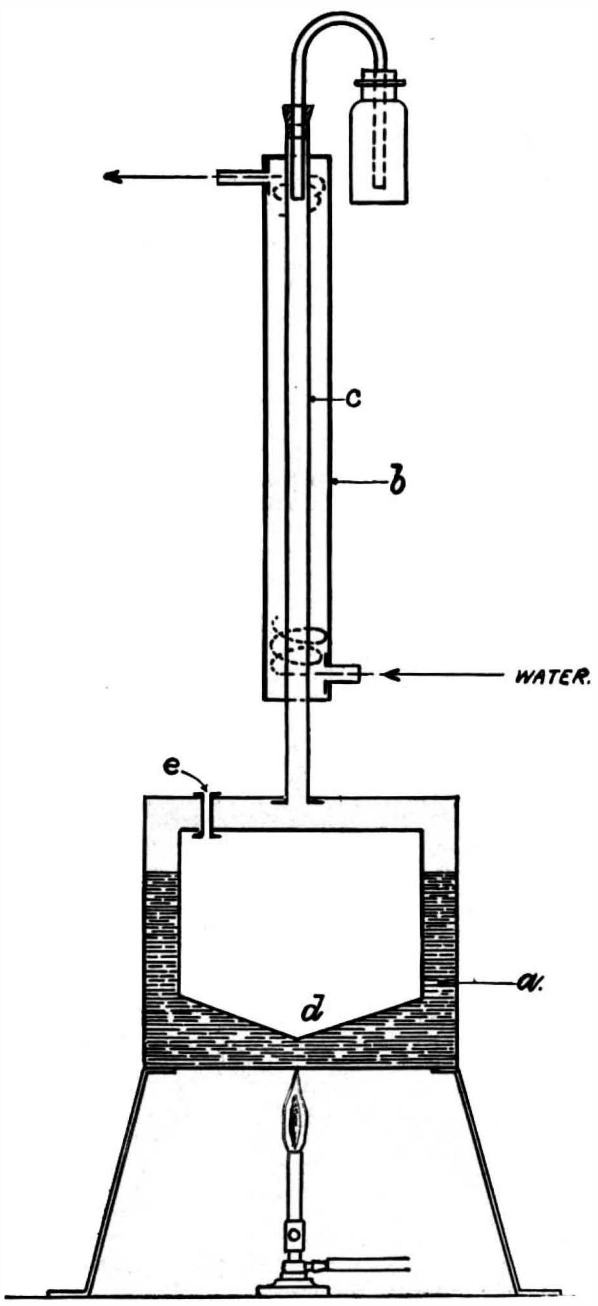


FIG. 6.—OVEN FOR NEW 115 DEG. C. TEST.

Will's test was thoroughly tried by Mr. C. P. Beistle, of the Frankford Arsenal laboratory, no expense nor time being spared in setting up the rather elaborate apparatus required, and in conducting the test. The results obtained were unsatisfactory and failed to distinguish a bad from a good nitrocellulose, and the test was abandoned. This test, as well as modifications of it, have been investigated in several laboratories in this country, but in all cases eventually discarded as impracticable.

The following reasons are given as the cause of unsatisfactory results:

(1) 135 deg. C. is too high a temperature for stability-testing purposes.

(2) Decomposition is measured only by the nitrogen evolved.

(3) From Prof. Will's experiments and diagrams it is not at all clear where to draw the line between a stable and an unstable product.

(4) The statement is made in Prof. Will's report that for a certain nitrocellulose, heated for thirty hours and losing one-fourth its original nitrogen, the evolution of nitrogen in equal intervals of time was identical; while in another place it is stated that 10 grammes of nitrocellulose gave four times the amount of nitrogen that was given off by 2.5 grammes. This latter statement is correct, judging from our own experiments, but it contradicts the former, since the amount of unchanged nitrocellulose in the former experiment is constantly decreasing.

(5) It is practically impossible to buy or make CO_2 which is free from air; and as it is difficult to pass CO_2 through the apparatus at a uniform rate, the air-content of the gas gives rise to serious errors, and if the current is too rapid it may cool the sample, and it, the CO_2, will not be completely absorbed by the sodium hydrate solution; if too slow, the gases of decomposition are not carried away fast enough, which may affect the decomposition, as stated by Prof. Will.

(6) If the reduction tube and copper spirals are not hot enough, or the CO_2 passed too fast, some of the products of decomposition may escape reduction.

(7) Unstable products are liable to explode which might cause considerable annoyance both to the operator and the apparatus.

(To be continued.)

* Mittheilungen a. d. Centralstelle f. Wissenschaft. Untersuch. December. 1900, Neu Babelsberg. Also abstr. in Jour. Soc. Ch. Ind., June 30, 1900.

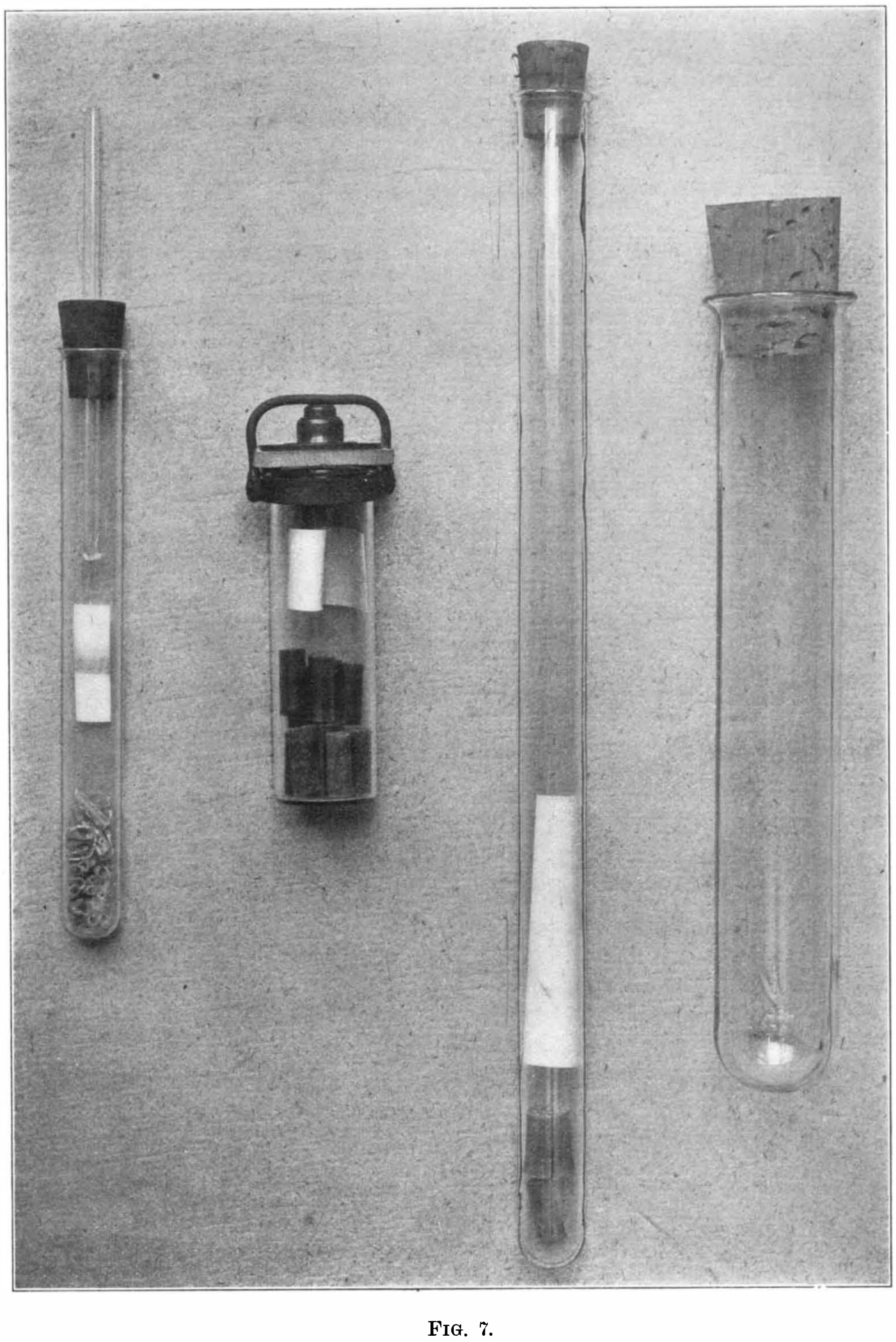


FIG. 7.

A. Arrangement of tube and sample for KI-starch test. *B.* Arrangement of tube and sample for Vieille test.
C. Arrangement of tube for German 135° C. test. *D.* Arrangement of tube for Explosion test.

The electric current of American central electric stations is generated by 12,484 dynamos, with an indicated capacity of 1,624,980 horse power. The private stations contain 85.4 per cent of all dynamos, and their horse power forms 90.6 per cent of the total horse power of dynamos of every description. The machines in most general use, in both private and municipal stations, are those which generate an alternating and polyphase current. Of the total number of these machines reported, 16 per cent are operated in municipal stations, but their horse power capacity forms only 9.2 per cent of that of all machines of this variety. While the municipal stations contain a very small proportion of the number and horse power of the different classes of dynamos, the proportion of direct current, constant amperage arc dynamos installed in such stations is larger than that of any other variety, being 16.4 per cent of the number and 19.3 per cent of the horse power of all machines of this class.

[Concluded from SUPPLEMENT No. 1461, page 23415.]

THE MORPHOLOGICAL METHOD AND PROGRESS.*

By Prof. G. B. HOWES, D.Sc., LL.D., F.R.S.

PASSING to the Recent Fishes alone, the discovery which must take precedence is that of the mode of origin of the skeletogenous tissue of their vertebral column. The fishes, unlike all the higher Vertebrata, have, when young, a notochord invested in a double sheath, there being an inner chordal sheath, an outer cuticular, which latter is alone present in all the higher groups. The skeletogenous cells, by whose activity the cartilaginous vertebral skeleton is formed, arise outside these sheaths; but whereas, when proliferating, they in one series remain outside, they in the other, by the rupture of the cuticular sheath, invade the chordal. This distinction enables us to discriminate between a Chordal series, which embraces the Chimæroids, Elasmobranchs, and Dipnoi, and a Perichordal, consisting of the Teleosts, Ganoids, and Cyclostomes.

In consideration of the enormity of the structural gap between the cyclostomes and the higher Vertebrata this is an extraordinary result. For be it remembered that, in addition to their well-known characters, the lampreys and hags (1) in the total absence of paired fins; (2) in the presence of branchiæ, ordinarily seven in number, fourteen in Bdellostoma polytrema, numerically variable in individuals of certain species between six and fourteen, and doubtfully asserted in the young of one to be originally thirty-five; and (3) in the carrying up of their oral hypopophysis by the nasal organ, whereby it perforates the cranium from above, as contrasted with all the higher Vertebrata, in which, carried in with the mouth-sac, it perforates it from beneath, exhibit morphological characters of an extraordinary kind. And if we are to express these char-

* Address before the British Association.

acters in terms, we may distinguish the Cyclostomes as apterygial and epicraniate, the higher Vertebrata as hypocraniate.* But this notwithstanding, the aforementioned subdivision of the Pisces into two series, which would associate the teleosts and ganoids with the cyclostomes, as distinct from the rest, receives support from recent study of the head-kidney by a Japanese, who seeks to show that the organ so called in the Elasmobranchs is of a late-formed type peculiar to itself; and it is also in agreement with one set of conclusions previously deduced from the study of the reproductive organs.

To deal further with the fishes is impossible in this address, except to remark that recent discovery in the Gambia that the young of the Teleostean genera Heterotis and Gymnarchus bear filamentous external gills, renders significant beyond expectation the alleged presence of these among the loaches, and shows that adaptive organs of this type are valueless as criteria of affinity.

In palæontology, as in recent anatomy, our records of detail have increased beyond precedent, often but to show how deficient in knowledge we are, how contradictory are our theories and facts.

In dismissing the fishes, I wish to comment upon our accepted terms of orientation. To speak of the median fins as dorsal, caudal and anal, of the pelvic as ventral, and of the pectoral in its varying degrees of forward translocation as abdominal or thoracic, though a convention of the past, is to-day inaccurate and absurd. I question if the time has not come at which the terms thoracic (pulmocardiac) and abdominal are intolerable, as expressing either the subdivisions of the body-cavity or anything else, outside the Mammalia, which alone possess a diaphragm. Even in the birds, to grant the utmost, the subdivision of the cœlom, if accurately described, must be into pulmonary, hyper-pulmonary, and cardio-abdominal chambers; while with the reptiles the modes of subdivision are so complex that a special terminology is necessary for each of the several types extant.

In the fishes, where the pericardium is alone shut off, the retention of the mammalian terms but hampers progress. This was indeed felt by Duméril, when in 1865 he attempted a revisionary scheme. Since, however, one less fantastic than his seems desirable, I would propose that for the future the "anal" fin be termed ventral, the "ventral" pelvic; and that for the several positions of the pelvic, that immediately in front of the vent, primitive and embryonic (which is the position for the Elasmobranchs, Sturiones, Lower Siluroids and all the higher Vertebrata), be termed proctal, the so-called "abdominal" pro-proctal, the so-called "thoracic" jugular (in that it denotes association with the area of the "collar-bone"), and the so-called "jugular" mental. The necessity for this becomes the more desirable, now that it is known that a group of Cretaceous fishes (the Ctenothrissidæ), hitherto regarded as Berycoids, are in reality of clupeoid affinity, despite the fact that at this early geologic period they had translocated their pelvic fin into the jugular ("thoracic") position.

The sum of our knowledge acquired during the last twenty-eight years proves to us that, among the bony fishes, the structural combination which would give us a premaxillo-maxillary gape dentigerous throughout, a proctal pelvic fin, a heart with conal valves, would be the lowest and most primitive. Inasmuch as this character of the heart, so far as at present known, exists only among the Clupesoces (pikes and herrings and their immediate allies), these must be regarded as lowly forms; wherefore it follows that the possession of but a single dorsal fin is not, as might appear, a necessary index of a highly modified state.

Before I dismiss the vertebrates, a word or two upon a recent result of morphological inquiry which concerns them as a whole. I refer to the development of the skull. Up to 1878 it was everywhere thought and taught that the cartilaginous skull was a compound of paired elements, known as the trabeculæ cranii and parachordals, and that the former contributed the cranial wall. Huxley in 1874, from the study of the cranial nerves of fishes, had reiterated the suggestion he made in 1864, when dealing with the skull alone, that the trabeculæ might be a pair of præ-oral visceral arches, serial with those which support the mouth and carry the gills. The next step lay with the Sturgeon, in which in 1878 it was found that the cranial wall is originally distinct. And later, when the facts were more fully studied in sharks, batrachians, reptiles, and birds, it became evident that the trabeculæ, though ultimately associated with the cranial wall, take no share in its formation, and that when first they appear they are disposed at right angles to the parachordals and the axis, serially with the visceral arches behind. Huxley was right; and although this consideration by no means exhausts the category of independent cartilages now known to contribute to the formation of the skull, it proves that the cartilaginous cranium, like the bony one, which in the higher vertebrate forms replaces it, is in its essence compound.

I now pass to the Invertebrata. Of the Oligochæta and Leeches I have spoken, and we may next consider the Arthropods. Of the Insecta, our knowledge has gained precision, by the conclusion that the primitive number of their Malpighian tubes is six, and by the study of development of these in the American cockroach Doryphora, which has rendered it probable they may be modified nephridia, carried in as are those of some oligochætes with the proctodeal invagination. An apparent cervical placenta has been discovered in the orthopteran Hemimerus, which would seem to suggest homology with the so-called "trophic vesicle" of the Peripatoids, as exemplified by P. Novae-Britannica. In this same orthopteran there have been recognized, in secondary proximity to the "lingua," reduced maxillulæ, which, fully developed and interposed between the mandible and first maxilla, in Japyx, Machilis, Forficula, and the Ephemera larva, give us a fifth constituent for the insectan head. And when it is found that all the abdominal segments of the common cockroach, when young, are said to bear appendages, of which the cerci are the hindermost, we have a series of facts which revolutionize our ideas. Little less striking is the discovery that in the caterpillar of the bombycine genera Lagoa and Chrysopyga seven pairs of pro-legs occur.

The fuller study of the apertures of the tracheate body has resulted in the discovery that the Chilopoda are more nearly related to the Hexapoda than to the Diplopods; wherefore it is proposed to reclassify the Tracheata, in accordance with the position of the genital orifice, into Pro- and Opistho-gonata. In a word, the "Myriapoda," if a natural group, are diphylectic.

Our knowledge of the Peripatoids (Arthropoda malacopoda) has increased in all that concerns distribution and structure. They are now known, for example, from Africa, the West Indies, Australia, and New Zealand, and for examples from the two latter localities and Tasmania the generic name Ooperipatus has but lately been proposed, to include three species, characterized by the possession of an ovipositor, of which two have been observed to lay eggs.

Work upon the Crustacea in our own land, notorious for the tendencies of some of its devotees in their stickling for priority, has within the last twelve years advanced beyond all expectation. Much of our literature has been systematized, and an enormous increase in our knowledge of new forms has to be admitted, thanks to memoirs such as those of the "Investigator," "Naples Zoological Station," and others which might be named; while in the discovery and successful monographing, in the intervals of six years' labor at other groups, of a new family of minute Copepods (the Choniostomatidæ), parasitic on the Malacostraca, embracing forty-three species, difficult to find, we have an almost unique achievement. The hand which gave us this has also provided a report which embraces the description of a nauplius of exceptional type, which, by a process of reasoning by elimination, masterly in its method, has been "run to ground" as in every degree of probability the larva of Darwin's apodal barnacle Proteolepas bivincta, of which only the original specimen is known.

There is but one other crustacean record equal in rank with this, viz., the discovery of the genus Anaspides. Originally obtained from a fresh-water pool on Mount Wellington, Tasmania, at 4,000 feet, it has since been found in two other localities. It is unique among all living forms, in combining within itself characters of at least three distinct suborders of "prawns," for with a schizopod body it combines the double epidodial lamellæ of an amphipod, the head of a decapod, pedunculated eyes and antennulary statocysts), apart from characters peculiarly its own. There is reason to believe that the nearest living ally to this remarkable creature is a small eyeless species (Bathynella natana) obtained from a Bohemian well; and if its presumed relationships to the Palæozoic "pod-shrimps" be correct, this heterogeneous assemblage may perhaps be the representatives of a group of primitive Malacostraca, through which, by structural divergence, the establishment of the higher crustacean suborders may have come about.

It is pertinent to this to note that work upon cave-dwelling and terrestrial forms, upon "well-shrimps" and the like, has produced important results. And interesting indeed is the recent discovery of three species, living at 800 to 900 feet above sea-level, in Gippsland, one an amphipod, two of them isopods, which, though surface-dwellers, are all blind. While they prove to be species of genera normally eyed, they in their characters agree with well-known American forms; and the bleaching of their bodies and atrophy of their eyes proclaim them the descendants of cave-dwelling or subterranean ancestors, among whom the atrophy took place.

Huxley in 1880 rationalized our treatment of the higher Crustacea, by devising a classification by gills, expressive of the relationships of these to the limb-bases, interarticular membranes and body-wall. Hardly had his influence taken effect when, by work extending over the years 1886 to 1893, in the study of Penæus, the Phyllopods, Ostracods, and other forms, evidence had been accumulating to show that the crustacean appendage, even to the mandible itself, has primarily a basal constituent (protopodite) of three segments; that the branchiæ one and all are originally appendicular in origin; and that the numerical reduction of the basal (protopoditic) segments to two, with the assumption of a non-appendicular relationship by the gills, is due to coalescence of parts, with or without suppression. The evidence for this epoch-making conclusion, which simplifies our conceptions and brings contradictory data into line, is as irresistible as it is important, and there has been nothing finer in the whole history of crustacean morphology. With it, the attempt to explain the supposed anomalous characters of the antennule by appeal to embryology goes to the wall; and, taking a deep breath, we view the Crustacea in a new light.

There remains for brief consideration one carcinological discovery second to none which bears on the significance of larval forms. It is that of the Trilobite Triarthrus Becki, obtained in abundance from the Lower Silurian, near New York, with all its limbs preserved. In the simplicity of its segmentation and the biramous condition of its limbs it is primitive to a degree. Chief among its characters are the total absence of jaws in the strict sense of the term, and the fact that of its three anterior pairs of appendages the third is certainly and the second apparently biramous, the first uniramous and antenniform. In this we have a combination of characters known only in the nauplius larva among all living crustacean forms; and the conclusion that the adult trilobite, like that of the Euphausiaceæ, Sergestidæ, Penæidæ, the Ostracods, and Cirripedes of to-day, was derived by direct expansion of the nauplius larva can hardly be doubted. Much yet remains to be done with the study of the Triarthrus limbs; and the suggestion of a foliaceous condition by those of the pygidium, which are youngest, is a remarkable fact, the meaning of which the future must decide. We should expect the condition to be a provisional one, since while we admit the primitive nature of the phyllopods as an order, we cannot regard the foliation of their appendages as anything but a specialization. Be this as it may, the structural community between the nauplius larva and the trilobite is now proved; and when we add that in the yolk-bearing higher Crustacean types (e. g. Astacus) a perceptible halt in the development may be observed at the three-limb-bearing stage; that in Mysis the vitelline membrane is shed but to make way for a nauplius cuticle; and that the median nauplius eye has long been found sessile on the adult brain of representative members of the higher crustacean groups, up to the lobster itself, our belief in the ancestral significance of the nauplius larval form is established beyond doubt.

The thought of the nauplius suggests other larval forms. The gastrula is no longer accepted without reserve; the claims of the blastula, planula, parenchymella, not to say the plakula, have all to be borne in mind. It is of the Trochophore, however, as familiar as the nauplius, that I would rather speak, as influenced by recent research. It is supposed to be primitive for the mollusks and chætopod worms at least; and various attempts have been made to bolster it up, and to show that if we allow for adaptive change, its characters, well known, are constant within the limits of its simpler forms.

It is now more than forty years ago that the late Lacaze-Duthiers described for Dentalium a larval stage, characterized by the possession of recurrently ciliated zones, which by reduction, with union and translocation forward, give rise to the trochal lobe. It is now known that in the American pelecypod Yoldia limatula a similar stage is found, in which a "test" of five rows of ciliated cells, is present; and of the young of Dondersia banyulensis the like is true. But whereas in the Yoldia the ciliated sac is ultimately shed, in the Myzomenian the escape of the embryo is accompanied by rupture which liberates the anterior series of ciliated zones in a manner strongly suggestive of forward concentration, leaving the posterior circlet with its cilia attached.

This "test" has also been seen in two species of Nucula, and pending fuller inquiry into the Myzomenian and a reinvestigation of Dentalium, I would suggest that this recurrently ciliated sac is representative of a larval stage antecedent to the trochophore, for which the term protochal may suffice. This term has indeed been already applied to a larva of certain Polychæta, which might well represent a modification of that for which I am arguing; and quite recently it appears to have been observed near Ceylon for a species of the genus Marphysa.

The discovery of this larva in Dondersia was accompanied by that of a later-formed series of dorsal spicular plates, which for once and for all, in realizing a chitonid stage, demolish the heresy of the "Solenogastres," mischievous as suggesting an affinity with the worms. Like that of the supposed cephalopod affinities of the so-called "Pteropods," it must be ignored as an error of the past.

Returning to the protrochal stage, whatever the future may reveal concerning it, by bringing together the Lamellibranchiata, Scaphopoda and Polyplacophora, it associates in one natural series all the bilaterally symmetrical Mollusca except the cephalopods. In doing this, it deals the death-blow to the supposed Rhipidoglossan affinity of the Lamellibranchiata; and in support of this conclusion I would point out that the recently discovered eyes of the mytilids are in the position of those of the embryo Chiton, and that just as Dentalium, in the formation of its mantle, passes through a lamellibranchiate stage, so are there lamellibranchs in number in which a tubular investment is found.

This protrochal larva has an important part to play. It may very possibly explain phenomena such as the compound nature of the trochal lobe of the limpet, the presence of a post-oral ciliated band in the larva of the ship-worm, and of a præ-anal one in that of various molluscan forms. In view of it, we must hesitate before we fully accept the belief in the ancestral significance of the trochophore. And it is certain that an idea, at one time entertained, that the Rotifer (Trochosphæra) which so closely resembles it as to bear its name is its persistent representative, is wrong, since

* It is an interesting circumstance, if their "ciliat d sac" is rightly homologized, that Amphioxus and the Tunicata present a corresponding dissimilarity, allowance being made for the fact that in Botryllus, Goodsiria and Polycarpa the sac overlies the ganglion. It is pertinent here to recall the ammocœte-like condition of the "endostyle" in Oikopleura flabellum.

this is now known to be but the female of a species having a very ordinary male.

Through the Rhipidoglossa we pass to the Gastropods, which are one and all asymmetrical, for even Fissurella, Patella, and Doris, when young, develop a spiral shell; while Huxley in 1877 had observed that the shell of Aplysia, in its asymmetry, betrays its spiral source.

The notion, which until recently prevailed, that among these gastropods the non-twisted or so-called euthyneurous condition of the visceral nerve-cords, as exemplified by the Opisthobranchs, is a direct derivative of that of the Chitons has been proved to be erroneous, since the nerves in Actæon and Chilina, like those of the prosobranchs, are twisted or streptoneurous. And as to the torsion of the gastropod body, recent research, in which one of my pupils has played a part, involving the discovery of paired renopericardial apertures in Haliotis, Patella, and Trochus, has resulted in proof that the dextral torsion which leads to the monotocardiac condition does not uniformly affect all organs lying primitively to the left of the rectum, as we have been taught; since, concerning the renal organs, it is the primitively (pretorsional) left one which remains as the functional kidney its ostium as the genital aperture. Nor is the primitively right kidney necessarily lost, for while its osteum remains as the renal orifice, its body, by modification and reduction, may become an appendage of the functional kidney, the so-called nephridial gland. And we now know there are cases of sinistral torsion of the visceral hump, in which the order of suppression of the organs is not reversed, the arrangement being one of adaptation of a dextral organization to a sinistral shell.

Though thus specialized and asymmetrical as a group, the gastropods are yet plastic to an unexpected degree. Madagascar has yielded a Physa (P. lamellata) with a neomorphic gill, a character shared by species of Planorbis (P. corneus and P. marginatus), and an Ancylus in which the lung-sac is suppressed; while St. Thomas's Island has given us a snail (Thyrophorella Thomensis), the peristome of whose shell is produced into a protective lid.

In palæontology history records the fact that in 1864 Huxley observed that the genus Belemnites appears to have borne but six free arms; a startling discovery which lay dormant till the present year. And the recent study of the fauna of the great African lakes, in bringing to light the existence of a halolimnic molluscan series in Lake Tanganyika, has opened up new possibilities concerning the palæontological resources of enormous aqueous deposits, recently discovered in the interior, and has entirely changed our geological conceptions of the nature of Equatorial Africa.

Time prevents my dealing with other groups, and it must suffice to say that with those I have not considered substantial work has been done. From what has been said, it is natural to expect that in some direction or another so vast an accumulation of facts must have extended the Darwinian teaching; and it is now quite clear that this has been the case with the two post-Darwinian principles known as "Substitution" and Isomorphism or "Convergence."

The former may be exemplified by nothing better than the case of the Rays and Skates, in which, under the usurpation of the propelling function of the tail by the expanded pectoral fins, the tail, free to modify, becomes in one species a lengthy whiplash, in another a vestigial stump, in others, by the development of powerful spines, a formidable organ of defense. In both the Rays and certain other fishes subject to the working of this law, modification goes further still, in the appearance of electric organs in remotely related genera and species, by specialization of the muscular system of the trunk or tail, or, as in the case of Malapterurus, of "tegumental glands." In this we have a difficulty admitted by Darwin himself, which now becomes clear and intelligible, since there is nothing new. There has simply come about the conversion, in one case of the energy of muscular contraction, in the other of glandular secretion, into that of electrical discharge, with accompanying structural change. The blind locust (Pachyramina fucifer) of the New Zealand Limestone caves presents an allied case, since here, under the reduction of the eye, the antennæ, elongated to a remarkable degree, have become the more efficiently tactile; and it is an interesting question whether this principle may not explain the attenuation of the limbs in the recently discovered American Proteoid (Typhlomolga Rathburni) of the Texan subterranean waters.

And as to isomorphism, by which we mean the assumption of a similar structural state by members of diverse or independent groups, I would recall the case of the Eocene Creodont Patriofelis and the seals, and that of the Myriapods to which I have already alluded, and would cite that of the Dinosaurs and Birds, heterodox though it may appear, for reasons I have given.

As our knowledge increases, there is every reason to believe that, in the non-appreciation of these principles in the past, not a few of our classifications are wrong. We have even had our bogies, as, for example, the so-called Physemaria, which deceived the very elect; and before I close I wish to deal briefly with a question of serious doubt, which these considerations suggest.

It is that of the position in the zoological series of the Limuloids, popularly termed the King Crabs. These creatures, best known from the opposite shores of the Northern Pacific, but found in the Oriental seas, as well as far south as Torres Strait, have been since 1829 the subject of a difference of opinion as to their zoological position and affinities. Within the last twenty years there have been three determined advances upon them, and of these the third and most recent may be first discussed. It has for its object the attempt to prove that they are intimately associated with the cephalaspidian and other shield-bearing fishes of the Devonian and Silurian epochs, and that through them they are ancestral to the Vertebrata. The latest phase of this idea is based on the supposed existence in a Cephalaspis of a series of twenty-five to thirty lateral appendages of arthropod type. When, however, it is found that the would-be limbs are but the edges of body-scutes misinterpreted, suspicion is aroused; and when, working back from this, an earlier attempt reveals the fact that the author, compelled to find trabeculæ, in order to force a presupposed comparison between the architecture of the Cephalaspidian head-shield and the Limulus' prosomal hood, resorts to a comparison between the structure of the former in general and that of the cornu of the latter, with details which on the piscine side are not to date, the argument must be condemned. It violates the first principles of comparative morphology, and is revolting to common sense; and as to the fishes concerned, we know that they have nothing whatever to do with the Limuloids, for we have already seen that, with their allies the Pteraspidiæ, they are a lateral branch of the ancestral piscine stem.

The second advance upon the king crabs has very much in common with the first. It has engrossed the attention of an eminent physiologist for the last six or seven years, and by him it was in detail set before Section I at our meeting of 1896. Suffice it to say that it specially aims at establishing a structural community between the king crabs and certain vertebrates, favorable to the conviction that the Vertebrata have had an arthropod ancestry. When we critically survey the appalling accumulation of words begotten of this task, it is sufficient to consider its opening and closing phases. At the outset, under the conclusion that the vertebrate nervous axis is the metamorphosed alimentary canal of the arthropod ancestor, the necessity for finding a digestive gland is mainly met by homologizing the so-called liver of the arthropod with the cellular arachnoid of the larval lamprey, in violation of the first principles of comparative histology! At the close we find ingenious attempts to homologize nerve tracts and commissures related to the organs of sense, such as are invariably present wherever such organs occur. Sufficient this to show that the comparison, in respect to its leading features, is in the opening case strained to an unnatural degree, in the closing case no comparison at all. Finding, as we do, that the rest of the work is on a par with this, we are compelled to reject the main conclusion as unnatural and unsound; and when we seek the explanation of this remarkable course of action, we are forced to believe that it lies in the failure to understand the nature of the morphological method. For the proper pursuit of comparative morphology, it is not sufficient that any two organisms chosen here and there should be compared, with total disregard of even elementary principles. Comparison should be first close and with nearly related forms, passing later into larger groups, with the progressive elimination of those characters which are found to be least constant. And necessary is it, above all things, that in instituting comparison it should be first ascertained what it is that constitutes a crustacean a crustacean, a marsipobranch a cyclostome, and so on for the rest. We have tried to accept this theory, fascinated both by the arguments employed and by the idea itself, which for ingenuity it would be difficult to beat, but we cannot; and we dismiss it as misleading, as a fallacy, begotten of a misconception of the nature of the morphological method of research. It is of the order of events which led Owen to compare a cephalopod and a vertebrate, led Lacaze-Duthiers to regard the Tunicata and Lamellibranchs as allied; and with these and other heresies it must be denounced.

Passing to the third advance, extending over the last twenty years, it may be said to consist in the revival of a theory of 1829, which boldly asserts that Limulus is an Arachnid. In the development of the defense there have been two weak points but lately strengthened, viz., the insufficient consideration of the palæontological side of the question and of the presence of tracheæ among the Arachnida. Under the former there was, until recently, assumed the absence of the first pair of appendages in the Eurypterida; but it may be said that they have since been observed in Eurypterus Fischeri of the Russian Silurian, and E. scoticus from the Pentland Hills, in both of which they consist of small chelate appendages flexed and limuloid in detail, somewhat reduced, perhaps, and inclosed by the bases of the succeeding limbs, which become apposed as the anterior end is reached. Since by this discovery the Limuloids, Eurypterids and Scorpionids are brought into a numerical harmony of limb-bearing parts, we may at once proceed to other points at issue. So far as the broader structural plan of Limulus and the Scorpion are concerned, all will agree to a general community, except for the organs of respiration; but concerning the cœlom, the mobile spermatozoa and the more detailed features under which Limulus is held to differ from the Crustacea and to resemble the Arachnida, I would remark that while motile spermatozoa are characteristic of the Cirripedes, the rest of the argument is weakened, by the probability that the "arachnidan" characters which remain may well have been possessed by the crustacean ancestors, and that Limulus, though specialized, being still an ancient form, might have retained them. The difficulty does not seem to me to lie in this, or with the excretory organs, if we are justified in accepting the aforementioned argument that the so-called Malpighian tubes may be inturned nephridia, ectodermal in origin, and in knowledge of the existence of endodermal excretory diverticula in the Amphipods. These facts would seem to suggest that as our experience widens, differences of this kind will disappear.

As to the tracheal system, now adequately recognized by the upholders of the arachnid theory, the presumed origin of tracheæ from lung-books, the probability that the ram's-horn organ of the Chernetidæ may be tracheal, the presence of tracheæ in a simple form in the Acari, and, by way of an anomaly, in a highly organized form on the tibiæ of the walking legs of the harvestmen (Phalangidæ), are all features to be borne in mind. While I am prepared to admit that this wide structural range and varied distribution of the tracheæ lessen their importance as a criterion of affinity, I cannot accept as conclusive the evidence for the assumed homology between lung-books and gills. And here it may be remarked that a series of paired abdominal vesicles, recently found in the remarkable arachnid Kœnenia, invaginate as a rule, but in one example everted, seized upon in defense of this homology, have not been so regarded by those most competent to judge.

There remains the entosternite, an organ upon which much emphasis has been placed. Not only does a similar organ exist, apart from an endophragmal system, in Apus, Cyclops, some Ostracods, and Decapods, but, regarding the question of its histology, it may be pointed out that, from all that is at present known, the structural differences between these several entosternites do not exceed those between the cartilages of the sepia body. And when it is found that the figures and descriptions of the entosternite of Mygale ("Mygale sp.," "Mygalomorphous Spider," auct.) have been thrice presented upside down, the reliability of this portion of the argument is lessened, to say the least.

Recent observation has sought to clench the homology of the four posterior pairs of limbs of the King Crab and Scorpion, by appeal to a furrow on the fourth segment in the former, believed to denote an original division into two; but I hesitate to accept this until myological proof has been sought.

Returning, amid so much that is problematic, to the sure ground of palæontology, I wish to point out that when all is considered in favor of the arachnid theory there still remains another way of interpreting the facts.

In both Limulus and the Scorpion the first six of the eighteen segments are well known to be fused into a prosoma bearing the limbs, but while in the Scorpion the remaining twelve are free, in Limulus they are united into a compact opisthosomal mass. In dealing with the living arthropods, there is no character determinative of position in the scale of this or that series more trustworthy than the antero-posterior fusion of segments. It has been called the process of "cephalization," and the degree of its backward extension furnishes the most trustworthy standard of highness or lowness in a given assemblage of forms. In passing from the lower to the higher Crustacea, we find this fusion increasing as we ascend; and it therefore becomes necessary to compare the Scorpion with the other Arachnida, Limulus with the Eurypterida, in order the better to determine the position of each in its respective series, by the application of this rule.

As to the number of segments present, variation is a matter of small concern, in consideration of the mode of origin of segmentation and the wide numerical range—from seven in the Ostracods to more than sixty in Apus—the segments of the crustacean class present.

On the arachnidan side, in the Solifugæ but the third and fourth segments are fused; the remaining four of the prosomal series with the ten which remain are free. In Kœnenia four of the prosomal segments alone unite; the fifth and sixth with the rest are free. And when we pass to the Limuloids and the descending series of their allies, we find it distinctive of the Eurypterida that all the opisthosomal segments are free. If we can trust these comparisons, we must conclude that the Eurypterida of the past, in respect to their segmentation, simplify the Limuloid type, on lines similar to that on which the Solifugæ and Kœnenia simplify the Higher Arachnid and Scorpionid type, and that therefore, if the degree of antero-posterior fusion of segments has the significance attached to it, Limulus and Scorpio must each stand at the summit of its respective series. If this be admitted, it has next to be asked if, in comparing them, we may not be comparing culminating types, which might well be isomorphic.

The scorpions are known fossil by two genera, Palæophonus and Proscorpius, from the Silurian of Gotland and Lanarkshire the Pentland Hills and New York State; while recent research, in the discovery of the genus Strabops, has traced the Eurypterida back to the Cambrian, leaving the scorpions far behind. One striking feature of the limbs of the Palæozoic Eurypterids is their constantly recurring shortness and uniformly segmented character, long known in Slimonia, and less conspicuously in Ptergotus itself, retained with development of spines in three of five known appendages of the recently described eurypterid giant Stylonurus. The minimum length yet observed for these appendages is that of the Silurian species Eurypterus Fischeri, discovered by Holm in Russia in

1898. This creature is one of the few eurypterids in which all the appendages are preserved, and it is the more strange therefore that the advocates of the arachnid theory should ignore it in their most recent account. Allowing for the specialization of its sixth prosomal appendage for swimming, the fifth is but little elongated, the second, third, and fourth are each in total length less, by far, than the transverse diameter of the prosoma, and uniformly segmented, giving the appearance of short antennæ. They seem to be seven-jointed, and are just such appendages as exist in the simpler crustacean and tracheate forms; and in the fact that their structural simplicity is correlated with the independence of the whole series of opisthosomal segments they lend support to the argument for isomorphism.

With this conclusion, we turn once more to the Scorpions, if perchance something akin to it may not be in them forthcoming. The Silurian genus Palæophonus, especially as represented by the Gotland specimen, reveals the one character desired. Its body does not appear to be in any marked degree simpler than that of the living forms; but on turning to its limbs, we find the four posterior pairs, in length much shorter than those of any living species, all but uniformly segmented. In this they approximate toward the condition of the limbs of the Eurypterida just dismissed, and their condition is such that had they been found fossil in the isolated state they would have been described as the limbs of a Myriapod, and not of a scorpion at all. Indeed, their very details are what is required, since in the possession of a single terminal claw they differ from the limbs of the recent scorpions as do those of the Chilopoda from the hexapods.

With this the scorpionid type is carried back, with a structural simplification indicative of a parallelism with the other arthropod groups; and while the facts do not prove the total independence of the scorpionid and limuloid series, they bring the latter into closer harmony with the Eurypterida of the past. They prove that the Silurian Scorpions simplify the existing Scorpionid type, on precisely the lines on which the Eurypterida simplify the Limuloid; and they do so in a manner which suggests that a distinction between the Crustacea vera and the Crustacea gigantostraca (to include the Eurypterida and Xiphosura) is the nearest expression of the truth. It becomes thereby the more regrettable that in a recent revision of the taxonomy of the Limuloids the generic name Carcinoscorpius should have found a place.

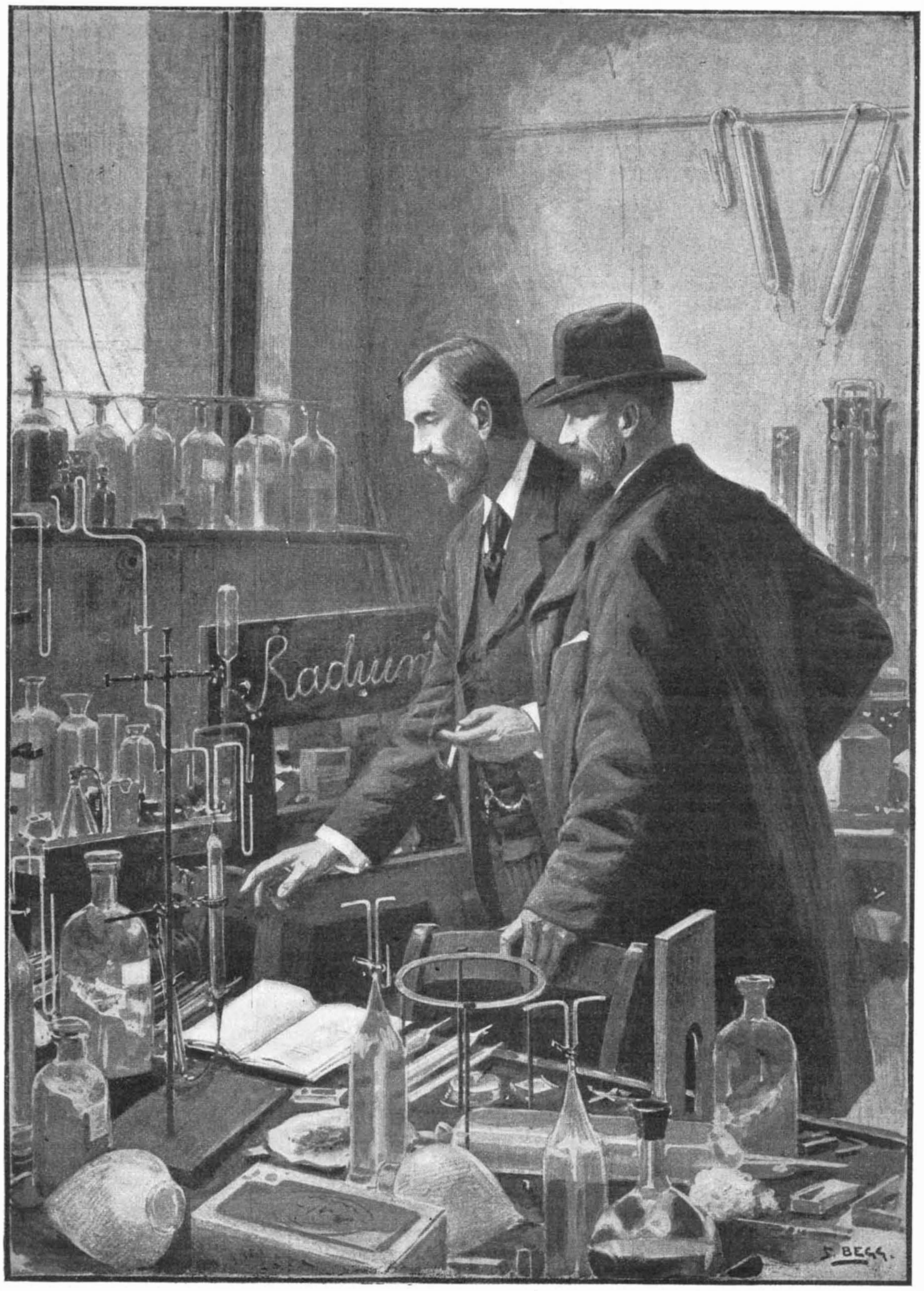
I foresee the objection that the antenniform condition of the shorter limbs may be secondary and due to change. There is no proof of this. Against it, it may be said that the number of the segments is normal, and that where nature effects such a change, elongation is with the multi-articulate state the only process known; as, for example, with the second leg of the Phrynidæ, the so-called second pareiopod of the Polycarpidea and the last abdominal appendage of Apseudes.

That advances such as we have now considered should lead to new departures is a necessity of the case; and it but remains for me to remind you that within the last decade statistical and experimental methods have very properly come more prominently into vogue, in the desire to solve the problems of variation and heredity. Of the statistical method, by no means new, I have but time to recall to you the Presidential Address of 1898 by my friend and predecessor in this chair, himself a pioneer; and of the experimental method I can but cite an example, and that a most satisfactory one, justifying our confidence and support. It concerns the late Prof. Milne-Edwards, who in 1864 described, from the Paris Museum, the head of a rock lobster (Palinurus penicillatus), having on the left side an antenniform eye-stalk. With the perspicuity distinctive of his race, he argued in favor of the "fundamental similarity of parts susceptible to revert to their opposite states." The matter remained at this till, on the removal of the ophthalmite of certain Crustacea, it was found that in regeneration it assumes a uniramous multiarticulate form; and it is an interesting circumstance that in the common crayfish the biramous condition normal to the antennule may occur. An example this of a fact which no other method could explain.

When all is said and done, however, it is to the morphological method that I would appeal as most trustworthy and sound. And when we find (1) that in certain compound Tunicates the atrial wall, in the egg development delimited by a pair of ectoblastic invaginations, in the bud development may be formed from the parental endodermic branchial sac; (2) that regenerated organs are by no means derivative of the blastemata whence they originally arose; (3) that in the development of a familiar star-fish the inner cells of the earliest segmentation stages, by intercalation among the outer, contribute half the fully-formed blastula; (4) that there are Diptera in existence in which, while it is well-nigh impossible to discriminate between the adult forms, there is reason to believe the pupa cases are markedly and constantly distinct; it becomes only too evident that the latter embryonic and adult states are those most trustworthy for all purposes of comparison, and that it is by these that our animals can best be known and judged. Caution is, however, necessary with senility and age, since certain skulls have been found to assume at this period characters and proportions strikingly abnormal, and by virtue of the most important discovery, which we owe to the Japanese, that in certain Holothurians the calcareous skeletal deposits may so change with age as to render specific diagnoses based on their presumed immutability invalid. Advance, real and progressive, is in no department of zoological inquiry better marked than comparative morphology, and it is for the preeminence of this that I would plead. Educationally, it affords a mental discipline second to none.

We live by ideas, we advance by a knowledge of facts, content to discover the meaning of phenomena, since the nature of things will be for ever beyond our grasp.

And now my task is done, except that I feel that we must not leave this place without a word of sympathy and respect for the memory of one of its sons, an earnest devotee to our cause. William Thompson, born in Belfast, 1806, became in due time known as "the father of Irish natural history." By his writings on the Irish fauna, and his numerous additions to its lists, he secured for himself a lasting fame. In his desire to benefit others, he early associated himself with the work of the Natural History Society, which still flourishes in this city. He was president of this section in 1843, and died in London in 1852, while in the service of our association, in his forty-seventh year, beloved by all who knew him. His memory still survives; and if, as a result of this meeting, we can inspire in the members of the Natural History and Philosophic Society of this city, as it is now termed, and of its Naturalists' Field Club an enthusiasm equal to his, we shall not have assembled in vain.



PROF. SIR W. RAMSAY, DISCOVERER OF THE TRANSMUTATION OF RADIUM TO HELIUM, DESCRIBING THE PROGRESS OF HIS RECENT WORK TO PROF. CURIE, OF PARIS, JOINT-DISCOVERER (WITH MADAME CURIE) OF RADIUM.

PROF. SIR W. RAMSAY AND PROF. CURIE.

NOT so long ago Prof. Curie, who with Mme. Curie discovered radium, read a lecture in London. His visit to England was the occasion of his meeting Sir William Ramsay, whose researches into the properties of radium have been no less remarkable than those of Prof. Curie himself. The picture which we herewith present is taken from the Illustrated London News.

INVENTION IN THE CYANIDE PROCESS.

THE cyanide process is one of the most interesting of all of those known to metallurgical science. For many years prior to its practical application in the treatment of ores it was known that dilute solutions of cyanide of potassium would dissolve minute particles of gold. Patents were taken out for a process to treat ores by this method, and since the first patents were taken out there have been a score or more of patents issued in the various countries of the world for modifications of the original process. No other process has stimulated the inventive faculties of those engaged in its practice to such an extent. The devices for the chemical manipulation and mechanical handling of the pulp are numerous, and many of these processes are successful on certain classes of ore, while others are equally so on other ores.

The one element which has presented the greatest difficulty, aside from certain base minerals contained in ores which render them difficult of treatment by the cyanide method, is the satisfactory working and mechanical handling of slimes. These are treated at the various works in a variety of ways. In one locality sliming the ore is avoided as far as possible. In another no objection is found in slimes. At one mill the slimes are separated from the sands and each class is treated separately, the former by percolation, the latter by one of the numerous schemes devised by the ingenious operators. At another mill slimes and sands are treated together and the operators report no particular difficulty. The fact that this is so, proves that the ores of various mining districts differ in a marked degree, but that this physical difference is not always perceptible to the eye.

The principal difficulty in treating slimes and sands together is reported to be due to the fact that an even distribution of the two classes of material is difficult to obtain. A slight interference in the flow of pulp

into the tanks, any temporary stoppage in the supply from the mill, results in the formation of a thin "floor" of more or less impervious slimes on the bed of sand beneath. A series of such interferences usually results in producing several thin sheets in succession, intercalated with the sands, rendering percolation slow if not impossible. To overcome this difficulty various kinds of distributors have been devised and are in successful operation. Where the sands and slimes are separated before treatment the sands rarely offer any difficulty in the passage of solutions, but the slimes problem is an ever present one, and numerous and ingenious are the devices improvised and applied in attempts to successfully meet the troublesome problem.

Decantation of solutions has been successfully practised on talc ores where the slimes were of infinitesimal fineness. By successfully is meant commercial success, though the tailings may still contain 40 per cent or 50 per cent of the original values. Where decantation is practical the solution is clarified by the addition of lime to the charge. As a matter of course this leaves a thick sludge in the bottom, which contains gold-bearing solution. The only way in which an additional portion of these values can be economically saved is by adding weak solution and reagitating and resettling the charge, and again decanting the liquor.

To treat slimes, and also to hasten percolation, one of the first devices employed was the vacuum filter. This was arranged by building a false bottom containing the filter in a steel tank, and attaching the vacuum pump to the chamber beneath. This resulted in successful treatment of some kinds of material, but with slimes the layer on the filter generally became too thick and dense to permit a long continued passage of the solution, so the charges had to be reduced to thin sheets to hasten the operation, but this was found to greatly reduce capacity.

The filter press was next tried, and in some districts this device in one or the other of its manifold forms is in successful use. In others its employment is said not to have been attended with satisfactory results. One device is simply an application of the vacuum pump to the treatment of slimes, and presents a large superficial area, which the original vacuum filters did not afford.

Experimentation is constantly in progress and newer and at present unheard-of devices may be expected in the future in the practical working of the cyanide process, for the field is broad.—Mining and Scientific Press.

LANDSCAPE GARDENING AT THE LOUISIANA PURCHASE EXPOSITION.*

By Mark Bennett.

The visitor will expect something unusual in landscape effects at the World's Fair, and he shall not be disappointed. From one glorious prospect he may pass to another. From one superb vista he may turn to revel in the exquisite beauty of others no less pretentious. In designing the landscape features of this great exposition, the architect in charge, Mr. George E. Kesler, has had ever in mind the central idea that this is a city of gigantic palaces, rather than a group of buildings set in a park. The treatment is therefore generally of a formal character, and the embellishment is along the borders of the thirty-five miles of roadways within the two square miles of exposition area.

The most elaborate of the formal gardening will be upon the slope of what is popularly known as the Cascade Gardens. These gardens are in the southern part of the central picture, south of the grand basin which lies between the Education and Electricity buildings, and will represent an expenditure of one million dollars. The feature is half a mile in length, extending in a long southern sweep around the end of the basin and the communicating lagoons. The slope is 300 feet wide, with a rise of 60 feet. The crowning feature is an elaborate architectural work of noble proportions and most exquisite and perfect detail. The combined genius of architect and artist is strongly in evidence in the magnificent masterpiece, which consists of several parts. The central part is a festival hall, of circular form, 200 feet in diameter and carrying the largest dome ever constructed, which towers 200 feet above the foundation of the building. Colonnades 52 feet high extend east and west from the festival hall and terminate in two restaurant pavilions, each 130 feet in diameter and 150 feet high. Each of the colonnades is divided into seven circular bays, before each of which will be placed a statue or sculptured group of heroic size to represent a State or Territory. The entire fourteen divisions of the grand Louisiana Purchase, in commemoration of whose acquisition the Exposition is held, will thus be represented in sculpture. The terrace upon which the statuary will stand is known as the Terrace of States, and overlooks almost the entire sweep of gardens and cascades.

The cascades are three in number, the central by far the largest. The water gushes from an artistic hood or fount, 20 feet above the level of the terrace, spreads out into a stream 45 feet wide and 14 inches deep, and leaps from wider to wider down the long slope, spreading to a width of 150 feet as it takes its final plunge into the grand basin. The other two cascades have their sources in fountains in the center of large basins upon the terrace opposite each of the restaurant pavilions. These cascades have nearly the same form as the larger one, and flow toward the central cascade into the grand basin. At night the cascade will be illuminated from beneath the water, the effect being that of luminous water.

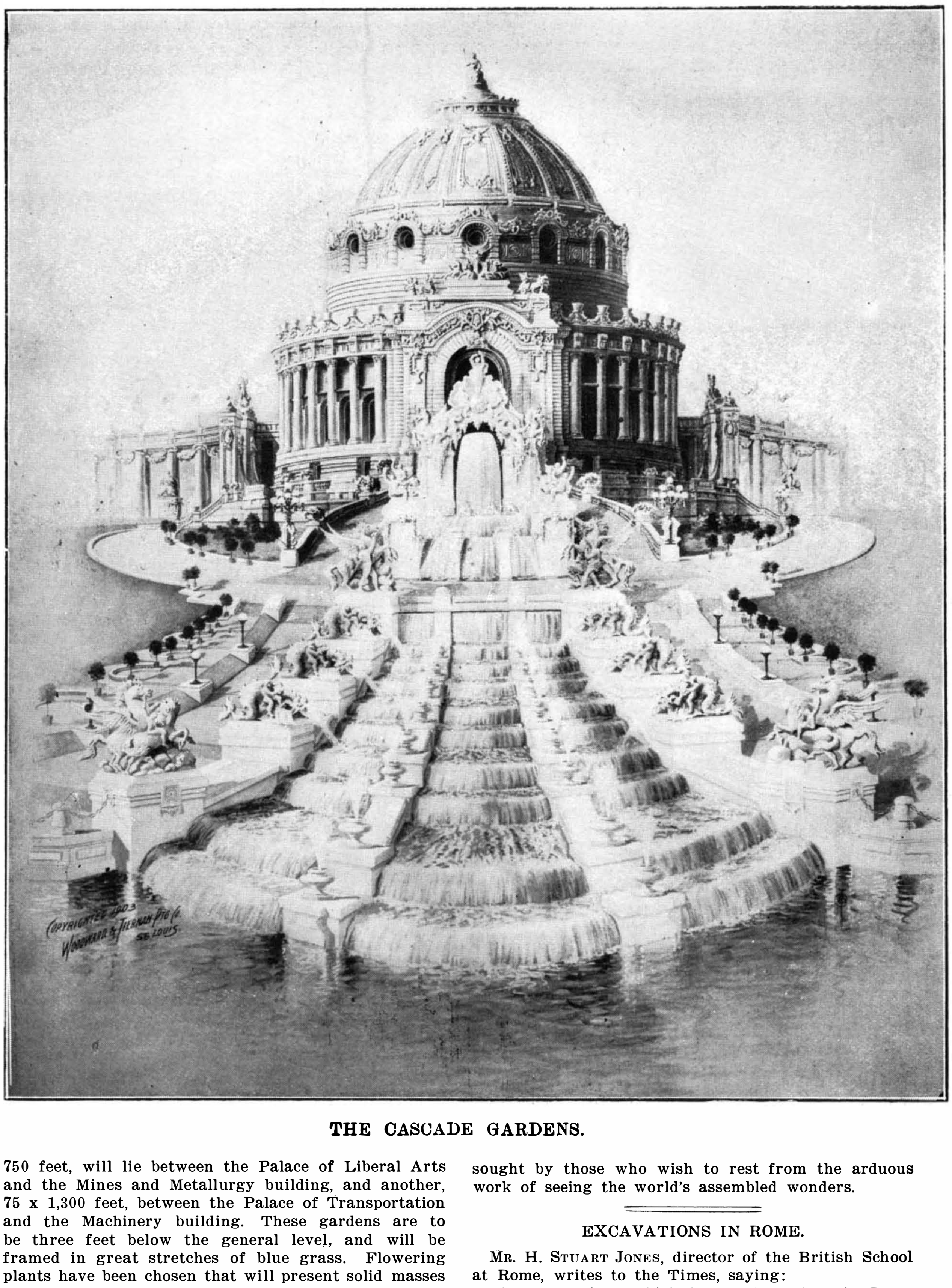
Between and beyond the cascades are the great lawns, with their rich embroideries of flowers. Cement walks and flights of easy steps are provided throughout the vast gardens, and a liberal use of sculpture completes the decorative detail. Seen from every point of view, the Cascade Gardens will hold the rapt attention of the visitor longer than any one feature of the great exposition. These gardens close the main avenue, which leads into the exposition from the northeastern entrance to the grounds, and every patron of the fair will have many a look at their changing beauty.

Another garden of especial prominence will be situated in front of the United States government building, in full view from the main transverse avenue. This garden is also upon a slope, so that its many beauties may be seen from the avenue as well as from the building above. The same advantage attaches to sunken gardens, which are to be features of the main transverse avenue. One of these bright gardens, 75 x 750 feet, will lie between the Palace of Liberal Arts and the Mines and Metallurgy building, and another, 75 x 1,300 feet, between the Palace of Transportation and the Machinery building. These gardens are to be three feet below the general level, and will be framed in great stretches of blue grass. Flowering plants have been chosen that will present solid masses of color and bloom the entire season, such as the phloxes, petunias, geraniums, and verbenas. Foliage plants will also be much used.

In the landscape work throughout the central picture large trees are a part of the decoration. These are from 12 to 18 inches through the trunk, and to secure them involved a formidable undertaking in transplanting. This work was done so successfully that every tree is flourishing. Long lines of big trees border the main avenue, and their bright green and ample shade add essential elements to the general picture.

The outdoor exhibits of the departments of horticulture and agriculture, the exhibits of the United States government and the gardens surrounding the pavilions erected by foreign governments and the various States all enter into the landscape picture. Some of these features will be very elaborate. France will have a reproduction of the garden of Versailles, surrounding the Grand Trianon, of which the French building is a replica.

Appropriate landscape embellishments will surround the British pavilion, which is a reproduction of the Orangery of Kensington Palace. East of the Palace of Agriculture are six acres planted in roses, more than 50,000 rose trees being there on exhibition. All told, more than 40 acres are given up to outdoor exhibits, upon grounds around the palaces of Agriculture and Horticulture. Among the features upon the slope north of the Agriculture building is a floral clock one hundred feet in diameter, giving the correct time. The outdoor exhibit of the Department of Agriculture of the United States occupies six acres and includes a map of the United States, indicating in useful plants characteristic of each State. The map is surrounded by exhibits of grasses, medicinal and poisonous plants. China, Japan, Germany, and other nations will have special landscape features. A large area of woodland is embraced in the exposition grounds, where the visitor may enjoy the coolness, if not the quiet restfulness of the forest. The State buildings will stand well among the big trees, and their verandas will be much sought by those who wish to rest from the arduous work of seeing the world's assembled wonders.



THE CASCADE GARDENS.

* Specially prepared for the Scientific American Supplement.

EXCAVATIONS IN ROME.

Mr. H. Stuart Jones, director of the British School at Rome, writes to the Times, saying:

The excavations which have taken place in Rome during the past summer have resulted in discoveries of considerable importance.

In the Forum Comm. Boni, whose patient and methodical explorations continue to merit the highest praise, has once more been richly rewarded. The great discovery of the year is that of a large base of concrete which must at one time have supported a colossal monument occupying a central position in the area of the Forum. The base measures about 40 feet by 20 feet, and in its lower portion some of the beams and planks used in setting the concrete are still imbedded. It blocks one of the subterranean galleries which Comm. Boni believes to have been constructed by Julius Cæsar in connection with gladiatorial shows. In the upper surface are imbedded three large travertine sockets, in which the supports of the monument were fixed. What, then, was this monument? Comm. Boni

does not hesitate to identify it as the *Equus Domitiani*, a colossal equestrian statue of Domitian, described by Statius in the Silvæ. The positions of the sockets, he argues, correspond with those of the legs of the Emperor's charger, one foreleg, of course, having been raised. There can, at any rate, be no question that the base occupies precisely the position assigned to it by the poet. The statue, which was probably destroyed after the *damnatia memoriæ* of Domitian, seems to have been about six times lifesize.

The interest in these discoveries is, however, far surpassed by that which attaches to the excavations on the site of the Ara Pacis Augustæ. The Ara Pacis Augustæ, which incorporated more fully than any other monument the spirit of the Golden Age, commemorated the return of Augustus from the western provinces in 13 B. C. and the completion of his proudest achievement, the establishment of the Pax Romana throughout the empire. The monument included not merely the Altar of Peace itself, but also the precinct in which it stood and the inclosing wall, whose sculptured panels form the masterpiece of Augustan sculpture. Along the outer face ran two bands of relief, the lower of which consists in conventional systems of branches, foliage, and flowers, instinct with animal life, while the upper and more important frieze represents a procession in which Augustus himself, with his family, as well as the great ecclesiastical dignitaries of imperial Rome, takes part, as well as scenes of sacrifice or of religious import. Numerous panels of the frieze have already been brought to light, and others may be expected to follow in due course. The main interest, of course, attaches to the band representing the procession; and here a slab of high importance has been unearthed in the last few days. The block fills a gap between two slabs, at present preserved in the Uffizi at Florence. It is not completely exposed to view, but it is beyond doubt that upon it were represented two, at least, of the greater *flamines*—perhaps the Flamen Quirinalis and the Flamen Martialis—with their attendants. Unfortunately, the work, which is being carried on under the able direction of Cav. Pasqui, is attended with great difficulties. The base of the monument lies not only 18 feet below the soil, but about 6 feet below the present level of spring water, which constantly streams into the excavations. Moreover, the foundation walls of the Palazzo Fiano Ottoboni and other buildings which traverse the area of the monument must be tenderly dealt with. The excavations will, therefore, shortly be suspended and the necessary work of underpinning, etc., preparatory to their resumption in the spring will be begun. The remains of the Ara Pacis must, therefore, for the present remain under water.

WHY A FLAME EMITS LIGHT—THE DEVELOPMENT OF THE THEORY.

By Prof. ROBERT MONTGOMERY BIRD, Ph.D., University of the State of Missouri.

As one would naturally suppose, the theory now generally held regarding the nature of an ordinary flame and its power to emit light is not altogether the result of modern research, but one which has been evolved from very ancient and hazy notions. Naught else is to be expected when we consider the important place fire has held throughout the development of mankind. It is the first recorded object of his worship, and we have reason to believe that all architecture had its beginning in rude structures erected to protect the sacred fire. It is not the nature of man to see phenomena so striking as those which attend the consumption of matter by fire and not speculate upon them. But the centuries had multiplied and modern times had been reached before man's ideas regarding fire, flame and light became distinct, and the use of these terms differentiated. The best text-books and works on natural philosophy published near the end of the eighteenth century still used the terms with great looseness, and the conceptions of the material nature of flame and light were yet in their death struggles.

After the corpuscular theory of light had given place to the wave theory, conflicting ideas arose as to why and how a flame emits light waves. When it was agreed that the waves were sent out by solid particles of carbon heated to incandescence, the question of the origin of the carbon, or the chemical changes taking place in the flame, was discussed, and along with this the source of heat which renders it incandescent. The last and most generally accepted answer to these two questions—the origin of carbon particles and the source of heat—is given in the "acetylene theory," first advanced in 1892 by Prof. Vivian B. Lewes, of England.

This theory expressed briefly is that a portion of the hydrocarbon gas, by the heat of combustion of another portion, is converted into acetylene, and that this on being decomposed by heat furnishes the carbon particles, which particles are rendered incandescent mainly by the heat liberated when the gas is decomposed; acetylene being a substance which absorbs heat during its formation and hence liberates heat when it breaks down. Whatever is burned, whether a solid candle or liquid oil, must pass through the gaseous state, and hence this applies to all flames used for lighting purposes.

But before explaining this theory more fully and seeing upon what experimental evidence it is based, it would be well to consider its genesis and briefly recall the ancient notions regarding "artificial" light.

Light was first confused with seeing, and it is said that up to the time of Aristotle men commonly thought they saw by reason of something shooting out from the eyes and coming in contact with objects; the converse of the Cartesian conception of many centuries later, that certain movements in bodies cause them to shoot out minute particles in all directions, which, striking the eye or causing "globules" of air to strike it, excite vision.

The fluid nature of fire and the corporeal nature of light, which were believed in throughout the early and middle ages, seem to have been first doubted by Sir Francis Bacon about the end of the sixteenth century, although he was by no means sure that these conceptions were wrong. Bacon classed together the light from flames, decayed wood, glowworms, silks, polished surfaces, etc., and said that inasmuch as some animals can see in the dark, air has some light of itself. Boerhaave, somewhat later, also expressed doubts as to the substantive nature of fire.

Among the first recorded experiments upon the nature and action of luminous flames are those which were carried out by Sir Robert Boyle between 1660 and 1670. He attempted to prove by experiment whether the light from a flame is like that from the sun, and whether it is corporeal or merely a quality. He allowed a flame to play on metals directly and also when in open and sealed vessels, and because the substance formed a calx and gained in weight, he thought that the light or flame (he uses the terms indiscriminately) had combined with the metal, and hence it must be a fluid. Boyle also conducted a large number of experiments upon live or "quick" coals, phosphorescent bodies, animals and insects to see the effect of exhausting a receiver in which they were placed, and he seems to have concluded that the lights from live coals, rotten wood and putrefying fish differ not in kind but only in degree. He considered that the increase of light from coals, etc., and the reviving of certain insects when air was readmitted to the receiver, indicated a relation between a visible flame and the so-called "vital flame." But he would not commit himself upon the question of the supposed kinship between the "flame" from live coals and rotten wood and the "vital flame" thought to be burning in the hearts of all living beings.

The interesting views of Sir Isaac Newton are set forth in a number of queries published in his work entitled "Optics." As is well known, Newton believed in the material nature of light, and he asserted that the change of light into matter and of matter into light is an acknowledged possibility and of common occurrence. He attributed the light which appears when a body is rapidly and repeatedly struck or when heated beyond a certain point, as when flint and steel are struck together, etc., to vibrations of the parts of the body so rapid as to throw off the particles which, according to Newton's idea, occasion the sensation of light. With these he also classed electric sparks, saying that the "electric vapor" excited by rubbing glass against a strip of paper or the end of the finger held to it is thereby so agitated as to cause it to emit light. He thought the light from glowworms and putrefying matter was of the same kind as the above, and said that the light seen at night in the eyes of certain animals, cats for instance, is "due to vital motions."

Regarding true luminous flames Newton's ideas were nearer those of the present time. He wrote, "Is not fire a body heated so hot as to emit light copiously? For what else is a red hot iron than fire? And what else is a burning coal than red hot wood?" "Is not flame a vapor, fume or exhalation heated red hot, that is, so hot as to shine? For bodies do not flame without emitting a copious fume, and this fume burns in the flame. Metals in fusion do not flame for want of a copious fume." "All fuming bodies as oil, tallow, wax, wood, etc., by fuming waste and vanish into burning smoke." "Put out the flame and the smoke is visible, it often smells; and the nature of the smoke determines the color of the flame." "Smoke passing through flame can not but grow red hot, and red hot smoke can have no other appearance than that of flame."

During the hundred years, more or less, following the publication of Newton's views there was little change in the prevailing theories. Stahl said "flame is light" liberated from bodies in the act of combustion, and that light and heat are the constant attendants of fire; fire combined with combustible matter was "phlogiston." Scheele said light, heat and fire are combinations of air and "phlogiston." Lavoisier thought flame to be light disengaged from air, with which it had been in combination, and this idea seems to have been adopted by most of the French chemists.

There might be mentioned in this connection the queer ideas regarding our being able to see objects, and the emission of light by incombustible bodies, which were held during the latter half of the eighteenth century. As expressed by Macquer, and quoted by Fourcroy,* "The vibrations (under the impulse of more or less heat) dispose the particles (of bodies) in such a manner that their faces, acting like so many little mirrors, reflect upon our eyes the rays of light which are in the air by night as well as by day; for we are involved in darkness during the night for no other reason but because they are not then so directed as to face our organs of sight."

At a single step we pass from the rather crude ideas of the older thinkers to those ideas which obtain at the present day, and the transition finds little expression in the literature.

About the year 1816 Sir Humphry Davy advanced what has been known ever since as the "solid particle" theory of luminosity; a theory which went unchallenged for forty-five years and was accepted by practically every one.

He was experimenting upon the combustion taking place in his famous safety lamp and said, "I was led to imagine that the cause of the superiority of the light of a stream of coal gas might be owing to the decomposition of a part of the gas toward the interior of the flame, where the air is in smallest quantity, and the decomposition of solid charcoal, which, first by its ignition and afterward by its combustion, increased to a high degree the intensity in the light; and a few experiments soon convinced me that this was the true solution of the problem." "Whenever a flame is remarkably brilliant and dense, it may always be concluded that some solid matter is produced in it; on the contrary, whenever a flame is extremely feeble and transparent it may be inferred that no solid matter is formed." The idea that solid carbon in the flame is the source of its light was not original with Davy—he says it was suggested by a Mr. Hare—but it was Davy's investigations which put it on a firm basis and he formulated the theory.

Davy showed the relation between the heat and light of flames, the effects of rarefaction and compression of the surrounding air and the influence of cooling and heating. He pointed out also that a luminous flame will deposit carbon on a cold surface, and if rendered non-luminous no carbon can be obtained. These conclusions were immediately accepted and were not seriously disputed until the appearance in 1861 of a communication to the Royal Society from E. Frankland.

In this article Frankland advanced what has come to be known as the "dense vapor" theory. He and his adherents claimed that, although solid particles in a flame do cause it to emit light, the light from our ordinary illuminating flames is dependent to a great extent upon the presence of dense, transparent, hydrocarbon vapors from which it is radiated, and is not due to the presence of incandescent solid carbon particles. They further claimed that the soot deposited is not carbon, but a mixture of dense hydrocarbons of remarkably high boiling points.

Frankland was led to take up his investigations by seeing a report that candles burned at the same rate on the top of Mont Blanc as in the valley at its foot; and a second report regarding the retardation of the bursting of shells with time fuses at high elevations in India.

Besides carrying on investigations in artificially rarefied air in his laboratory, he climbed to the top of Mont Blanc with a goodly supply of standard candles and timed their slow wasting away; probably keeping warm in the meantime by the fire of his enthusiasm. Many interesting facts were brought to light by these investigations, but his use of them in interpreting the causes of luminosity in ordinary flames led him into error, and, although he found adherents at the time, his views have long since been replaced by those based upon more careful observation. The importance of the work of Frankland lay not so much in what he did as in what he led others to do; and since the publication of his views a great deal has been done by Heumann, Stein, Smithells, Burch, Lewes and others.

Stein disproved Frankland's assertion that soot is a mixture of dense hydrocarbons by showing that it can not be volatilized even by great heat, and that it contains only about nine tenths of one per cent of hydrogen, which can be separated from it only at high temperatures in an atmosphere of chlorine.

Nor did Frankland's view that glowing, dense vapors cause the light appeal to Heumann, who thought it unlikely that such dense vapors exist in a flame or that there is a sufficiently high temperature to cause them to glow. He knew, of course, that at a temperature like that of an electric arc many gases do glow and give continuous spectra, and that a highly heated gas under pressure acts likewise; but he argued that if carbon really does exist as such in a flame, it most probably is the source of luminosity. To prove its presence or absence he studied the effects upon a flame of heating and cooling it, of diluting and varying the temperature of the gases supplied to it, its transparency and the shadows cast by it, as well as other phenomena; and the results of his experiments led him to give unqualified support to the theory of Davy.

Some account of the salient features at least of Heumann's elaborate investigation must be given in order to convey any idea of his part in firmly fixing the "solid particle" theory. By allowing a luminous flame to play upon a surface which rapidly conducted heat away from it, like a platinum dish, its luminosity was destroyed. Heating the upper surface of the dish restored the luminosity, and hence Heumann concluded that cooling a flame diminishes its light-giving properties, while heating increases them. He varied the temperature of illuminating gas before it reached the burner and found that the same effects were produced. The heating in some cases increased the normal light-giving power as much as a hundred and twenty-five per cent. Further investigation showed that luminosity can also be diminished or destroyed by rapid oxidation of the hydrocarbons, as well as by diluting them with a neutral gas like nitrogen or carbon dioxide; the effect of dilution being to necessitate a higher temperature for luminosity. He next rendered a flame non-luminous by cooling, introduced chlorine into it to break down the hydrocarbons, and obtained a brilliant light. A porcelain pot introduced into the lower part of a flame cooled it and decreased its light, but collected no carbon, while, if introduced into the upper part, its *under side* became coated with soot. Heumann argued that if Frankland was right and the light is reflected from dense hydrocarbon vapors, these should be condensed on all sides of the rod at once in a quiet flame, while, as a matter of fact, soot was de-

* Fourcroy's "Chemistry," press date 1796.

posited only on the under side, and furthermore, soot can also be collected upon a surface too hot to condense hydrocarbons at all. He therefore concluded that the surface merely stops carbon which is formed lower down in the flame. If one luminous flame is allowed to play against another, the carbon is rolled up and can be seen as glowing particles in the outer non-luminous sheath.

Frankland has said that flames cannot contain solid particles because they are transparent. Heumann pointed out that thick flames are opaque and that thin ones are no more transparent than is an equal layer of soot rising from burning turpentine; the rapidity of the motion of the particles preventing any obstruction to the view, just as is the case with a rapidly revolving, spoked wheel.

Heumann next took up the phenomena of shadows and showed that the luminous portion casts a definite shadow when interposed between sunlight and a screen, and that the shadow is continuous for a luminous turpentine flame and the column of soot above it. And further, that a hydrogen flame which ordinarily casts no shadow and gives no light will cast a sharp shadow and emit a fairly bright light if passed through suspended lampblack or if it sweeps any solid matter into the flame. Luminous vapors do not cast shadows, absorption bands being very different from true shadows.

C. J. Burch found that when sunlight is reflected from a luminous flame it is polarized, while if reflected by glowing vapors, however dense, it does not exhibit this phenomenon. Sunlight which was reflected and refracted by luminous flames was found to exhibit phenomena identical with that reflected and refracted by non-luminous flames rendered luminous by the introduction of solid matter, and also with light reflected and refracted, by the very finely divided solid matter held in suspension in a liquid. The phenomena presented by like experiments with glowing vapors were totally different. All of Burch's work was confirmed by Stokes some years later.

There was now left no shadow of doubt about carbon being the source of the light rays, and the next question that concerned investigators was the chemical changes which give rise to carbon particles.

Sir Humphry Davy thought the separation of carbon to be due to a decomposition of the hydrocarbon compounds (of which all illuminants are composed) within the flame where the air is in smallest quantity, and no other cause was assigned by other investigators. Prior to 1861 the view, it seems, was that carbon is liberated because of a supposed greater affinity of oxygen for the hydrogen of the hydrocarbon than for the carbon, there not being enough for both. But these points had to be tested.

In the study of the chemical changes that take place, a flame burning at a circular orifice offered the best conditions. As explained in text-books of chemistry, such a flame may be thought of as being made up of an inner, faintly luminous cone fitting into an outer, brightly luminous one—as a finger fits into a glove finger—this latter being surrounded by a non-luminous sheath of water vapor and carbon dioxide. It was desirable to separate these two cones, in order to study the gas after it had left the inner cone and before any change had been brought about by the conditions existing in the outer cone. This separation was first accomplished by Techlu, in France, and Arthur Smithells, in England, working independently, with a piece of apparatus, the essential features of which are pictured in cross-section in Fig. 1. By a proper control of the relative proportion of gas and air the inner cone was made to burn at the orifice *i*, while the outer cone burned at the orifice *o*. The outer cone got its oxygen from the surrounding air, while that for the lower flame was supplied along with the gas. The temperature of each cone was measured and the gases entering and leaving each were analyzed. It was found that as the proportion of gas to air was increased, the tip of the inner or lower cone became *brightly* luminous and a column of soot passed upward through the tube, becoming *faintly* luminous in the outer edge of the upper flame. As soon as the inner cone becomes luminous the unsaturated* hydrocarbon compound known as acetylene begins to appear among the gases passing to the outer cone.

Vivian B. Lewes now attacked the problem as to how carbon comes to be in the flame in the free state. He analyzed gas drawn from different parts of a coal-gas flame, measured the temperature of its different parts, etc., publishing his results between 1892 and 1895. These results may be stated as follows: Coal-gas consists mainly of a mixture of hydrogen and hydrocarbons, both saturated and unsaturated. In an ordinary "fishtail" burner flame all hydrogen is consumed before the middle of the luminous portion is reached. Of the *saturated* hydrocarbons about seventy-five per cent disappears as such in the dark portion and about twenty-four per cent is lost in the lower half of the luminous part. In the dark part there occurs a transformation of saturated into unsaturated hydrocarbons, along with a general breaking down of all to yield products less rich in hydrogen and the oxides of carbon. At the point where luminosity just begins, seventy to eighty per cent of the unsaturated compounds is acetylene, although less than one per cent was originally present. No acetylene could be found in the flame when it was made non-luminous.

By causing pure gases to pass through tubes heated to known temperatures and analyzing the products formed, Lewes studied the effects of heat upon both saturated and unsaturated hydrocarbons. At 800 deg. C. an unsaturated compound, like ethylene, C_2H_4, breaks down into hydrogen and the still more unsaturated acetylene, C_2H_2. At 1200 deg. C. the very stable, saturated hydrocarbons decompose into acetylene and hydrogen, and the acetylene in turn decomposes into carbon and hydrogen. Even very dense hydrocarbons decompose at 1200 deg. C. These results strengthened Lewes's conviction that under the baking action of the flame-walls in the lower portions acetylene is produced in relatively large quantities and that this is the source of the carbon.

The question which immediately presented itself was, Does there exist in an ordinary flame such conditions of temperature as may bring about the formation of

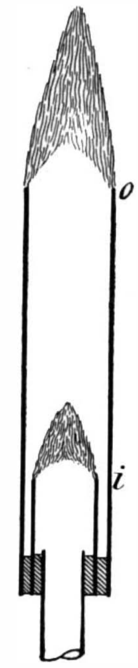


FIG. 1.

acetylene from the very stable constituents of the illuminants? On measuring the temperatures at various places the necessary temperatures were found to exist.

The work was complete and conclusive and forced a general acceptance of the theory that acetylene is the immediate source of the carbon.

But a yet harder problem presented itself. What gives rise to heat sufficient to make the carbon become incandescent?—a burning question certainly, and one not easy to answer.

From the time of Davy to the year 1892 the only opinion was that the burning hydrogen, carbon monoxide and hydrocarbons furnished the heat necessary to raise carbon to incandescence. In that year Lewes advanced his "latent heat" theory. This theory declared that the latent heat set free when acetylene is decomposed instantly heats the carbon particles thus set free to incandescence.

After showing that the heat of combustion of a flame is only sufficient to render carbon faintly luminous, Lewes compared the temperatures of flames burning coal-gas, the unsaturated hydrocarbon gas, ethylene, and the still less saturated acetylene, and also the amount of light given by each when burning equal volumes of gas per hour from burners best suited to each. He likewise studied the temperatures developed when acetylene is exploded and the localization of the heat set free by its decomposition. His experiments were ingenious and convincing. By comparing ethylene, C_2H_4, with acetylene, C_2H_2 (where for equal consumption the same number of carbon atoms were present), and also with coal-gas, it was seen that

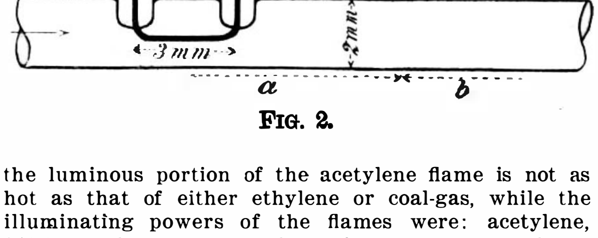


FIG. 2.

the luminous portion of the acetylene flame is not as hot as that of either ethylene or coal-gas, while the illuminating powers of the flames were: acetylene, 240.0 candle power, ethylene, 65.5 c.p., and coal-gas, 16.8 c.p. Evidently the heat of combustion does not account for the incandescence of the carbon; for if it did, the cooler acetylene flame would give less light, while, as a matter of fact, it gives twice as much as the ethylene and about fourteen times as much light as the very much hotter coal-gas flame. It was evident that our temperature measuring instruments do not detect the heat of the carbon particles themselves.

To see if luminosity be even partly due to the latent heat of acetylene, Lewes exploded that gas in a closed tube. This was done by wrapping a bit of fulminate of mercury in tissue paper and suspending it by copper wires joined by platinum in contact with the fulminate, and passing an electric current. There followed a brilliant flash of light and a complete decomposition of the gas, and of the eudiometer as well. Pieces of glass were coated with carbon, and the tissue paper was not scorched except in a small hole where the explosion of the fulminate had burst through. This experiment showed the formation of carbon, the emission of a brilliant light and the localization of the heat liberated. But as the decomposition in a flame can hardly be as rapid as in this experiment, and as hydrogen and oxygen also give a feeble light when exploded, he sought to detect the rise in temperature at the moment of decomposition when this is caused by heat. He arranged a thermo-couple in a small tube so that only the turn of wires was exposed, and after sweeping out the air passed a slow current of acetylene through the tube, the arrangement being as shown in Fig. 2. The heat was raised throughout the tube at a rate of about 10 deg. C. per minute, and almost as soon as the temperature of area *a* passed 800 deg. C. it took a sudden leap to 1,000 deg. C., the gas burst into a lurid flame and streams of carbon passed on through the tube. Although the temperature of area *b* was made considerably higher than *a* the carbon passing through it was not luminous. This experiment would seem to leave no doubt that the incandescence is caused by latent heat, yet further evidence was produced. In another experiment in which diluted acetylene was used it required a higher heat to cause the decomposition and luminosity. This latter is the condition existing in a flame, and the temperature there found is above that required. In other experiments it was found that if the flame temperature were high enough the luminosity was directly proportional to the amount of acetylene in the flame *at the point where luminosity generally begins*. Acetylene was introduced at the corresponding place in a non-luminous flame through very fine holes in a small capillary platinum tube, and the rate of its flow, as well as that of the illuminating gas, was measured and controlled so as to have present the amount of acetylene, which analysis showed to exist in a similar luminous flame. At the holes there was an intense light, and dull red streams of carbon passed upward in the flame.

Lewes sums up his conclusions, drawn from all his work, about as follows: When the hydrocarbon gas leaves the jet at which it is burned, those portions which come in contact with the air are consumed and form a wall of flame, which surrounds the issuing gases. The unburnt gas in its passage through the lower heated area undergoes a number of chemical changes, brought about by the heat radiated from the flame walls; the principal change being the conversion of hydrocarbons into acetylene, hydrogen and methane. The temperature of the flame rapidly increases with the distance from the jet and reaches a point at which it is high enough to decompose acetylene into carbon and hydrogen with a rapidity almost that of an explosion. The latent heat so suddenly set free is localized by the proximity of carbon particles, which by absorbing it become incandescent and emit the larger part of the light given out by the flame; although the heat of combustion causes them to glow somewhat until they come into contact with oxygen and are consumed. This external heating gives rise to little of the light.

There have been opponents to this theory of the cause of luminosity—as there are, fortunately, of all theories—but the evidence is so strong and covers so many points, and so many investigators have confirmed one part or another of the work, that it has been generally accepted as a true statement of the facts with which it deals.—Popular Science Monthly.

CONTEMPORARY ELECTRICAL SCIENCE.*

VOLTA EFFECT.—G. C. Simpson constructed a cage of galvanized iron gauze one meter square, and suspended wires, plates, or gauzes of various metals inside it, connecting them by means of a wire of the same metal with one pair of quadrants of an electrometer whose other quadrants were earthed. The cage was earthed also, and served to eliminate any external electric field. After an hour or two, the electrometer showed a constant deflection, which differed in sign and in amount from one metal to another. The readings were as follows: Copper, 0.70 volt; iron, 0.4; tin, 0.25; lead, 0.23; magnalium (magnesium-aluminium alloy), —0.28; and sodium, —0.7 volt. It will be noticed that the numbers agree very well with Volta's differences of potential between these metals and zinc, the zinc being represented by the case. The final readings of the electrometer could be much accelerated by increasing the ionization by means of Röntgen rays.—G. C. Simpson, Phys. Zeitschr., June 1, 1903.

WEHNELT INTERRUPTER.—E. Hauser has found that the rate of interruption of the Wehnelt interrupter may be greatly increased, and its starting potential lowered, by employing dilute sulphuric acid, and adding to it 20 per cent. of its weight of sulphate of magnesia. Taking sulphuric acid solution of specific gravity 1.050, the maximum current is lowered from nearly 40 amperes to 12.5 amperes at 118 volts, and the starting of the interrupter occurs at 20 volts with 5.5 amperes. A still lower starting current is obtained with a half-saturated solution of sodium bichromate to which 11 per cent. by volume of sulphuric acid is added. In that case the interrupter works with only 3.5 amperes. But the starting voltage is much higher (50 volts) than in the case of magnesium sulphate. The depolarizing liquid used in the Radiguet cell, consisting of 120 grammes sodium bichromate, 250 cubic centimeters sulphuric acid, and 720 cubic centimeters water, gives a starting voltage of 20, a starting current of 12 amperes, and a maximum voltage and current of 118 and 40 respectively.—E. Hauser, Soc. Fisica y Quimica, Madrid, May 25, 1903.

* The terms "saturated" and "unsaturated" have reference, among other things, to the relative quantity of hydrogen to carbon in the molecule, an unsaturated compound having relatively less hydrogen than a saturated one.

* Compiled by E. E. Fournier d'Albe in the Electrician.

THE ARNOLD ELECTRO-PNEUMATIC RAILWAY SYSTEM: ITS APPLICATION AND EXPERIMENTS THEREWITH IN CONNECTION WITH THE LANSING, ST. JOHNS & ST. LOUIS RAILWAY.

By BION J. ARNOLD.

[IN a preliminary statement Mr. Arnold alludes to his persistent advocacy of the use of the alternating current directly in motors for electric railways, for several years past, and to the fact that but few engineers in this country advised it. Only recently has the three-phase system been advocated and demonstrated abroad, but now important advances have been made in the development of a single-phase system, which is expected to work a revolution in electric railway work.

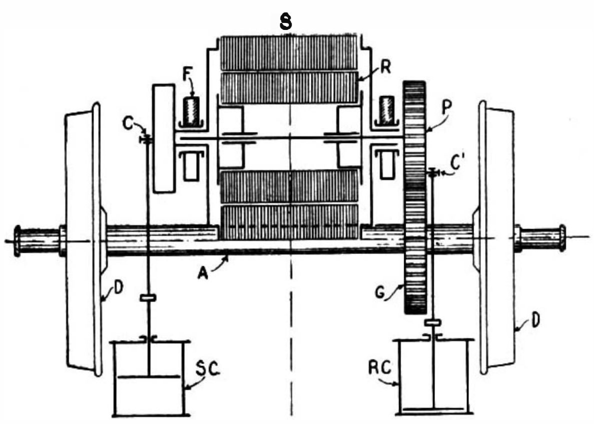


FIG. 1.—DIAGRAM OF TRUCK.

Since the announcement of the principles of his single-phase system before the Great Barrington convention Mr. Arnold has been conducting experiments on a large scale at his own private expense, expecting to celebrate the incoming of the year 1904 with a public demonstration over a road twenty miles long, with the idea of showing that a single-phase electric railway is not only operative, but efficient, and less costly than any other system of the direct-current type. But his expectations were met by disappointment, in consequence of a destructive fire occurring on December 18, 1903, at Lansing, Mich., in the car barns, which destroyed two new cars built for his system, and so damaged an experimental electric locomotive as to render it inoperative, thereby necessitating an abandonment of the proposed test.

Mr. Arnold is convinced from experiments so far conducted that the year 1904 will be an epoch-making one, marking a revolution from the direct-current to the alternating current for railway work. He predicts there will be a beginning on a large scale of the displacement of the steam locomotive on railways by the use of a substantial form of overhead construction, rather than the third rail. He intends to give the results of his experiments at a later date before the American Institute of Electrical Engineers. In January, 1900, he examined a route for a road between Lansing and St. Louis, Mich., a distance of sixty miles. By November 15, 1901, twenty miles of road were completed to St. Johns, Mich., over which steam trains were operated. After much delay the electrical equipment was completed for this section by December 15, 1902.

On June 15, 1903, two trips were made, each three miles long, with his first experimental machine. On the first trip seven persons were carried, and thirteen on the second.

The correctness of the theory of the operativeness of the improvement was demonstrated; but owing to the somewhat crude electro-pneumatic motor, full and efficient tests could not be obtained. Since these trials a double-equipped truck has been perfected, which was built in the form of a locomotive, and this was entirely completed with test instruments, ready for operation, when the fire occurred. The main economy claimed consists in keeping a constant, uniform load on the motor. Mr. Arnold now describes fully his system as explained below. We are indebted to him for plans, photographs, and details.—ED.]

ROADBED AND TRACK.

The Lansing, St. Johns & St. Louis Railway was originally projected to extend from Lansing, the capital of Michigan, northward through St. Johns, Alma, and St. Louis, a distance of about sixty miles, but up to the present time only that portion extending from Lansing to St. Johns, a distance of twenty miles, has been constructed.

This road was built in accordance with steam railroad practice, with easy grades and curves, so that steam locomotives could be operated over it until such time as electrical equipment could be put upon it; the idea being to complete the road in such a manner that it could be utilized for both freight and passenger service, and thus secure all the business available from the territory through which it passes.

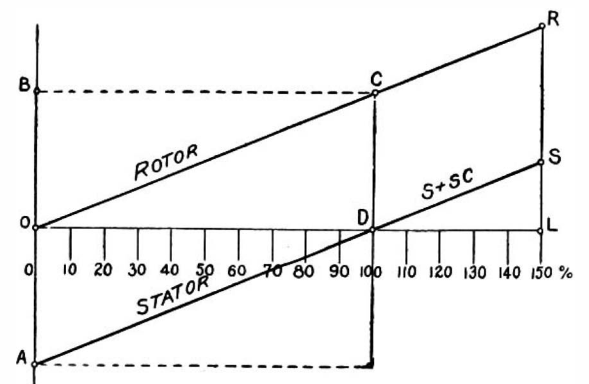


FIG. 2.—DIAGRAM OF OPERATION.

The road is equipped with 67-pound T-rails, laid on ties spaced 2 feet apart between centers, and as alternating high-tension current was to be used, but one of these rails was bonded with 38-inch 4/0 bonds extending entirely around the splice bars.

Since it was impossible to secure rails from the rail manufacturers in time, rails and splice bars were secured from one of the leading steam railways, and this necessitated the adoption of a supported joint and a long bond, as there was not room under the splice bars for concealed bonds.

The road as at present constructed between Lansing and St. Johns has no grades exceeding 1 per cent, and no curves exceeding 7 degrees, except in the cities themselves, where the terminals of the road run over the streets and make such curves as ordinary street cars make, the minimum radius being 50 feet. At each city a terminal was planned, so that all freight would be diverted to connecting steam roads, thus making it unnecessary for the freight service to pass over the city streets or curves.

At the Lansing end it was necessary to pass over the steam railway tracks of the Pere Marquette Railroad, and this necessitated the construction of a bridge, with pile approaches. The grade as approached from the Lansing end was 4 per cent for a distance of about seven hundred feet, and after passing over the bridge the descending grade is 2.3 per cent for about five hundred feet. At the St. Johns end there is a grade on the principal street of the town averaging about 2 per cent for about fifteen hundred feet.

OVERHEAD CONSTRUCTION.

Considerable care was taken in planning a suitable insulator for carrying the trolley wire, an annealed glass insulator being used.

In the overhead construction wood is used for the pole, crossarm, and brace, and the insulator is supported by means of a short span wire from iron brackets secured to the wooden crossarm. This construction insures a high insulation at a low first cost, the entire line having been constructed at but a slightly increased expense over the cost of standard construction, and at the same time so built that in case of failure of the alternating motor system the standard direct-current motor system could be put into service without changing any parts. Even holes for the pins for carrying the extra feeders which would be required were provided.

The line and track work were constructed in such a manner that no expense was incurred for any parts which would not be required for standard construction in case it became necessary to ultimately adopt the standard direct-current motor system; the entire idea in the construction of the road being to save first cost and to invest all that was invested in such a manner that all material purchased would be utilized in case either system were adopted; and should the alternating system prove successful, the additional investment for a direct-current motor system need not then be installed.

The working conductor was placed twenty-two feet above the top of the rails, in order that trainmen when standing upon the tops of the freight cars going over the road could not come in contact with the working conductor.

It was planned to operate the entire road from a single 00 trolley wire, and with one rail bonded as hereinbefore mentioned; this amount of copper being sufficient to operate four 40-ton cars at an average speed of thirty miles per hour with power house located one and one-half miles from one end of the line, and operating with from six thousand to ten thousand volts on the working conductor.

The power house is located at one end of the line, owing to the electric company from which power is purchased by the railroad having a water power at this point. Current is transmitted to the nearest end of the line over two No. 3 wires. The power is furnished from a 300-kilowatt rotary converter generating at 380 volts, at 25 cycles, the energy from which is stepped up to the working pressure of the line. It was the intention, after experimenting a sufficient length of time to determine the best voltage for the working conductor, to have the generators for the permanent plant constructed so as to generate at this determined voltage, and it was for this reason that a temporary rotary converter was first installed to conduct the experiments with.

During the preliminary experimental period upon the apparatus hereinafter described, all power was transmitted from the above-mentioned power house to a point about two miles distant, where were located the car barns in which the preliminary experiments were made.

The conditions under which the first application of the system took place having thus been set forth, it may be well, in order to get clearly before the reader the principles on which the system is based, to quote here the statements made by Mr. Arnold before the Great Barrington convention on June 19, 1902, as follows.

"The principles underlying the system I advocate, and which I call an electro-pneumatic system, are as follows:

"1. A single-phase or multiphase motor, mounted directly upon the car, designed for the average power required by the car, and running constantly at a constant speed and a constant load, and, therefore, at maximum efficiency.

"2. Instead of stopping and starting this motor and dissipating the energy through resistances, as is customary with all other systems known to me, I control the speed of the car by retarding or accelerating the parts usually known as the rotor and stator of the motor, by means of compressed air, in such a manner that I save a portion of the energy which is ordinarily dissipated through resistances, and store it to assist in starting the car, helping over grades, for use in switching purposes, and for the operation of the brakes.

"3. By this method of control I secure an infinite number of speeds from zero to the maximum speed of the car, which may or may not be at the synchronous speed of the motor, for with the air-controlling mechanism working compressing, the speeds below synchronism are maintained, and by reversing the direction of the air through the controller speeds above synchronism may be attained for reasonable distances.

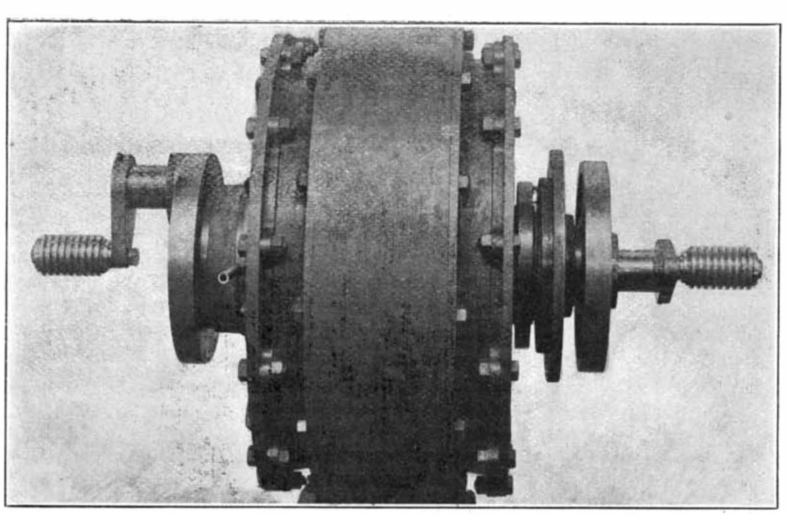


FIG. 3.—OUTSIDE VIEW OF ELECTRIC MOTOR.

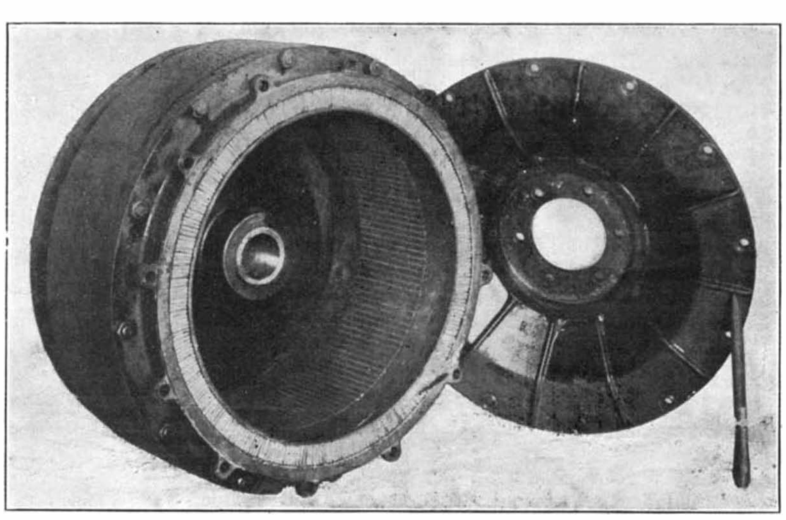


FIG. 4.—INTERIOR OF ELECTRIC MOTOR.

This feature gives to the alternating-current motor the element absolutely essential for practical railway work, for it permits a car or train to ascend a grade at any speed with the motor working at its maximum efficiency and imparting its full torque to the car. When descending the grade the motor may utilize its full power drawn from the line in compressing air, or it may be used to compress air with the stored energy of the train, thereby acting as a brake.

"4. By virtue of the air-storage feature, each car becomes an independent unit and capable, in case of loss of current from the line, of running a reasonable

distance without contact with the working conductor. This feature will enable a car to work on a high-tension trolley wire or active conductor over private right of way, and allow the active conductor to be stopped where the private right of way ceases, and the car to proceed through a city or town on any tracks, whether electrically equipped or not, until it reaches the outskirts of the city or town, where it can take up the

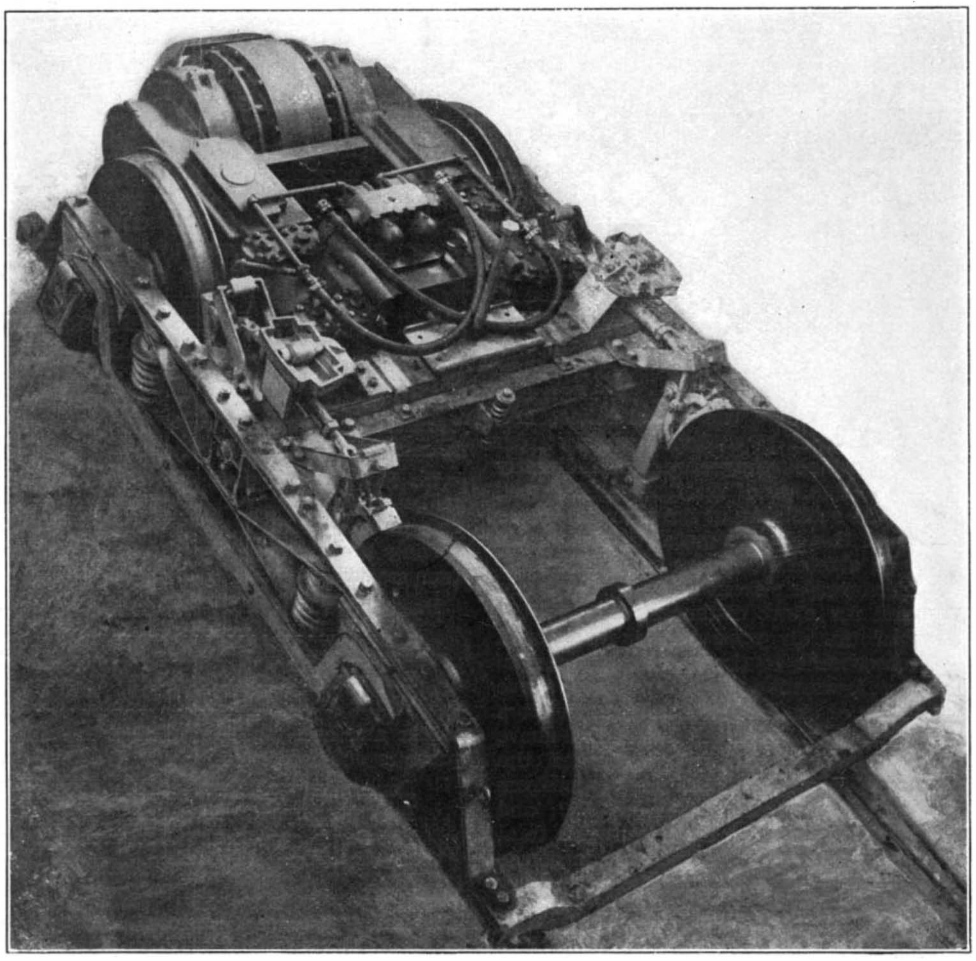


FIG. 5.—FIRST EXPERIMENTAL MOTOR WITH MOTOR FORWARD.

working conductor again on private right of way. This feature is also valuable in switching work, for each car being independent, it can leave the main-line track and operate over switches or sidings without complicating the yards with additional overhead or third-rail conductors, thus necessitating through-line conductors over main-line track or tracks only.

"5. Since a single-phase motor can be used, the motors can be supplied with current from a single overhead wire or third rail, and with a single-rail return circuit, thus permitting the overhead construction, or third-rail construction, to conform to the standard to to-day, except that a much higher working voltage can be used, provided the insulation is taken care of. Furthermore, in steam railway work this system, by virtue of its single-phase feature, will only require the use of one of the track rails for the return circuit, thus leaving the other rail for the use of the signal system, which up to the present time, does not seem to have been satisfactorily solved without the use of one of the track rails.

"6. The current will be taken from the working conductor at any voltage up to the limit of the insulation, and in case this voltage is high (I am building my line for 15,000 volts), a static transformer will be carried upon each car, and the pressure reduced from the line voltage to the voltage of the motor, which in the case under consideration is designed for 200 volts. Where it is unnecessary to utilize so high a line pressure, the motor may be designed for the working voltage, and the current fed directly from the working conductor into the motor, thus eliminating the static transformer. When a high-voltage working conductor and static transformer are used, and it is thought advisable to use a working conductor through cities or towns, this working conductor will be supplied with energy through a stationary transformer at each city limit, thus making the working conductor through the cities or towns safe.

"7. By virtue of the speed of the motor and its constant load, either when the car is in motion or when it is standing still, and the motor is compressing air, the variable load now customary in electric-railway power plants is eliminated, and the power station works at practically a constant load, thereby eliminating a large part of the investment at present requisite in power station and line construction. Furthermore, by virtue of the air-storage feature, each car, in the particular apparatus I have designed, is capable at any time, when current is on the working conductor, of delivering to the car wheels a much greater torque in proportion to the capacity of the motor than is possible with any electrical system known to-day

"I believe that by the adoption of this system the following results will be accomplished:

"1. The entire elimination of the present standard system of rotary converter sub-station plant, together with the maintenance thereon, and the cost of the necessary attendants.

"2. The absorbing and rendering available for useful work in starting, or otherwise, of a large percentage of the energy stored in the moving mass, which under the present methods of operation is dissipated at the brake shoes.

"3. A large reduction in the first cost of electrically equipping long-distance railroads, thereby making it feasible, from an engineering and business standpoint, to equip many roads which cannot now be shown advisable, thus opening up the steam railway field to the industry in which we are now engaged."

The following description will explain more in detail the application of the principles of the system and the mechanism of its working parts:

Fig. 1 represents diagrammatically the working parts of one form of the system. The rotor R of a single-phase induction motor is geared to the axle of the car, and by means of crank pin C' secured in pinion P also drives the compressor cylinder $R\ C$, while stator S can freely revolve around the rotor, and drive by means of crank pin C the compressor cylinder $S\ C$. Both cylinders are piped to air reservoirs located under the car, and are also provided with suitable valves manipulated from a single controller on the car platform for making them perform their various functions; thus the entire regulation of the speed and power of the car are controlled by the air cylinders, and no other regulating devices are necessary. The cylinder valves are electrically operated, which makes it possible for each cylinder when driven by the electric motor to compress air into the tanks, and when operated by compressed air to furnish mechanical energy for moving the car. When, for instance, the cylinder is compressing air, the valves work like inlet and outlet poppet valves of a common air pump, while on the other hand, if the cylinders are supplied with compressed air, each valve is operated electrically by a pilot solenoid connected with the valve seat in such a manner that the energy for moving the valve is supplied by the compressed air, thereby making the valve practically self-actuating. The time of operation of the valves is controlled by a series of collector rings revolving with the engine shaft, and their regular operation is interrupted and varied to suit the requirements by means of the motorman's controller.

When a rotary or turbine type of air engine is used, all of the above valves and reciprocating parts

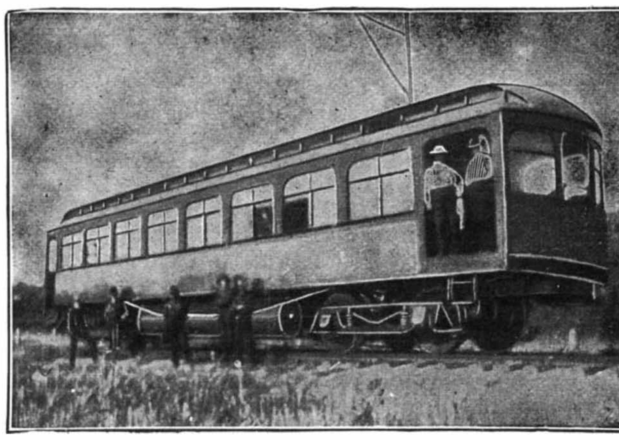


FIG. 7.—COMPLETE CAR.

are eliminated, and their entire controlling mechanism consists of two air valves operated from a single engineer's valve, which may be located upon the platform of the car or in the cab of the locomotive, and so arranged that one or more units may be operated from the platform or cab of any unit without the necessity of connecting wires between the units.

Since the motor may be of the simplest types of induction motor without a commutator, and the system does not require the manipulation or breaking of the main current, the motor may be designed for any working voltage and be of any type which will maintain a constant speed when provided with a constant load. This eliminates the necessity of all step-down transformers, resistances, or other regulating devices, and confines the current to the motors themselves, and as these are below the car floor, the danger from the current is reduced to the minimum.

At the same time, the air cylinders, in addition to performing all the functions of speed control, give to the machine the independent unit element, and the ability to store the kinetic energy of the train in stopping and utilize it in starting. On account of these and other features, the electric motors of this system can be much smaller in capacity, when rated as continuous working motors, than those of other systems not possessing this equalizing load feature, and the capacity of the power house and line can be reduced to about one-half of what would be required with systems where the fluctuating starting loads of the cars are transmitted back to the power house.

In order to better understand the different operations of the system, Fig. 2, showing a speed diagram, has been prepared, in which on the axis of abscisses $O\ D\ L$ are represented the different car speeds in

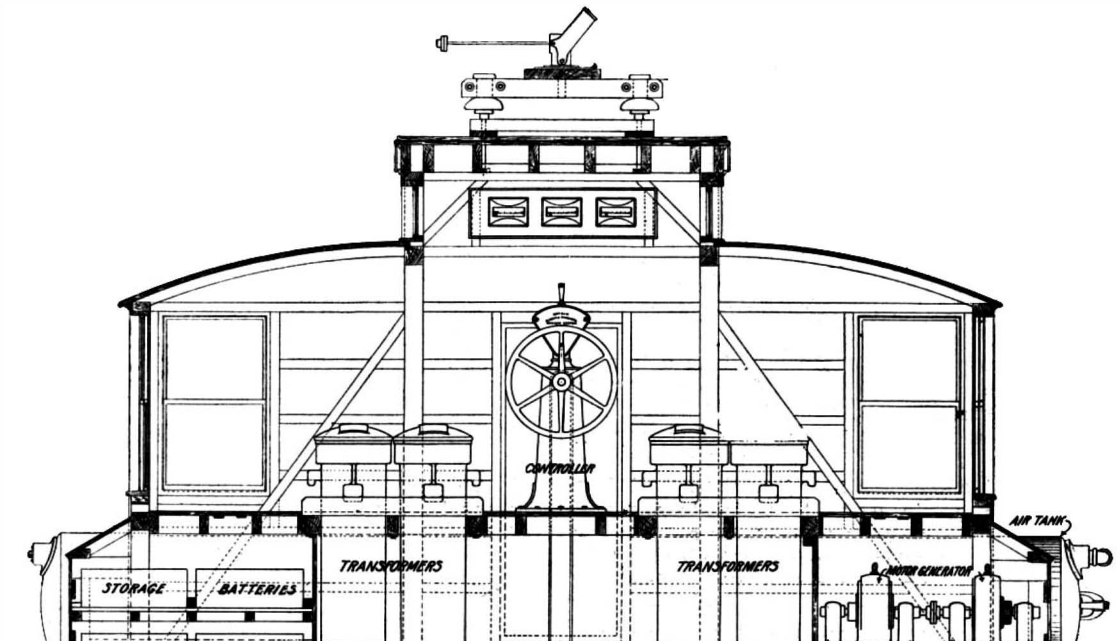


FIG. 6.—LONGITUDINAL SECTION OF ELECTRIC LOCOMOTIVE.

per cent of the synchronous motor speed, while the co-ordinate axis *A O B* represents the rotor and stator speeds corresponding to the car speeds shown.

The operation of the car may be divided into the following periods:

1. *Standing in the Station.*

Referring to Fig. 1, the rotor *R* is standing still, while the stator *S* runs with full synchronous speed. The stator is then transferring the full energy of the electric motor through crank *C* to the compressor cylinder *S C*, which energy is being delivered in form of compressed air into the air reservoir.

Since the relative velocity between the stator and the rotor is, under all conditions of operation, constant, the speed curves of stator and rotor may be represented by two parallel lines *O C R* and *A D S* in Fig. 2. The origin *O* of the given co-ordinate system represents the period of rest of the car, and therefore indicates zero rotor speed and full stator speed in a negative or downward direction, as the stator is now revolving in the opposite direction from that which the rotor must revolve to drive the car forward.

Let it be further assumed that for an instant *O A* equals the active torque of the stator, then it will be easily understood that *O B*, which equals *O A*, represents the reactive torque of the rotor exerted on the car axle, meaning that if the car is free to move, the reactive torque can be used advantageously for the starting and acceleration of the car.

When the car is standing in a station, it is held at rest by moving the controller to such a position that the outlet pipe from rotor cylinder *R C* is throttled, thereby increasing the pressure behind the piston to such an extent that it overcomes the effort of the rotor *R* to revolve, thus tending to cause the stator *S* to revolve, and at the same time holds the car at rest without the use of wheel brakes.

2. *Starting and Acceleration.*

To start the car, the air cushion behind the piston of *R C* is removed, and the air which is being compressed by cylinder *S C*, supplemented by the stored air from the tanks, is admitted to cylinder *R C* with the controller at the position of maximum cut-off. The rotor then begins to revolve, and as it accelerates, the stator slows down by exactly the same amount that the rotor has increased its speed; and as the rotor and car speed increases, the controller is gradually moved to a smaller percentage of cut-off until the car speed corresponds to the full synchronous speed of the motor, at which time the stator comes to rest.

During this period of acceleration the air compressed by cylinder *S C*, instead of being delivered to the tanks to lose its heat, is delivered, hot, directly to the rotor cylinders, thus greatly increasing the efficiency of the combination, as the heat usually lost in air systems is utilized and the advantages of heated air gained without a reheater; and as the pressure used is low, many of the ordinary difficulties in the use of compressed air disappear. If the rate of acceleration is such that cylinder *R C* uses all of the air supplied by the cylinder *S C*, no exhaust to the atmosphere from cylinder *R C* takes place.

Referring now to Fig. 2, which graphically represents this process, since the electric motor runs always at a constant speed and a constant load it has a constant torque, and therefore the distance between lines *O C R* and *A D S* may be considered as representing the energy delivered by the electric motor.

The length of any ordinate extending from *O D* to *O C* represents the proportionate amount of energy derived from the electric motor which is applied directly through pinion *P* and gear *G* of Fig. 1 to the propulsion of the car, while the corresponding ordinate extending below *O D* to *A D* represents the proportionate amount of the energy of the electric motor which is absorbed in compressing air through cylinder *S C*, which energy, in the form of air, is immediately transferred to cylinder *R C* and is utilized in accelerating the car.

In practice, however, since there will be a loss in transferring the energy from electrical energy to energy in the form of compressed air and back again into mechanical energy, this loss, whatever it may be, must be drawn from the storage tanks, and the requisite amount of air from these tanks supplied to rotor cylinder *R C*, in order to maintain the full power of the electric motor upon the car axle during the period of acceleration. Should it be desired to accelerate at a greater rate than the full power of the electric motor is capable of giving to the car, the additional energy may be supplied in the form of air from the storage tanks through cylinder *R C*, thus increasing the total energy given to the car during acceleration, in which case this total power would be represented for any given instant by a point above line *B C*.

3. *Full Speed.*

When the rotor has reached full synchronous speed, by the previous operation, this speed can be maintained by moving the controller to another position, which will throttle the outlet pipe of cylinder *S C* until the reaction due to the pressure behind the piston equals the full capacity of the electric motor. An overload or underload may be placed upon the motor by varying this pressure, but under normal conditions of operation cylinder *S C* is provided with an automatic valve which keeps a constant pressure behind its piston, thus maintaining an absolutely constant load upon the electric motor, and consequently a uniform demand of electrical energy from the line. This uniform load is represented by the parallel lines *O C R* and *A D S* of Fig. 2.

With the controller set at full-speed position, the inlet valves of rotor cylinder *R C* are held open, and the piston runs free, and the electric motor now gives its full power to the car axle, and the stator and its air mechanism will remain at rest as long as the car runs at the speed corresponding to the synchronous speed of the motor.

4. *Speed Variations.*

There are usually certain places on any road where high rates of speed can be maintained for short distances, and as these speeds might be higher than the synchronous speed for which the motor was designed, they are provided for as follows:

Assuming that the car is running at synchronous speed, the controller may be moved to such a position that the valves of stator cylinder *S C* operate in such a manner as to cause it to act as an engine and revolve stator *S* in the same direction as rotor *R* is revolving. This now causes, owing to the constantly electrically-maintained relative difference in speed between the stator and the rotor, an increase of speed of the rotor and car axle, due to the motor automatically working as a magnetic clutch, without mechanical contact; and if the resistance of the car or train is less than the capacity of the electric motor, the air necessary for revolving the stator can be obtained, hot, from the rotor cylinder *R C* without drawing from the tanks, and a speed above synchronism indirectly proportioned to the resistance of the train, maintained indefinitely. When the resistance of the train is greater than the capacity of the electric motor, speeds above synchronism can be obtained only by supplying rotor cylinder *R C* with stored air from the tanks, and can only be maintained for short distances, or until the storage capacity of the air reservoirs is exhausted. This condition corresponds to the spurts that can be made by a steam locomotive when working above the steaming capacity of the boiler. The distance from the line *O D L* to that portion of the line *A D S* above *O D L* in Fig. 2 represents, at any given speed, the proportionate amount of energy which must come from the tanks and be supplied through cylinder *S C*; and the distance from *D L* to *C R* represents the total energy given to the car by the combined action of the electric motor and the stator cylinder when operating under these conditions.

The energy delivered to the car can be still further increased by admitting air into rotor cylinder *R C* and allowing it to work as an engine.

5. *Retardation.*

To bring the car or train to rest, instead of applying mechanical brakes to the wheels in the ordinary manner, and thereby dissipating the entire stored energy of the car or train in the form of heat, this energy is saved in the form of compressed air, to assist in starting the car or train, by setting the controller in such a position that rotor cylinder *R C* compresses air and delivers it into the storage tanks. Any desired rate of retardation can be secured by throttling the delivery pipes from rotor cylinder *R C*, and in practice this pipe is provided with an automatic valve which releases just before the slipping point of the wheels, thus allowing the motorman to brake as rapidly as he desires without liability of flattening the wheels. Supplemental wheel brakes are provided for emergency, but need not often be used, and the ordinary wear and tear on them saved. When the car is again at rest, the cycle of performance as above given is repeated for the next run.

6. *Reversing.*

When it is desired to run the car backward for short distances, the electric motor is not disturbed, and the power is furnished by the rotor cylinder *R C* by reversing the action of the valves; but if it is desired to run backward for any great distance, the current is thrown off the motor, the stator engine reversed, and the stator brought to speed by the air, when the current is again thrown on to the motor, and the cycle of operation is the same as when running forward.

Fig. 3 represents the exterior of the electric motor, showing the cranks of the stator and rotor, also collector rings for operating the valves of the air cylinders when working as engines.

Fig. 4 shows an interior view of the stator of the motor with the flange removed, the rotor of the motor being of the standard squirrel-cage induction type.

Fig. 5 shows, mounted upon a truck, a view of the first electro-pneumatic motor constructed, and upon which the first experiments were conducted.

Since the single motor represented in Fig. 5 was too small in capacity to propel so large a car, it was decided to experiment with an improvised locomotive, consisting of the truck and motors similar to Fig. 6, carrying suitable air tanks and transformers upon a temporary frame structure. With an equipment of this kind, the trial runs were made and passengers carried on June 15, 1902.

Fig. 6 shows a double truck fitted up in the form of a locomotive, in longitudinal section; it was this locomotive that was recently destroyed by fire. In order that the locomotive might operate as an independent air unit upon tracks not equipped with overhead electrical conductor, it was provided with a small storage battery and small generator for charging the batteries and for operating the headlight. These auxiliaries are not necessary for the successful operation of the system, provided the locomotive can always be supplied with electric current from the working conductor, for then the valves can be made to operate from alternating current and thus eliminate the use of motor-generator and batteries. When, however, it is desired to operate independently of the electric conductor, these auxiliaries are necessary, and one set may supply an entire train. It will be seen that the locomotive is also provided with transformers, another auxiliary which is unnecessary in case the motors are designed for the voltage transmitted over the working conductor; but in this case transformers were used because the manufacturer of the motors could not be induced at the time they were purchased to build a high-tension motor for railway work, consequently the parts of a standard motor were utilized, and a pressure of 200 volts adopted for the motors, as this was the most economical voltage that could be used with the particular parts selected. This locomotive was provided with all necessary testing instruments, and had been operated in the barns for some time and found to perform all its functions successfully, and would have been placed on the road, and experiments with it would now be in process had it not been destroyed.

TRADE NOTES AND RECIPES.

Cement to Unite Objects of Crystal.—Dissolve 8 grammes of caoutchouc and 150 grammes of gum mastic in 600 grammes of chloroform. Leave alone, hermetically closed, for eight days, then apply with a brush, cold.—Science Pratique.

To Keep Wood from Warping.—Immerse the wood to be worked upon in a concentrated solution of sea salt for a week or so. The wood thus prepared, after having been worked upon, will resist all changes of temperature.

Paste Shoe Blacking.—

Soap	122 parts.
Potassium carbonate	61 parts.
Beeswax	500 parts.
Water	2,000 parts.

Mix and boil together until a smooth, homogeneous paste is obtained, then add

Bone black	1,000 parts.
Powdered sugar	153 parts.
Powdered gum arabic	61 parts.

Mix thoroughly, remove from the fire, and pour while still hot into boxes.—Drug. Circ.

Bromide Printing.—A contributor to the Pharmaceutical Journal says he has found suitable for use with all descriptions of bromide paper a developer composed as follows:

Amidol	2 grains.
Sodium sulphite	30 grains.
Potassium bromide	1 grain.
Water	1 ounce.

He says that with a fairly correct exposure this will be found to produce prints of a rich black tone, and of good quality, and adds that the whole secret of successful bromide printing lies in correctness of exposure. It is generally taken for granted that any poor, flat negative is good enough to yield a bromide print, but, in his experience, this is not so. A negative of good printing quality on P. O. P. will also yield a good print on bromide paper, but considerable care and skill is necessary to obtain a good result from a poor negative. The above developer will not keep in solution, and should be freshly prepared as required. The same formula will also be found useful for the development of lantern plates, but will only yield black-toned slides.

Parlor Experiments.—The mystery of the "wonderful bottle," from which can be poured in succession port wine, sherry, claret, water, champagne, or ink at the will of the operator, is easily explained. The materials for the deception consist of an ordinary dark-colored pint wine bottle, seven wine glasses of different patterns and the chemicals described below:

Solution A: A mixture of tincture of ferric chloride dr. vi., hydrochloric acid dr. ii.

Solution B: Saturated solution of ammonium sulphocyanide dr. i.

Solution C: Strong solution of ferric chloride dr. i.

Solution D: A weak solution of ammonium sulphocyanide.

Solution E: Concentrated solution of lead acetate.

Solution F: Solution of ammonium sulphide dr. i., or pyrogallic acid dr. i.

Package G: Pulverized potassium bicarbonate dr. iss.

Having poured two teaspoonfuls of Solution A into the wine bottle, proceed to treat the wine glasses with the different solutions, being careful, of course, to note and remember into which glasses the several solutions are placed. Into No. 1 wine glass pour one or two drops of Solution B; into No. 2 glass pour one or two drops of Solution C; into No. 3 one or two drops of Solution D; leave No. 4 glass empty; into No. 5 glass pour a few drops of Solution E; into No. 6 glass place a few grains of Package G; into No. 7 glass pour a little of Solution F.

When before the audience request some one to bring you a carafe of cold drinking water, and to guarantee to the company that it is pure, show that your wine bottle is (practically) empty. Fill it up from the carafe, and having asked the audience whether you shall produce wine or water, milk, or ink, etc., you may obtain either by pouring a little of the water from the bottle into the prepared glass, thus No. 1 glass gives a port wine color, No. 2 gives a sherry color, No. 3 gives a claret color, No. 4 left empty to prove that the solution in the bottle is colorless, No. 5 produces milk, No. 6 effervescing champagne, No. 7 ink.—American Druggist.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

American and Other Interests in Mexico.—In its issue of August 8, 1903, the South American Journal, a British publication, has an editorial on "British Trade in Mexico." After a word commendatory of a report by British Consul Leay, it goes on to say:

"The report is well worth the attention of our manufacturers and merchants, since it emphasizes the fact which has been generally known for many years that British trade with Mexico has seriously declined and will probably continue to diminish. So much is this the case that there is not a single British firm or merchant in the city of Veracruz nor, we believe, in any of the other ports or cities of Mexico. On the other hand, trade between the Republic and the United States continues to flourish and increase and, besides, the Americans are actively engaged in investing large sums in mining and other enterprises in the country. These investments, according to a recent report, now exceed $500,000,000, whereas the British investments in railways, etc., have not recently made any advance, but were mostly made many years ago. The causes of our retrogression are well worth being made the subject of careful inquiry. It can not be alleged that it is on account of stagnation in the country, since no other Latin American Republic can show such a record of progress and progression in recent years as Mexico, although it is true that business is now disarranged, but only temporarily we believe, through the fall in the value of the silver standard.

"Mr. Leay has evidently taken great pains to make his report of service to exporters, since he has gone into numerous details in describing the classes of goods which are in demand, and has specified the manner in which they should be packed and invoiced for the customs authorities. This makes his report one of the most valuable which we have received through the foreign office for a long time and, in fact, ought to be a model for other consuls. There is also a series of tables of statistics relating to the imports and exports and to the shipping entering Mexican ports during the last five years. The decline of British trade is clear from the figures we quote from the report. In the years 1893-1895 imports from the United Kingdom formed 17 per cent of the total; in the period 1898-1900, 18 per cent; and last year it was only 13 per cent. In 1901-2 the imports from the United Kingdom and its colonies were valued at $8,142,038, against $9,659,515 in 1900-1901, a loss of $1,517,477. It is fair, however, to mention that the import trade between Mexico and other European countries has also declined in that period, Germany showing a decrease from $6,890,964 to $6,277,785, a difference of $613,179; France comes next with a decrease of $272,524—that is, from $6,389,715 to $6,117,190. On the other hand, the imports from the United States increased from $34,260,160 to $36,401,420, a gain of $2,141,260, almost exactly the value of the trade lost by Europe. It should be borne in mind that these figures represent, as nearly as possible, actual values, since in Mexico the excellent system has been adopted of valuing exports and imports at the actual rates of exchange of the day, another instance of the careful and practical methods of Señor Limantour.

"The high rate of exchange has tended to stimulate domestic manufactures in many important lines, while the government has made some efforts to encourage exports with a view to reducing the unfavorable balance payable in gold. This has been especially the case with cotton manufactures, and the steps recently taken are likely to result in diverting to Mexican mills a considerable portion of the trade in several Latin American countries at present principally in British hands. Great progress has been made in the last few years in diversifying the industries of Mexico, and the decline in silver has not, therefore, found the country entirely dependent upon its mineral exports. Railway building in various parts of the Republic has continued vigorously, and the investment of capital, particularly American, in mines, plantations, and industrial enterprises has been as great as ever, till at present the American capital alone is estimated to amount to over £100,000,000 ($486,600,000).

"How to Obtain Trade.—The consul makes the following important suggestions for improving trade:

"'We can not afford to ignore the Mexican market, nor a country whose revenues have increased in twenty years from £2,000,000 to £6,000,000; imports from £3,000,000 to £13,000,000; and exports from £3,000,000 to £13,000,000. I would advise those who really wish to do business in Mexico, to guarantee fixed salaries to agents for a year or two with the promise of a certain commission in addition when the sales exceed a certain amount. The Americans have succeeded throughout the country by paying large salaries and being well represented.

"'We must make what the foreigner wants, and it would be well if on receipt of an order from this country the directions as to the goods required and the mode of shipment were followed absolutely.

"'We could do with more commercial travelers. The few we have are now almost all British, apparently excellent business men. They have a knowledge of the language and tact, which is perhaps even more necessary. Those with choice samples will always do well.

"'Price lists should be in Spanish, and firms should quote, as our travelers now do, f. o. b., c. i. f., inclusive. All prices should be quoted in sterling, or gold dollars perhaps better, reckoning $5 to the pound sterling. The Mexican seldom understands our pounds, shillings, and pence. To many old firms credit may safely be given, but the rule in other cases should be cash with order or against bill of lading.

"'Our merchants should do their best in filling orders for Mexico to dispatch the goods at once on receipt of order if in stock, or to put the order in hand immediately if the goods are to be manufactured. It is, as I have already pointed out, the proximity that gives the United States the advantage, and while that must always remain so we should do our best to reduce that advantage to a minimum. Merchandise can be ordered from the United States and delivered in Mexico in from three weeks to a month; from England in from eleven weeks to three months, and there is no reason, unless in exceptional cases, why there should be further delay. Besides, we have the other European countries to compete with and must show at least that we can do as well as they.'"

MEXICAN RAILWAYS.

The following is a *resumé* and condensation of articles in the Mexican Journal of Commerce of August 1, 1903:

"Mexico has 11,185 miles of railroad, valued at more than $1,000,000,000 Mexican. So recent a thing is railroad building in the Republic to the south that one sees engines in operation that hauled the first trains that Mexico ever ran. The earning capacity of capital in Mexico is considered safe. Fully $500,000,000 have gone in from the United States, and of this 70 per cent has gone into railroads. More is entering every day. Pullman cars, huge Mogul engines, and gigantic freight cars are the rule now, where hitherto they had been the exception. Most of the rolling stock was made in the United States. If Mexico is making her mark in industrial prosperity it is because the government was wise enough to get the railroads to give them a chance to grow; these brought investors, then manufacturers, then captains of industry, then prosperity. To-day trains run to all parts of the Republic, or will very shortly. Remote regions, held hitherto to be almost inaccessible, are being bound to the central city—the capital—by bands of steel. Ports like Veracruz are put into communication with transoceanic places. The rich mining and agricultural lands of the South are tapped till they pour their treasures into the world's markets. A mighty line is to connect Salina Cruz, on the Pacific, with Coatzacoalcos on the Gulf. According to careful estimates this road is to put New York and New Orleans 1,500 miles nearer to San Francisco than they would be by a passage through the canal at Panama. There are some who say it is to have a good deal of the trade that is to go over the Pacific. While the Panama Canal is to cost at least $180,000,000 gold, the Tehuantepec Railroad has cost about $45,000,000 silver, and will cost only a little more. The Mexican government is quietly giving it financial aid and encouragement. The revenue required to make the two enterprises—the canal and the railroad—pay is $10,800,000 gold, against $2,700,000 silver. The saving of time is estimated at a high figure—not only the 1,500 miles difference in distance, but the slowness with which ships will have to pass through the canal are considered. [This item is hardly as important as the writers would have their readers regard it, as the distance is so small.] An interesting feature is presented by the pan-American road which is rapidly reaching out toward Guatemala and is expected to form an important link in that chain of roads that is to connect Alaska and Canada with Patagonia, Brazil, and Chile. An independent line—that of Yucatan—capitalized at $30,000,000, every cent of which was raised at Yucatan, is to stretch its arms out toward Central Mexico. Besides these, there are numerous roads that touch the great lines, feeding them freight from remote and once almost inaccessible regions. These are mainly mining, logging, and plantation lines; but even these pick up quite a lucrative line of extra freight and passengers. 'It is a fact, as surprising as it is true,' says one of the writers from whose article much of this *resumé* is taken, 'that there is not a railway in Mexico, no matter how small and insignificant, but what enjoys a local passenger and freight traffic far in excess of the same pretensions in the United States.' [In this connection it is perhaps worth while to be reminded that there are over 200,000 miles of railroads in the United States, many of which were built long before any great or paying amount of freight or passengers was expected. The Mexican roads were very probably not built till the builders were fairly sure of both passengers and freight enough to pay.]

"Gigantic Growth of Mexican Railroads.—In 1873 Mexico had 335 miles of railway. Over these went 723,834 passengers and 150,473 tons of freight, and the receipts were $1,848,375. In 1900 there were 8,460 miles in operation; 10,709,462 passengers and 7,522,923 tons of freight were carried and the receipts were $49,425,478. Since 1900 the mileage, freight, number of passengers, etc., have gone on increasing. Better ballast, steel rails for iron, steel bridges for wooden, first-class rolling stock, etc., all mark the methods of the Mexican railroad management. In the face of almost insurmountable natural obstacles—up hills, over mountains, and climbing precipices—the roads have gone till the tale, when told, sounds almost incredible."

Industrial and Trade Notes.—Butter Production in Siberia.—The production of butter in Siberia is keeping pace with the development of that part of Russia's railroad or transportation facilities. Russian papers report an increase in dairies from 140 in 1898 to 1,107 in 1900 and 2,500 in 1902. The butter exports increased from 5,420,000 pounds in 1898 to 39,720,000 in 1900 and 90,280,000 pounds in 1902.

Artificial Pearls.—A report from the Osaka, Japan, exposition, published in European papers, says a Japanese has devised a plan for the artificial production of pearls. His method is to put a grain of sand or foreign substance forcibly into pearl oysters, which he afterward put back in the beds. In this way he gets pearls so like the natural pearls that connoisseurs can not tell them apart. It would be strange, thinks one writer, if they could, for the method employed by the Japanese is the one employed by nature. It is a well-known fact that pearls are produced by a grain of sand or some other foreign substance falling into the open oyster and being covered by the same substance as the interior of the shell. The pearls thus produced are being sold so cheaply that a fear is gaining ground that they may affect the market for "real" pearls—that is, pearls produced by accidents to the oysters rather than by the efforts of man. The "artificial" pearls are being put to exactly the same uses as the "real" ones.

A Silk Crisis in Europe.—A distinguished Italian silk manufacturer, Signor Stucchi—president of Como's Chamber of Commerce—is calling attention to the critical conditions prevailing among silk mills abroad. He seems to think the silk industries of France, Italy, Switzerland, Germany, and Austria are in danger. A savage competition has led to the production of a too cheap grade of goods. To accomplish this, the weight of the goods has been added to in the dyeing rather than in the weaving. The result is a vastly inferior product—one very deceptive but of little value. The disgusted and deceived public have turned to substitutes, articles so similar to silk that it is hard to tell them from silk. Science has helped with its power to mercerize cotton and other textiles, giving them the appearance of silk. Only a radical change can effect a reform, thinks Signor Stucchi, but no one land will be able to accomplish it; there must be a united movement of all silk-manufacturing countries. A movement is on foot for a congress or conference of the world's makers of silk.

American Capital in Canada.—A large pulp mill has recently been built at Brampton Falls, Quebec, 6 miles from Sherbrooke, at a cost of nearly $500,000 and is now in full operation and shipping its product to the United States. The capital to build and equip this plant came from the United States. This company will soon erect a paper mill at a cost of $300,000 to be operated in conjunction with the pulp mill. American capital is rapidly invading this part of the Dominion, and the near future will see the erection and equipment of many large manufacturing plants, which will greatly increase the wealth and business of this section and promote trade with the United States. American companies are now building factories in Canada and manufacturing the same goods that they turn out in the United States, thereby saving the Canadian duty and freight rates, which enables them to sell their goods at about the same prices as they obtain for them in the United States.—Paul Lang, Consul, Sherbrooke, Canada.

American Iron and Steel in Germany.—During the last few weeks the German bourses and trade circles have been much disturbed by reports that contracts had been made for the shipment of American iron and steel to Germany. The annual reports lately issued by the German chambers of commerce declare that the heavy imports of German manufactured articles by the United States in 1902 was the chief cause of relieving the severe industrial crisis which has overtaken Germany; but fears are expressed that these importations may cease and that the United States will inundate the European markets with its surplus of steel and iron products at prices with which the European markets can not compete.—Simon W. Hanauer, Deputy Consul-General, Frankfort, Germany.

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Other Reports can be obtained by applying to the Department of Commerce and Labor, Washington, D. C.

SELECTED FORMULÆ.

Paste for Affixing Cloth to Metal.—

Starch	20 parts.
Sugar	10 parts.
Zinc chloride	1 part.
Water	100 parts.

Mix the ingredients and stir until a perfectly smooth liquid results entirely free from lumps, then warm gradually until the liquid thickens.—Drug. Circ.

Copper Laundry Ink.—The following is said to make a fine, jet black laundry ink, though we have no personal experience with it:

a. Copper chloride, crystals	85 parts
Sodium chlorate	106 parts
Ammonium chloride	53 parts
Water distilled	600 parts
b. Glycerin	100 parts
Mucilage gum arabic (gum 1 part, water 2 parts)	200 parts
Anilin hydrochlorate	200 parts
Distilled water	300 parts

Make solutions a and b and preserve in separate bottles. When wanted for use, mix 1 part of solution a with 4 parts of solution b.—National Druggist.

Quick-Drying Cement for Leather.—A cement cannot dry more rapidly than the solvent holding the uniting substance, and you will notice that those solvents mentioned are among the most volatile in the list. The trouble about all such cements is that the surface directly exposed to the atmosphere is almost infinitesimally small—and the better the job the smaller the surface. It is, namely, the line around the edge of the patch, at the juncture of the two surfaces. The edges of the patch soon dry superficially, but the mass of the cement being then hermetically sealed to the atmosphere, can evaporate only through the leather, and hence, very slowly. The application of a hot smoothing iron to the surface of the patch expedites evaporation, but does not benefit the job much.—National Druggist.

Cement for Glass to Withstand Liquids and Heat.—A great many formulæ of cements have been put forward with the claim that they would resist boiling water, etc., but an actual trial of most of them has convinced the writer that the claims are but partially true. Some of the preparations resist the action of heat and moisture a short time, but generally yield very quickly. The following has proven the most resistant, under actual test, of any yet tried:

Silver litharge	100 parts
White lead	50 parts
Boiled linseed oil	3 parts
Copal varnish	1 part

Mix the lead and litharge thoroughly, and the oil and copal in the same manner, and preserve separately. When needed for use, mix in the proportions indicated (150 parts of the powder to 4 parts of the liquid) and knead well together. Apply to the edges of the glass, bind the broken parts together and let stand for from 24 to 48 hours.—National Druggist.

Perfumes for Soap.—From 1 to 2 ounces of the following mixtures are to be used to 10 pounds of soap:

I.

Oil of rose geranium	2 ounces.
Oil of patchouly	½ ounce.
Oil of cloves	½ ounce.
Oil of lavender flowers	1 ounce.
Oil of bergamot	1 ounce.
Oil of sandalwood	1 ounce.

II.

Oil of bergamot	2 ounces.
Oil of orange flowers	2 ounces.
Oil of sassafras	2 ounces.
Oil of white thyme	3 ounces.
Oil of cassia	3 ounces.
Oil of cloves	3 ounces.

III.

Oil of citronella	1 ounce.
Oil of cloves	1 ounce.
Oil of bitter almonds	2 ounces.

IV.

Oil of lavender flowers	2 ounces.
Oil of rose geranium	2 ounces.
Oil of rosemary	2 ounces.
Oil of caraway	1 ounce.

V.

Oil of lavender flowers	2 ounces.
Oil of rosemary	2 ounces.
Oil of nutmeg	2 ounces.
Oil of white thyme	2 ounces.
Oil of sassafras	2 ounces
Oil of red cedar wood	¼ ounce.

VI.

Oil of bitter almonds	1 ounce.
Oil of rose geranium	2 ounces.
Oil of lavender flowers	2 ounces.
Oil of red cedar wood	2 ounces.
Oil of caraway	2 ounces.
Oil of sassafras	2 ounces.
Oil of spruce	2 ounces.
Oil of citronella	2 ounces.

VII.

Oil of lavender flowers	8 ounces.
Oil of bergamot	4 ounces.
Oil of sassafras	2 ounces
Oil of cassia	½ ounce.
Balsam of Peru	2 ounces.

—Drug. Circ.

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