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CANADIAN MAGAZINE OF Science and the Industrial Arts.

Patent Office Record.

Vol. 11. JUNE, 1883. No. 6.

Communications relating to the Editorial Department should be addressed to the Editor, HENRY T. BOVEY, 31 *McTavish Street, Montreal.*

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THE MANUFACTURE AND APPLICATION OF ARTIFICIAL MANURES.—BY MR. SMETHAM.

(*Continued from page* 139.)

All the valuable constituents of guano are in a form readily available, but the condition is sometimes unsuited for sowing and the quality, moreover, varies considerably. Several large firms, have, therefore, undertaken the manufacture of dissolved guano, *i. e.*, guano treated with sulphuric acid, and send it out at a guaranteed strength. This is a decided gain to the farmer —who is thus protected against the fraudulent impostures of some dealers who, keeping to the letter of the law, sell inferior articles at high prices as pure Peruvian Guano. The credit of first introducing this form of manure into England is due to Messrs. Ohlendorff & Co., of London.

There is also in the market a class of so-called phosphatic guanos, in which the phosphoric acid exists as dibasic instead of tribasic phosphate of lime. To convert these into soluble phosphate only half the quantity of sulphuric acid is required, as to convert the ordinary tribasic phosphates, and consequently products of high quality are produced, which find their way into the market as phospho-guano, biphosphated guano, etc.

In conclusion I must express my indebtedness to my friend Mr. H. H. R. Shepherd for the kind assistance which he has given to me while compiling this paper.

Mr. King drew attention to the fraudulent manuring mixtures that are palmed off on the public. He had lately bought some manure as superphosphate of lime. Shortly afterwards the agent came to say the wrong manure had been delivered. Being a little suspicious, he had some of the lumps gathered off the field (it had been sown) and analysed, when it was found the manure was worth about £4 per ton. He had contracted for a quality at £12. He told the company from whom the manure was bought that they could take it off the ground if possible, but he was certainly not going to pay for it; he then had some good manure applied, and all he could say was that from the two he had an excellent crop of oats. Now he ventured to say that if he had n t mentioned that he was going to have the manure analysed he would never had heard anything as to the wrong delivery. Mr. King further stated that to show how valuable the assistance of the analyst was to a farmer, that on another occasion he thought potash would be capital stuff to put on a particular field, so he put some down and some time afterwards found on submitting some of the soil to Mr. Smetham for analysis, that there was enough potash on that ground, in 6 in. depth, to grow crops for over three hundred years. He thought the information imparted by papers like the present was extremely valuable, and that if there were some government standard for regulating the sale of manures a great deal of good would be done. He thought that unless farmers were careful to make progress that not only would America and Canada be supplying us with general agricultural produce, but we should be getting beef from the River Platte, especially as refrigerating appliances were becoming so perfect. It seemed extraordinary that while in England we have about one sheep per head of the population, in Australia they have thirty-five times as many per head; altogether we have 28 millions and they have 70 millions. It seemed to him that the value of land must largely go down unless Mr. Smetham or his chemical friends could give us some assistance in obtaining better results than have yet been obtained.

Mr. CHANTRELL said the subject of manures had been frequently brought before the Society, and especially in connection with the treatment of sewage and disposal of town refuse. A number of limited companies had been formed to carry out various ingenious schemes, duly patented, all of which he believed had ended in failure. In his own case he had brought two before this Society, in which the deodorising powers of charcoal was the main feature. As an old and successful patentee of apparatus for the revivification of animal charcoal for the use of sugar refiners, it was only natural that he should have great faith in charcoal.

Peat Charcoal was the feature of one company and Carbonised Street Sweepings Charcoal that of the other, and it is of this latter he would say a few words.

The wonderful properties of charcoal have been long known and admitted amongst sanitarians, but the difficulty has always been the procuring of it, at a very cheap rate.

In his studies as a microscopist years ago, he had been led into an investigation of garden soil (amongst other substances) in studying the lowest forms of life, believing that he should in the substance, called by the agricultural chemists "humus," find similar organisms to those found in vegetable decompositions, and he was right in this conclusion: he found the familiar amœba and numerous other organisms. It was these facts convinced him that garden soil would, when carbonised, produce a good charcoal.

It was then that the idea suggested itself that street sweepings (town refuse), if carbonised, would make the cheapest of all charcoals. After a number of experiments, he satisfied himself that this would prove the universal charcoal desired. A patent was taken out by him, and a company formed, arrangements were made with the Corporation of Salford for the use of a building belonging to them at their Ordsall Lane Manure Depot, in which to erect the carbonising furnaces and carry on the manufacture of charcoal manure, the corporation supplying the company with the street sweepings for carbonisation, and the excreta from the pails on very reasonable terms. The process was a very simple one, the street sweepings were passed into the self-feeding revolving retorts which conveyed the contents gradually over the furnaces and thence into sheet-iron coolers, when sufficiently cool these were emptied on to the floor, and finally trenched ready to receive the contents of the pails, these latter and the charcoal were then thoroughly mixed, and in a few days the manure was ready for the farmer. Large quantities of this manure were sold to Lincolnshire farmers at remunerative rates and bid fair to become a great success, but unfortunately the corporation advanced the rent of the premises and increased the prices of their refuse to that extent that the manufacture was finally abandoned Mr Chantrell who had taken shares in payment for his patent, was dissatisfied with the chemist of the company and his mode of management, determined to withdraw, and he was fortunate shortly afterwards to sell all his shares at the highest price, realising a very handsome sum.

One singular mistake made by the chemist and manager was the non-utilisation of the gases given off in the carbonisation of the street sweepings, which would have largely increased the value of this manure He might mention that this charcoal manure was always drilled in with the seed, showing that the Lincolnshire farmers knew what they were about.

Mr. Chantrell then mentioned some interesting experiments he was engaged upon in connection with the growth of plants, and particularly the part played by fungus and crystallisation in their decay. Some 12 months ago he examined a number of leaves of the well-known American Water Thyme, which has become such a pest in many of our canals as at times to impede the navigation, this weed the "anacharis alsinastrum" is a great favorite amongst microscopists for showing the circulation. A stray leaf had been left in an ordinary brass live-box, in fact thrown on one side, when about a month afterwards he by chance looked at it, and noticing something peculiar, he examined it under a microscope, and found to his surprise a curious fungus growth round about the leaf, a sort of mycelium. He applied the polariscope and then were revealed some most beautiful crystals, evidently proceeding from the fungus, and singular to say, this leaf continues to throw out the mycelium, and the crystals go on forming although the live-box is wrapped up in cotton wool and shut up in a tin box excluding the light, air and moisture, the fungus and crystals continue their growth, the only pabulum being this leaf of anacharis, now 12 months old. This investigation has led to some new discoveries in connection with portland cement, a manufacture which is assuming enormous proportions, and may be particularly observed in Liverpool, in its extensive e in the construction of the improved street pavements and Tramways; one can hardly believe that the first of these pavements, that in North John Street, has been down 10 years, and with one of the heaviest traffics in the world, is hardly a bit worse; it is the pavement of the future The testing of cements is becoming more general amongst Engineers, and tensile strain has been much increased of late, so that 500 lbs. to the inch (seven days after guaging) is by no means uncommon. It has always been said that the increase of the strength of cement was due to crystallisation. Mr. Grant's (the Engineer to the Metropolitan Board of Works) well-known experiments, ranging over years, points to this, but no one seems to have thought of using the microscope and polariscope to absolutely see, so to speak, the inner life of cement. I have been engaged for several months past in watching the crystallisation of portland cements, and I am able in 6 or 7 minutes to see the needles of crystallisation forming round the minute particles of cement, in star-like forms, these needles in course of a few days change, followed by crystals of carbonate of lime, etc., after a while the field assumes under the polariscope beautiful aesthetic forms, and a continued variety of crystals go on forming, ever changing and ever beautiful, and showing that by continued crystallisation it is that cement increases in tensile power.

The subject is an interesting one, and much of the quality of cements may be judged with the yet imperfect data, and promises important results in the future.

Mr. Buchanan said the remark made by Mr. Chantrell brought to his mind a connection he had with the "Carbon Fertilizer Co." of Oldham, who built large works in the outskirts of the town, and contracted with the corporation for the collection and treatment of the night soil and town's refuse, for manufacturing into artificial manure.

The Company supplied boxes in the closets for the collection of the refuse, which was deoderised with charcoal, and then conveyed by carts to their works, emptied on floors, and the liquid drained off into tanks below. The solid matters were conveyed to drying ovens, entering one end, thus carried to the further end by scrapers, and discharged in a semi dry condition on to bands, which carried it to a mill, to be broken and sieved as required; further bands then conveyed it to an elevator, which delivered it on to the top of a "Buchanan and Vicker's Patent Kiln" to be carbonized. This kiln was constructed so that all the moisture and gases given off could be collected, condensed and utilised.

The material discharged from the kiln was satisfactory in quality, but the quantity was disappointing, owing to the light specific gravity of the material, a low temperature could only be used in the kiln, too much heat caused expansion. Elaborate plans were prepared for pressing the wet materials into cubes to be dried the same as bricks, then to be ground and carbonized, but through the stoppage of the company this work was not executed.

He thought that had the same principle been carried on by a private firm and under economical management, the results financially would have been satisfactory.

Mr. Hill said he thought that the manure question was receiving more attention, as during the last year or two the price of ammoniacal liquor from gas works had risen considerably.

The President thought that he might mention that in Cornwall a great quantity of woollen rags was used on the land for manure, and also sea weed got from the shore, together with the sand. In Cornwall they have to manure the land very highly, as the rent per acre runs as high as £30 to £40.

Mr. Smetham in reference to Mr. King's remarks with regard to successful farming in the future, thought it was not so much a question of manures, as now manures were to be applied. In reply to Mr. Chantrell he thought it very wise for him to get out of the company as soon as possible, for it was perfectly evident that no charcoal of any commercial value could be obtained from street sweepings on account of sand being mixed with it, as to drilling the manure into the seed it was a very common practice. The crystals would probably be due to the formation of acid oxalate of potassium.

In regard to Mr. Hill's remarks as to the price of sulphate of ammonia, the principal cause of its enhanced value was scarcity of the nitrate of soda coming from Peru and Chili, and the nitrate being so expensive, more sulphate of ammonia has been used as manure. Brunner, Mond & Co. used a considerable quantity of ammonia also, for the soda ammonia process. They are the only makers in England that used this process, although there are many on the continent who use it. In reference to Mr. Siddeley's remarks, if he, Mr. Smetham, remembered rightly, some of the sand picked up from the Devonshire coast contained 85 per cent. of carbonate of lime, and consequently the sand would be of considerable use as manure, especially if the land were deficient in lime. He thought £40 an acre was very high. He also thought market gardening could be engaged in profitably by farmers, many of these round Liverpool obtaining renumerative results by this means. The A B C process for treating sewage consists in adding alum, blood and charcoal As far as his experience went he could not say the system was a profitable one, and he doubted very much whether it could be made profitable. There were all sorts of systems for treating sewage, but the cheapest plan was, where practicable, to send it right out to sea—the quantity of water in it, where the water closet system is used, rendering the extraction of the valuable constituents extremely difficult.

Gen. Scott had a system of treating sewage which consisted in allowing the sewage to ferment until the nitrogenous matters are converted to ammonia, then phosphoric acid and magnesia were added, by which means the ammonia was precipitated as ammonia magnesia phosphate, and then collected and dried and used for manure. Certainly a very excellent manure was obtained in experiments made at South Kensington. But in actual practice the process was not remunerative.

A unanimous vote of thanks was awarded to Mr. Smetham.

INCREASED EFFICIENCY OF RAILWAYS.

At a meeting of the Am. Soc. of Civil Engineers, held on the 16th of May, Mr. O. Chanute made the following remarks on the "Increased Efficiency of Railweys"—the subject of a paper read before the Society at a previous meeting.

He suggested that it was worth enquiring whether the diminished average mileage obtained from cars is an unmixed evil and whether there have not been changes in the methods of transporting business, which, while requiring less movement of cars, yet added to economy of trade and convenience of customers, and also whether the diminished mileage may not be off-set by decrease of empty mileage, and by savings affected to general business. Also that if expense can be saved to owners in the receiving or depositing of property, it enables them to pay a better freight rate.

The methods of transacting business connected with the transportation and handling of commodities have changed greatly during the past twenty years. It is worth investigating whether these changes which are beneficial to the country at large, have not conduced to the diminished average movement of cars, and whether this diminished movement has not really added to the facilities for transacting business, and that if these facilities be curtailed, it may be necessary to make corresponding reductions in freight charge.

Mr. Chanute also referred to the figures given by Mr. Shinn, which show that a large percentage of freight cars run empty. It costs nearly as much to travel an empty car as a full one, and by designing and managing cars so that they can be loaded back, and having a sufficient number to enable them to wait for such back loads, empty mileage may probably be reduced.

He also referred to the economy likely to result from the establishment of large warehouses at terminal points.

He also, while agreeing with Mr. Shinn that there are serious defects in the present system of mileage charges, suggested some objections to the per diem charge which Mr. Shinn proposes to substitute.

First, that it may lead to a considerable increase in the mileage of empty cars.

Second, that there would be difficulty in following the per diem charge over the different roads over which the car passes so as to afford a check to the owner.

Third, the probable increased expense in keeping the accounts beyond the present system, with the probable necessity for the establishment of a car clearing house.

Fourth, the opposition which will arise to the proposed change.

Fifth, the confusion and hardship likely to occur from changes of methods.

Mr. Chanute suggested these objections, not as insuperable, but to show that there must be a well matured plan presented, rather than merely the suggestion of a plan.

He also considered the charge of one dollar per day, proposed by Mr. Shinn to be entirely too large because it yields much more than the interest upon the cost, depreciation, and cost of repairs.

He presented figures showing the cost of the cars and of their maintenace upon the Erie, and the Pennsylvania railroads, and from these figures drew the conclusion that a per diem charge of 25 or 30 cents per day would be a fair one.

The paper was also discussed by Messrs. Cooper, Forney, Emery, Hamilton and Shinn.

THE GRANTHAM IRON WORKS.

(Drummondville, P. Q.)

BY B. J. HARRINGTON, PH. D.

Nearly a century and a half ago, the King of France, Louis XV,* displayed a most commendable zeal in stirring up certain of his subjects in the New World to take advantage of the deposits of bog iron ore, which had long before been discovered in the vicinity of Three Rivers, on the St. Lawrence. In 1730 he gave a Royal License to a company to work the ores, and even advanced 10,000 livres to aid in building a furnace, &c. No work having been done, he subsequently withdrew the license, but in 1735 granted it to another company, which received 100,000 livres in aid, and in 1737 erected a blast furnace, the stack of which is still standing. Several other furnaces have since been built in the same region, and also near the St. Francis River, south of the St. Lawrence, where ores similar to those of the St. Maurice, have long been known to exist.

Of the latter, one was erected in 1869, by the "St. Francis River Mining Company," at St Pie, in Yamaska County, and was sold in 1874 to Messrs. John McDougall and Co., of Montreal. Mr. Robert McDougall, of the St. Maurice Forges, was then appointed manager of the St. Pie Works, and under his superintendence, smelting operations were carried on for six years, when the furnace was abandoned, owing to the difficulty of obtaining sufficient supplies of ore within a reasonable distance.

It was, however, found that bog ore of good quality could be obtained in abundance in the vicinity of Drummondville, on the St. Francis; and, accordingly, an excellent site having been acquired near the town, a small blast furnace was erected in 1880. The enterprise proving successful, a second furnace was built, close to the first, in 1881; an office, store, dwellings for the workmen, &c., have also been put up, and now the scene presented is one of busiest activity.

For convenience in charging, the furnaces have been placed near the foot of the sloping bank of the St. Francis, where advantage can also be taken of the water-power afforded by the river. One stack is built of stone, the other of red brick, made of clay obtained on the spot. The internal measurements of the brick furnace are as follows:

	Ft.	In.
Height	32	0
Diameter at boshes	10	0
" of hearth	3	4
" of throat	4	0
Height of hearth	5	0

The stone furnace is thirty-four feet high, but otherwise similar in dimensions to the above. Both furnaces are lined with fire-bricks imported from England. The brick furnace has three tuyères, and is worked with hot blast; the other has the same number of tuyères, but the blast is cold. The blowing machinery is that which was formerly used for the bloomaries at Moisie, and is now driven by a Leffel turbine of forty-five horsepower. Each of the two horizontal blowing cylinders is eight feet long, and four and a half feet in diameter, the length of stroke being seven feet. When set up at Drummondville, this machinery was only intended to supply the blast for one furnace, and now it has to do duty for two, and when the water in the river is low the pressure obtained is insufficient, being at times only from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch of mercury. The hot-blast stove is of the ordinary type with siphon-pipes, but is defective in construction. The temperature of the hot blast on reaching the tuyères is said to be about 300°, and the manager states that with the blast heated to this temperature, the production of iron has been only about 10p.c. greater than with cold blast, and that no very marked difference in the quality of the iron has been observed.

The average charges employed are:

Bog iron ore	400-600 lbs.
Limestone	50 "
Charcoal	20 bu. = about 260 lbs.

The daily production of pig iron (mostly numbers 2 and 3) has not averaged more than five tons.* The

* Not Louis XIV, as stated in Mr. Swank's Census Report on the Iron and Steel Production of the United States, (Washington, 1881.) Louis XIV died in 1715.

* The iron is used entirely for car-wheels, and is worth from $28.00 to $30.00 per ton in Montreal.

ST GOTHARD TUNNEL.

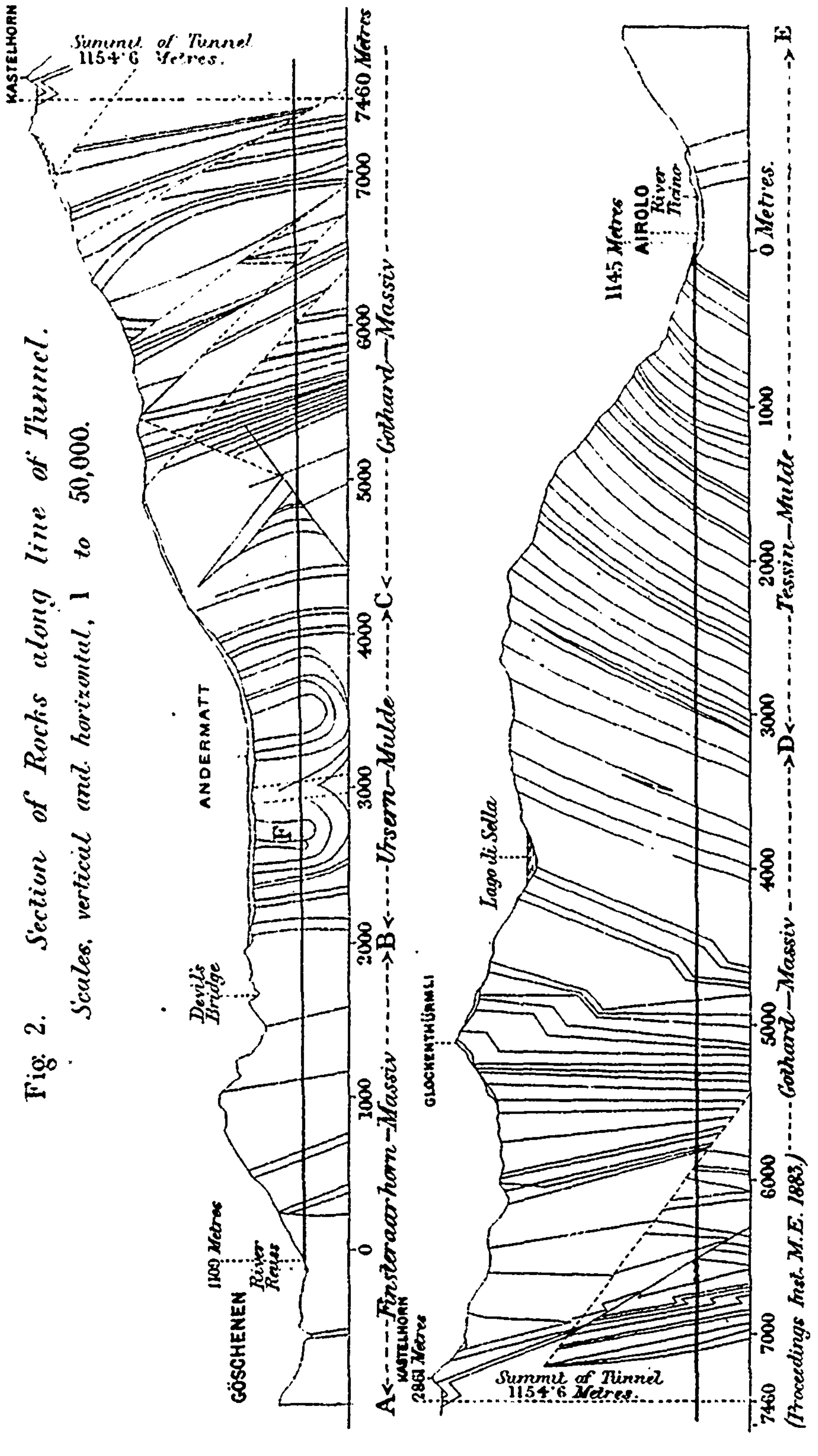
Fig. 1. *Plan of the St Gothard pass, with line of Tunnel.*

Scale 1 to 100,000.

ST. GOTHARD TUNNEL.

Fig 2. *Section of Rocks along line of Tunnel.*

Scales, vertical and horizontal, 1 to 50,000.



(Proceedings Inst. M.E. 1883.)

bog ore appears to be of better quality than much of that used at the St. Maurice Forges, and yields in the furnace an average of 44-45 per cent. of iron. Some of it is rich in manganese, and is only employed when it is desired to produce white iron. The limestone used as flux is a slaty argillaceous variety, apparently derived from the Levis formation. Analyses of samples made in the laboratory of McGill College, by Messrs. W. H. Howard (I), and E. H. Hamilton (II), gave:

	I	II
Calcium carbonate	49.25	52.12
Magnesium "	1.36	3.86
Ferrous "	5.03	4.82
Alumina	6.91	2.93
Insoluble matter	35.55	35.50
Copper	traces	traces
	98.10	99.23

The charcoal is chiefly obtained from soft wood and weighs about thirteen pounds to the bushel (the *minot.*) It is made entirely in brick kilns or charring ovens, of which there are fourteen, the internal dimensions being.

Length	50 feet
Width	16 "
Height	17 "

From thirty-five to fifty bushels of charcoal are obtained from a cord of wood, soft wood giving a larger yield by measurement than hard wood. From seventy to eighty men are constantly employed at the works, while, at certain seasons of the year, in addition to these, from 200 to 300 men are engaged in cutting wood and obtaining ore.

ELECTRICITY APPLIED TO EXPLOSIVE PURPOSES

BY PROF. F. A. ABEL., C B, F.R.S. ETC

(*Concluded from Page 151.*)

The conductivity of very fine wires could therefore be but slightly affected by physical differences in the metal, and the considerable difference in conductivity observed in different samples of platinum were therefore chiefly ascribable to variations in the degree of its purity. *It appeared likely* that definite alloys might furnish more uniform results than commercial platinum; experiments were therefore made with fine wires of German-silver, and of the alloy of 66 of silver with 33 of platinum employed by Matthiessen for the reproduction of B. A. Standards of electrical resistance. Both were greatly superior to ordinary platinum in regard to the resistance opposed to the passage of a current; German silver was in its turn superior to the platinum-silver alloy, although the difference was only trifling in the small length of the fine wire used in a fuse (0 25 inch), while the comparatively ready fusibility of the platinum-silver wire contributed, with other physical peculiarities of the two alloys, to reduce the fine German-silver wire to about a level with it. Moreover, the latter did not resist *the tendency to corrosive action, exhibited by* gunpowder, and other more readily explosive agents, which had to be placed in close contact with the wire-bridge in the construction of a fuze, while the platinum-silver was found to remain unaltered under corresponding conditions. Experiments having also been made with alloys of platinum with definite proportions of iridium, the metal with which it is chiefly associated, very fine wires of the alloy containing 10 per cent. of iridium were eventually selected as decidedly the best materials for the production of wire-fuzes of comparatively high resistance and uniformity, this alloy being found decidedly superior in the latter respect, as well as in point of strength (and therefore of managableness in the state of a very fine wire, 0 001 in. in diameter), to the platinum-silver wire. The fuzes now used in *military and submarine services were made with bridges of* iridio-platinum wire, containing 10 per cent. of the first-named metal.

The electrical gun-tubes in the navy were fired by means of a specially arranged Leclanché battery, and branch circuits worked to the different guns, in broadside firing, it was important that the wire-bridge of any one of the gun-tubes which was first fired should be instantaneously fused on the passage of the current, so as to cut this branch out of the circuit; in this respect the comparatively fusible platinum-silver alloy appeared to present an advantage, hence the naval electrical fuses were made with bridges of that alloy. Uniformity of *electrical resistance* had become a matter of such high importance in the delicate arrangements connected with the system of submarine mines, as now perfected, that the very greatest care was bestowed upon the manufacture of service electric fuzes and detonators, which were in fact made, in all their details, with almost the precision bestowed upon delicate scientific instruments, and the successful production of which involved an attention to minutæ which would surprise a superficial observer.

One of the earliest applications of electricity to the explosion of gunpowder was the firing of guns upon proof at Woolwich by means of a Grove battery and a gun-tube, which was fired by a platinum wire bridge, a shunt arrangement being used for directing the current successively into the distinct circuits connected with the guns to be proved When the high-tension fuze had been devised, gun-tubes were made to which it was applied, and an exploder was arranged by Wheatstone, having a large number of shunts, so that as many as twenty-four guns might be brought into connection with the instrument, and successively fired by the depression of separate keys connected with each.

The firing of cannon, as time-signals, was an ancient practice in garrison-towns, but the regulation of the time of firing the gun, by electrical agency from a distance, appears first to have been accomplished in Edinburgh, where, since 1861, the time-gun had been fired by a mechanical arrangement, actuated by a clock, the time of which is controlled electrically by the mean time clock, at the Royal Observatory on Calton Hill.

Shortly after the establishment of the Edinburgh time-gun, others were introduced at Newcastle, Sunderland, Shields, Glasgow, and Greenock. The firing of the gun was arranged for in various ways; in some instances it was effected either direct from the Observatory at Edinburgh, or from shorter distances, by means of Wheatstone's magneto-electric exploders. At present there were time-guns at West Hartlepool, Swansea, Tynemouth, Kendal, and Aldershot, which were fired electrically, either by currents direct from London, or by local batteries, which were thrown into circuit at the right moment by means of relays, controlled from St. Martin's-le-Grand.

About thirteen years ago the electrical firing of guns, especially for broadsides, was first introduced into the Navy, with the employment of the Abel high-tension gun-tube and voltaic piles. The gun-tubes then used were manufactured simply for the proof of cannon and for experimental artillery operations, and were of very simple and cheap construction. Experience proved them to be unfitted to withstand exposure to the very various climatic influences which they had to encounter in Her Majesty's ships, and in store in different parts of the world. The low-tension gun tubes, having a bridge of very fine platinum-silver wire, surrounded by readily ignitable priming composition, was therefore adopted as much more suitable for our naval requirements.

The arrangements for broadsides or independent firing, and also for the firing of guns in turret-ships, had been very carefully and successfully elaborated in every detail, including the *provision of a so-called drill or dummy electrical gun-tube,* which was used for practice, and refitted by well-instructed sailors. The firing-keys, and all other arrangements connected with electrical gun-firing, were specially designed to ensure safety and efficiency at the right moment.

The electric detonators for firing out-rigged torpedoes, or for other operations to be performed from open boats, corresponded, so far as the bridge was concerned, with the naval electric gun tubes, and were fired with a specially-fitted Leclanché battery. These electric appliances were now distributed throughout the navy, and the men were kept, by instruction and periodical practice, well versed in their use.

The application of electricity to the explosion of submarine mines, for purposes of defence and attack, received some *attention from the Russians during* the Crimean War under the direction of Jacobi; thus a torpedo, arranged to be exploded electrically when coming into collision with a vessel, was discovered at Yeni-Kale, during the Kertsch expedition in 1855. Some arrangements were made by the British, at the conclusion of the war, to apply electricity to the explosion of large powder charges for the removal of the sunken ships, etc., in Sebastopol and Cronstadt Harbours. In 1859, a system of submarine mines, to be fired through the agency of electricity by operators on shore, was arranged by von Ebner for the defence of Venice, which, however, never came into practical operation. Early in 1860, Henley's large magneto-electric machine, with a supply of Abel fuzes, and stout india-rubber bags, with fittings to resist water-pressure, were despatched to China, for use in the Peiho River, but no application appeared to have been made of them. The subject of the utilization of electricity for purposes of defence, however, did not receive systematic investigation in England or other countries until some years afterwards, when the great importance of submarine mines, as engines of war, was demonstrated by the number of ships destroyed and injured during the war in America.

The application of electricity to the explosion of submarine mines was very limited during that war, but arrangements for its extensive employment were far advanced in the hands of both the Federals and Confederates at the close of the war, men of very high qualifications, such as Captain Maury, Mr. N. J. Holmes, and Captain McEvoy having worked arduously and successfully at the subject.

The explosion of submerged powder-charges, by mechanical contrivances, either of self acting nature or to be set into action at desired periods, was accomplished as far back as 1583, during the seige of Antwerp, by the Duke of Parma, and from that period to 1854, mechanical devices of more or less ingenious and practicable character had been from time to time applied, to some small extent, in different countries, for the explosion of torpedoes. The Russians were the first to apply self-acting mechanical torpedoes with any prospect of success, and had the machines used for the defence of the Baltic been of larger size (they only contained 8 or 9 lb. of gunpowder), their presence would probably have proved very disastrous to some of the English ships which came into collision with and exploded them. Various mechanical devices for effecting the explosion of torpedoes by their collision with a ship were employed by the Americans, a few of which proved very effective. But although in point of simplicity and cost, a system of defence by means of mechanical torpedoes possessed decided advantages over any extensive arrangements for exploding submarine mines by electric agency. their employment was attended by such considerable risk of accident to those at whose hands they received application that, under many circumstances which were likely to occur they became almost as great a source of danger to friend as to foe.

The most important advantages secured by the application of electricity as an exploding-agent of submarine mines were as follows:—They might be placed in position with absolute safety to the operators, and rendered active or passive at any moment from the shore; the waters which they were employed to defend were therefore never closed to friendly vessels until immediately before the approach of an enemy; they could be fixed at any depth beneath the surface (while mechanical torpedoes must be situated directly or nearly in the path of a passing ship), and they might be removed with as much safety as attended their application

There were two distinct systems of applying electricity to the explosion of submarine mines The most simple was that in which the explosion was made dependent upon the completion of the electric circuit by operators stationed at one or more posts of observation on shore; such a system depended however, for efficiency, on the experience, harmonious action, and constant vigilance of the operators at the exploding—and observing—stations, and was, moreover, entirely, useless at night, and in any but clear weather.

The other, which might also be used in conjunction with the foregoing, was that of self-acting mines exploded either by collision with the ship, whereby circuit was completed through the enclosed fuse, or by the vessel striking a circuit closer, whereupon either the mine, moored at some depth beneath, was at once fired, or the necessary signal was given to the operator on shore

Continental nations had followed in our footsteps, in providing themselves with equipments for defensive purposes by submarine mines, and the Danes, Swedes, and Norwegians, had pursued the subject of submarine mines with special activity and success.

In the United States the subject of the utilization of electricity as an exploding agent for war purposes was being actively pursued, and important improvements in exploding instruments, electric fuzes, and other appliances had been made by Smith, Farmer, Hill, Striedinger, and others already mentioned, while no individual had contributed more importantly to the development of the service of submarine explosions than General Abbot, of the United States Engineers.

Illustrations of actual results capable of being produced in warfare, by submarine operations, had hitherto been very few; but of the moral effects of submarine mines there had already been abundant illustrations. In the war carried on for six years by the Empire of Brazil and the Republic of Uruguay and the Argentine Republic of Paraguay, the latter managed, by means of submarine mines, to keep at bay, for the whole period, the Brazillian fleet of fifteen ironclads and sixty other men-of-war. In the Russo-Turkish war submarine mines and torpedoes were a source of continued apprehension; and the French naval superiority was paralyzed, during the Franco-German war, by the existence, or reputed existence of mines in the Elbe.

The application of electricity to the explosion of military mines, and to the demolition of works and buildings, had been of great importance in recent wars in expediting and facilitating the work of the military engineer. The rapidity with which guns, carriages, &c., were disabled and destroyed by a small party of men who landed after the silencing of the forts at Alexandria, illustrated the advantages of electrical exploding arrangements, combined with the great facility afforded for rapid operations by the power possessed of developing the most violent action of gun-cotton, dynamite, &c., through the agency of a detonator.

The application of electricity to the explosion of mines for land defences during active war was not an easy operation, inasmuch as not only the preparation of the mines, but also the concealment of electric cables and all appliances from the enemy, entailed great difficulties, unless the necessary arrangements could have been made in ample time to prevent a knowledge of them reaching the enemy.

But few words need be said to recall to the minds of Civil Engineers the facilities which the employment of electricity to explosive purposes afforded for expediting the carrying out of many kinds of works in which they were immediately interested. Electrical blasting, especially in combination with rock-boring machines, had revolutionized the operation of tunnelling and driving of galleries; and, although in ordinary mining and quarrying operations the additional cost involved in the employment of fuzes, conductors, and the exploding machine, was not unfrequently a serious consideration, there were, even in those directions, many occasions when the power of firing a number of shots simultaneously was of great importance. There was little doubt, moreover, that accidents in mining and quarrying would be considerably reduced in number, if electrical blasting were more frequently employed.

The conveniences presented by electrical firing arrangements, under special circumstances, were interestingly illustrated by a novel proceeding at the launch of a large screw steamer at Kinghorn, in Scotland, which was recently accomplished by placing small charges of dynamite in the wedge-blocks along the sides of the keel, and exploding them in pairs, hydraulic power being applied at the moment that the last wedge was shot away.

In the deepening of harbours and rivers, and in the removal of natural or artificial submerged obstructions, the advantages of electric-firing were so obvious that extended references to them were unnecessary.

A substitute for electrical-firing, which had been applied with success to the practically simultaneous firing of several charges, consisted of a simple modification of the Bickford fuze, which, instead of burning slowly, flashed rapidly into flame throughout its length, and hence had received the name of instantaneous fuze, or lightening fuze. The fuze burned at the rate of about 100 feet per second; it had the general appearance of the ordinary mining-fuze, but was distinguished from the latter by a coloured external coating. Numerous lengths of this fuze were readily coupled up together, so as to form branches leading to different shot-holes, which might be ignited together, so as to fire the holes almost simultaneously. In the Navy this fuze was used as a means of firing small gun-cotton charges to be thrown by hand into boats when these engaged each other, the fuze being fired from the attacking boat by means of a small pistol, into the barrel of which the extremity was inserted.

ST GOTHARD TUNNEL.

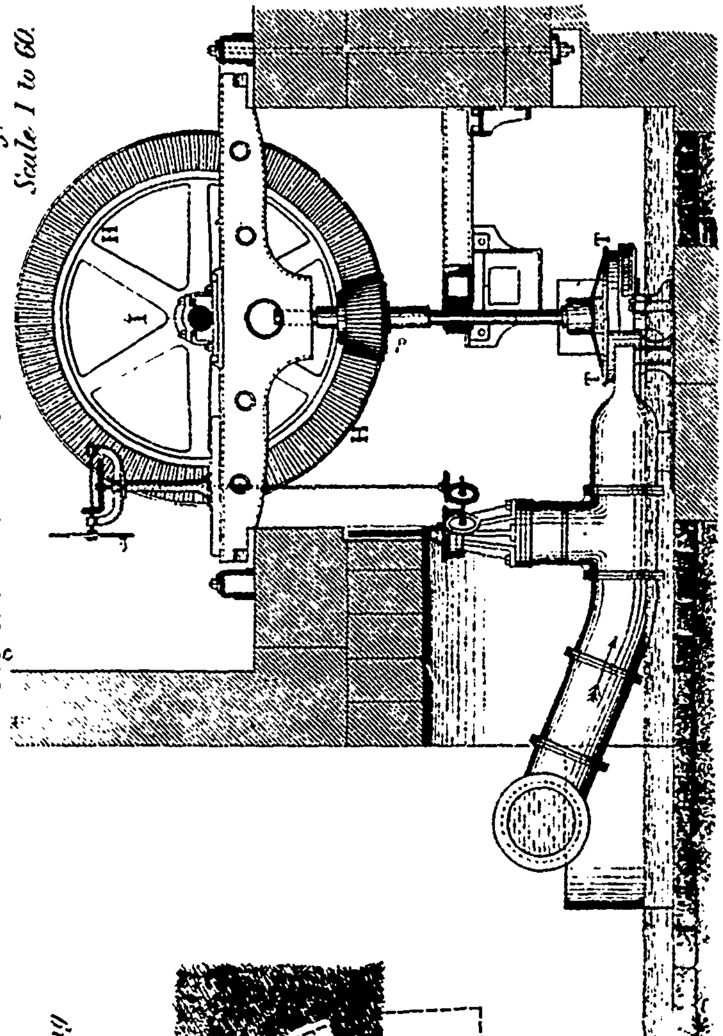


Fig. 5. Elevation of Turbine and Gearing, Airolo. Scale 1 to 60.

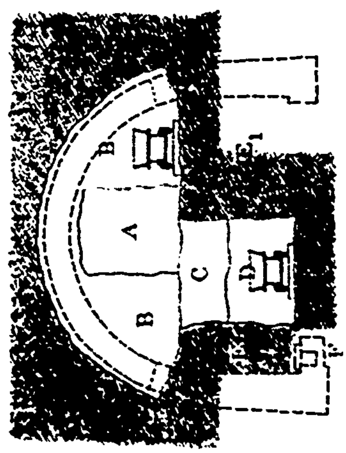
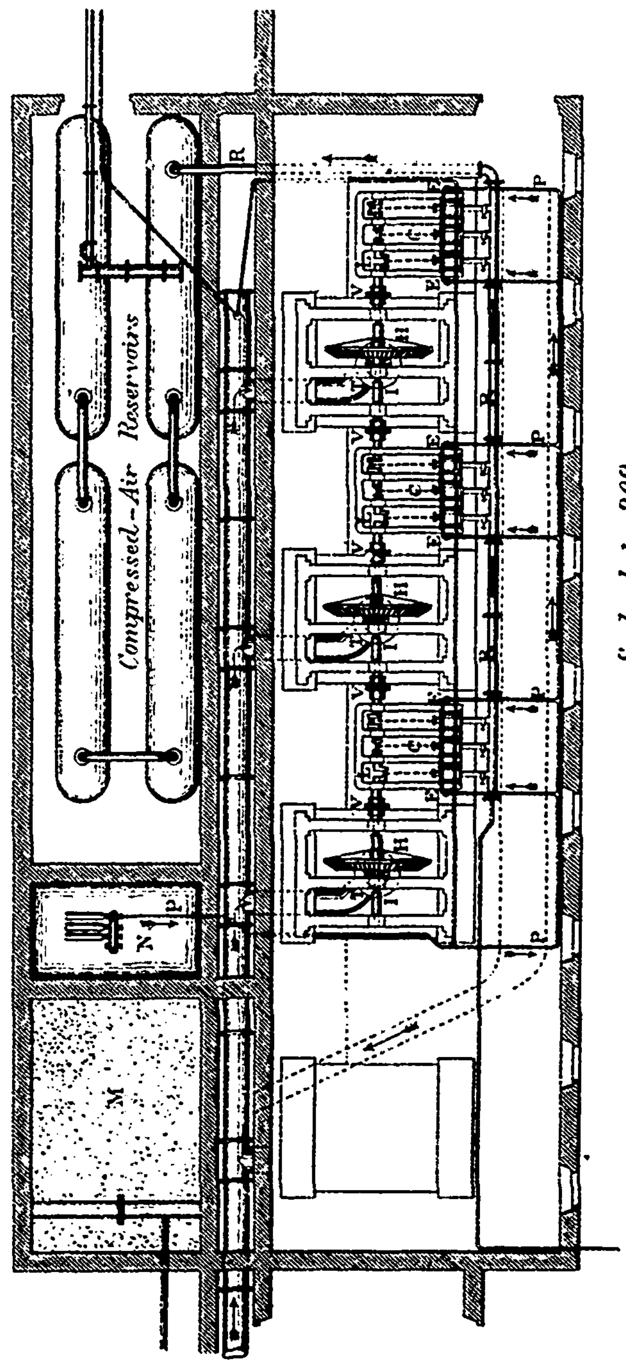


Fig. 3. Section showing mode of driving. Scale 1 to 200.

ST GOTHARD TUNNEL.

Fig 4. *Plan of Turbine Shop, Airolo.*



Scale 1 to 200.

ON THE ST. GOTHARD TUNNEL.

BY HERR E. WENDELSTEIN, OF LUCERNE.

A Paper read before the Institution of Mechanical Engineers, (Eng.)

The present paper is intended to give a brief sketch of the methods employed in constructing and working the great Tunnel piercing the chain of the Alps on the line of the St. Gothard Railway. A plan of the district passed through by the tunnel is given in Fig 1, Page 164, and a section of the tunnel, with the overlying rocks is given in Fig. 2, Page 165. Of the approaches to the tunnel on either side, which possess many points of great interest, no account will be attempted in the present paper; but it is hoped that this may be given in a future communication, which will also deal with the important questions of ventilation and temperature. The present paper will be concerned with matters of construction only.

The subject may be conveniently divided as follows:—

1. General Design.
2. Motive Power.
3. Air-Compressors.
4. Boring Machines.
5. Removal of Spoil.
6. Cost.

1. General Design.

The tunnel forms a straight line in plan, Fig. 1, Page 164, having a total length of 14,900 metres (about 9¼ miles) between the northern portal at Goschenen and the southern portal at Airolo. The former is at a height of 1,109 metres above the sea (about 3,640 feet), and the latter of 1,145 metres (about 3,760 feet). From the northern portal the line rises with a gradient of 0·5 per cent. (1 in 200), to a point 7,801 metres within the tunnel (about 4·9 miles), and then falls towards the southern portal with a gradient beginning at 0·05 per cent. then changing to 0·2 per cent., and ending at 0·1 per cent. The trigonometrical and other methods by which the centre line of the tunnel was originally fixed, and adhered to during construction, will not here be entered upon.

It will be seen by Fig. 1 that the actual carriage pass of the St. Gothard lies considerably to the west of the tunnel, and at a much greater elevation, namely 2,114 metres, (about 6,940 feet) above the sea. It was at first proposed to carry the railway over the plain of Andermatt, and for some distance further up the valley, and to pierce the main chain with a comparatively short tunnel not far from the pass. This tunnel could have been executed by means of shafts from above; but it was found that the plan would not have resulted in any true economy. The proposal belongs in fact to the period when there were still many who doubted the practicability of constructing tunnels of such a length as 9 miles. Even in 1859, M. Flachat, in his work "De la Traversée des Alpes," advised the giving up of the work already begun at Mont Cenis, and the substitution of a shorter tunnel at a higher level. He even maintained that all the Swiss passes might be crossed by summit railways, at a height of say 2,000 or 2,100 metres above the sea (6500 to 7000 ft). But the conditions of climate forbid any such attempt. The snow lies for 3 to 4 months of the year at the height of 2300 feet, for 5 to 6 months at a height of 3300 ft., and for 8 or 9 months at a height of 6000 to 7000 ft. At the level of 2300 ft. it attains every winter a depth of over 3 ft.; at 3500 ft. a depth of 6 ft.; at 4500 ft. (*e.g.* at Bardonnecchia on the Mont Cenis line) an average depth of 11 ft.; and at 5000 ft. a depth of about 13 ft. In addition, the well-known effect of snow drifts has to be considered. At heights of 5000 to 6000 feet a storm will often drift the snow to a depth of 50 ft. or more. Such masses cannot be attacked by the snow plough, and can only be removed by hand labour; which obviously could not be obtained to an extent sufficient to keep clear an ordinary railway, especialy as such drifts may occur at any point, and snow storms in such regions sometimes last for a week together.

The covering in of the railways by galleries, as practised on the Pacific line across the Rocky Mountains, would not solve the difficulty, both on account of the much greater cost of construction in that case, and from the fact that the lifting of trains to a higher level would largely and permanently increase the cost of haulage. In the case of the St. Gothard line, the only practical question was whether it should be continued over the plain of Andermatt to Hospenthal, at the height of about 4,800 ft. above the level of the sea. The tunnel would then have had a length of about 6¼ miles, say 3 miles less than its length as made. But this shortening of the tunnel would not have outweighed the disadvantages due to its higher level, as indicated above. An intermediate position between Goschenen and Hospenthal would not have shortened the tunnel by any material amount. It cannot be doubted therefore that the line actually chosen was the best for the St. Gothard Railway, especially looking to its great importance with regard to the traffic of Central Europe. For lines of less consequence, and in more southern latitudes, a higher level might of course be advantageous.

The construction of the long tunnel having thus been decided on, and the actual trace laid out, a contract was entered into with Messrs. Favre and Co., of Geneva, for the completion of the work. In this contract it was provided that the tunnel should be completed within eight years. This time is much shorter than that occupied in the case of the Mont Cenis Tunnel; but that was blasted by gunpowder instead of dynamite, and the boring machines had also been much improved in the interval. As a matter of fact, the time occupied was about 9½ years of continuous labour day and night, the work having been commenced in the summer of 1872, and completed towards the end of 1881.

It would have been possible to sink one shaft near Andermatt, at a distance of about 3½ kilometres (2·2 miles) from the northern portal. This shaft would have been about 300 metres deep (say 1000 feet). It is obvious that little would have been gained by this step, and the contractor never entertained the proposal.

The actual method of driving the tunnel is shown by the section Fig. 3, Page 168, and is known as the Belgian method. A heading A (in German *First-stollen*) was first driven at the top of the tunnel, 2·5 metres broad and 2·5 metres high (8·20 ft. square). Side widenings B B were then made on either side of this heading, so as to complete the whole arch of the tunnel (*Calotte*), which was then lined with brickwork. A bottom cut (*Sohlenschlitz*) was then made in the floor, extending to the bottom of the tunnel, but lying almost wholly on one side of the centre line. This was made in two cuts C and D, and when it was completed, an abutment (*Strosse*) was still left on each side, one of them much wider than the other. The narrower one E, was then cleared out and the side wall put in, as shown by dotted lines; and a single line of rails was laid, the laying of the second line being reserved for some later period when a double line should be made necessary by the increase of the traffic. This however was so large, from the period of opening, that the second line is already being laid. A drain F is cut at the corner.

The rocks passed through in the tunnel have been described as follows by the official geologist, Dr. Stapff, taking them in order from the north end,

1. The "Finsteraarhorn Massiv," A B, Fig. 2, Page 165, which is granitic gneiss, very hard and compact, and extends for about one-seventh of the distance.

2. The "Ursern Mulde," B C, which is gneiss, rich in mica, with intervening quartzose and greenish layers. There was some amount of water in this rock.

3. The "Gothard Massiv," of pure gneiss, C D, the beds intersecting the axis of the tunnel at a high angle, and occupying about one-half the total length.

4. The "Tessin Mulde" D E, which is mica schist, occupying one-fifth of the length at the southern end. This rock varied much, and yielded a good deal of water.

The whole of the rock lay in beds nearly at right angles to the axis of the tunnel, and was favourable both for boring and blasting; except the granite, No. 1 above, and a length of about 400 yards of serpentine, situated about 5,300 yards from the north entrance: these proved very hard.

There was also, about 2,800 yards from the north entrance, a length of about 85 yards at F. Fig. 2, where the gneiss changed into a species of china-clay. This became known, during the making of the tunnel, as the "pressure-length" (*Druck-partie*), and gave great trouble by collapsing. Unfortunately the critical nature of this clay was not at first recognised. It was worked by the Belgian method described above, driving the heading along the top; but in this compressible material it would have been better to adopt the German system, running the first heading along the bottom, and making good the walling on each side as the work proceeded. Instead of this, the arch at the top was first put in, and this, having no proper abutment or cross-tie, gradually spread at the springings and let down the crown. The first repairs attempted were not sufficiently systematic, and the length continued to move and collapse. It was finally made secure by walling of great thickness, and capable of resisting the extraordinary pressure.

2. Motive Power.

The motive power at both ends of the tunnel was furnished by the streams in the neighbourhood, but the conditions were by no means the same at the two ends. At Airolo the only available source at first was the Tremola torrent, from which the supply in the depth of winter sometimes fell to 200 cubic metres (7000 cub. ft.) per second. To obtain sufficient power it was necessary to lead the water from a vertical height of 181 metres (594 ft.) Such a head, applied to powers above 200 H P., is very rare, and occasions great practical difficulties. Besides the tendency to leakage in the pipes under such a pressure, the high speed of the issuing water, and consequently of the revolving turbines, forms a serious evil; since any want of adjustment or inferior workmanship causes great unsteadiness and consequent wear and tear. The water at such speeds has an extraordinary effect on both cast and wrought iron, and even on steel, riddling them with a number of small holes, and rendering renewal necessary in a few months. This effect is supposed to be due to oxidixation, stimulated by impact and by the air contained in the water. Subsequently, in 1874, a long channel was constructed from the Bedretta Thal, so as to open a second source of supply.

At Goschenen the supply was taken from the Reuss with a head of 93 metres (305 ft.), and the minimum supply was from 1200 to 2000 cubic metres (42,000 to 70,000 cubic ft) per second. The power thus obtained, amounting on the whole to 1500 H.P. at Goschenen and 1120 H.P. at Airolo, was made to actuate turbines driving high-speed air-compressors.

At Airolo the turbines, originally three in number, were supplied by Escher Wyss and Co., of Zurich, and are of the type called "tangent wheels" with vertical shafts. The diameter is 1·20 metre (3·94 ft.), thickness of metal, 27·7 millimetres (1·09 in.), and speed 390 rev. per min., giving a tangential velocity at the outside of 24·5 metres (80 38 ft.) per second. The water is passed through a distributor with guide-blades, having five orifices, any of which can be closed by a curved slide-valve. The distributor and guide-blades are of bronze, which in these cases lasts five or six times as long as iron or steel. Behind the distributor is a stop-valve, composed of a principal valve having a second and smaller one in the centre of it. This smaller valve is opened first and closed last, and thus diminishes the shock occasioned by starting and stopping the water under so high a pressure. The pivot of the turbine rests on four discs of hard bronze and two of hardened steel, all polished. The surfaces in contact are one concave and the other convex.

At Goschenen the turbines were on the Girard system, constructed by B. Roy and Co., of Vevey. These have horizontal axes and receive the water on a portion only of their circumference. The water passes through a distributor with eight orifices, regulated by a circular valve placed inside the revolving crown. The speed is 160 rev. per min., the outside diameter 2·4 metres (7·87 ft.) and the number of vanes 80. There were originally three of these turbines, each using 800 litres per second (35 cub. ft.), and each giving a net power of 250 H.P. In 1876 two similar turbines were added, each 5·05 metres outside diameter (16·56 ft.), and each using 480 litres (17 cub. ft.) per second, with a head of 73 metres (239 ft.), and giving a net power at the shaft of 325 H.P., at 70 rev. per min. A similar pair were fixed at the same time at Airolo.

3. Air Compressors.

At Airolo three sets of air-compressors, three in a set, were erected in 1873, by the "Compagnie de Construction" of Geneva. These were of the Colladon type, and was made with interchangeable parts, in or to reduce the time of repair to a minimum.

The three sets of compressors and the three turbines were mounted in succession along the shop, Figs. 4 to 6, Pages 165 169 and 172. the compressors C lying horizontally, whilst the turbines T are vertical. Above each turbine is a horizontal shaft I, carrying a level wheel H, which gears into a bevel pinion on the vertical turbine-shaft, Fig. 5. At each end of this shaft I, and in line with it, is another horizontal shaft L, having three cranks at 120°, to which are attached connecting-rods from the three compressing cylinders C. These shafts L can be connected with the first shaft I by clutch-gear V. Fig. 4, so that one or both sets of compressors can be worked as desired.

The compressors, Fig. 6, Page 172, are double-acting, and placed parallel to each other. The piston-rods N pass through both ends of the cylinders, and are worked by connecting-rods M from the three cranks. The diameter of the cylinders is 0·46 m. (18·11 in.), and the stroke of the piston 0·45 (17·72 in.) which at 390 revolutions per min. of the turbine gives a mean piston-speed of 1·35 m. per second (266 ft. per min.). The position of the cranks gives a uniform motion without the employment of a governor.

To cool the air during compression, two methods are adopted. In the first place the cylinder is provided with a jacket, in which there is a continual circulation of cold water. The piston-rod N is also made hollow, and carries within it a copper water-tube O, 0·04 metre diam. (1·57 in.). This tube, which is open at each end, has, near the middle, a collar Z outside it, of diameter equal to the bore of the rod, which it therefore closes. On each side of this collar the rod is pierced with three holes communicating with the interior of the piston, thus putting in communication the annular spaces within the piston-rod N, on either side of the collar Z. A small fixed tube Q passes through a stuffing-box into the water tube O. The cold water enters through the tube Q, returns from the other end outside the tube O, passes through the interior of the piston, to get from one side to the other of the collar, Z, and returns to the pipe Y, whence it is conducted away through a flexible hose. By this means the surfaces in contact with the compressed air, both inside and out, are kept always cool, whatever the speed; and if the air be dry, no other cooling arrangement is necessary.

Secondly, there are two spray injectors fixed at each end of the cylinder. The water for these is filtered first through a sand filter M, Fig. 4, Page 169, and then through a wire sieve into a reservoir N. The object of this filtration is to get rid of the fine granite silt found in Alpine water, and so to prevent the wear of the packings, &c. The filtered water arrives at the compressors through the pipes P, passes through the air-vessels E, is compressed by a pump attached to the cross-head of the compressor, and is forced as fine spray into the cylinder. The volume of injected water is less than $\frac{1}{1000}$ part of the air used in the same period. It passes with the compressed air through the exhaust S, Fig. 6, and through the pipes R, to the large reservoirs shown in Fig. 4, Plate 9, where the water is deposited.

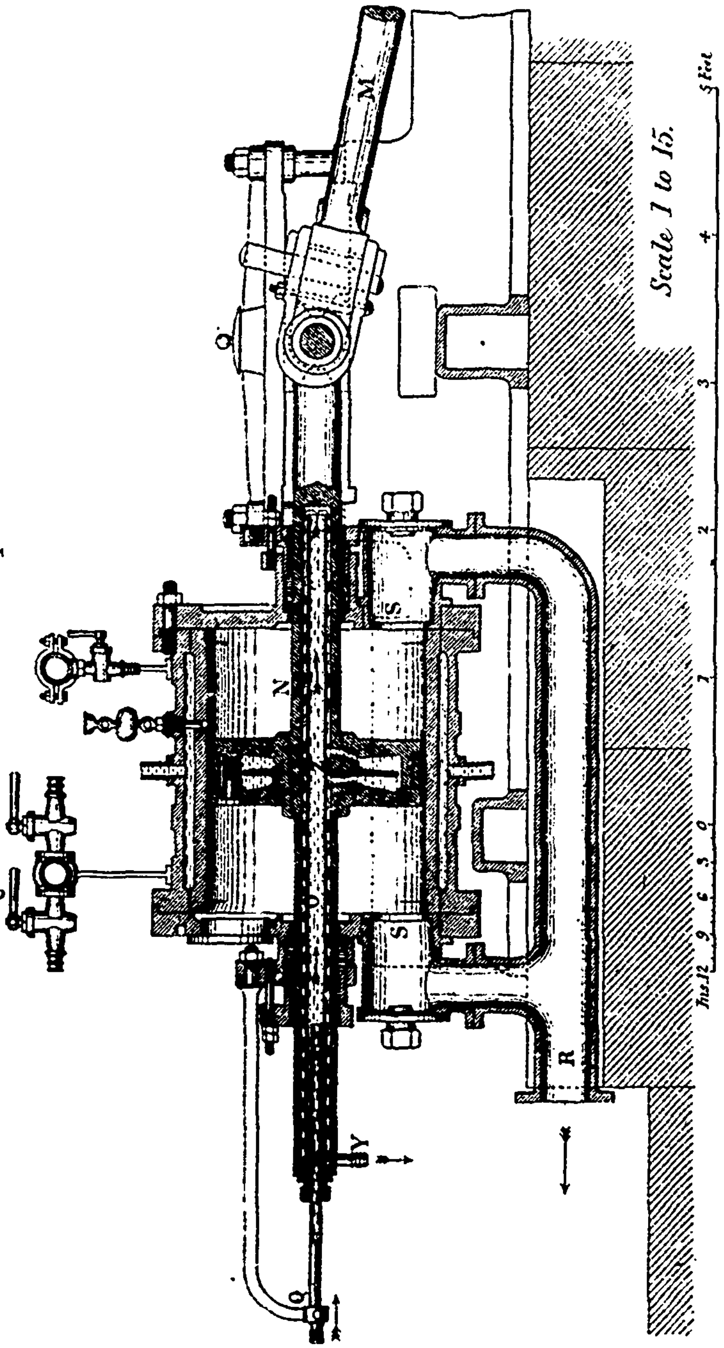
The compressors at Goschenen are similar in arrangement to those at Airolo, and have the same method of cooling the piston and cylinder, They were made by Messrs. B. Roy and Co., of Vevey. The turbines make 160 revs. and the driving-shaft 80 revs. per min.: the diameter of the cylinder is 0·42 metre (16·5 in.), and the stroke 0·65 (25·6 in.). Each set of three compressors will deliver 4 cb. m. (141 cub. ft.) per min., compressed to 8 atms. total. The piston packing is formed of two bronze rings, with a space between them, which is filled with water through a hole from the inside of the piston. This water forms a liquid packing, and at the same time cools the walls of the cylinder during the stroke. Some of it also escapes past the rings, and entering the cylinder takes the place of the spray in cooling the compressed air; for this purpose it is raised to a higher pressure when necessary by a special pump.

At each end of the tunnel two groups of compressors were added in February 1875 to the three sets of compressors first laid down and described above; the power of the latter falling short of the requirements of the work. Finally, in the summer of 1876, still larger power being required, two further pairs of large compressors of improved construction were laid down in a fresh building.

(*To be Continued.*)

A Granite shaft weighing 212 tons has been cut at Hurricane Island, Maine, and taken to Portland on a vessel, where it was loaded on four flat cars, and is to be carried to Washington. It is to be a part of the great Washington monument.

Telpherage.—The *English Mechanic* remarks: Besides electrical railways proper, there is a probability that Professor Fleeming Jenkin's system of telpherage will, before long, be practically tested on a working scale. It differs from a railway in being construcned of metallic cables stretched on insulating posts in sections: these will serve as the conductor of the current, and as support for the load, which will consist of an electro-motor as the "engine," and of suitably-shaped cars as the passenger or goods carriages, the trains being coupled up so as not to be longer than a section. The current is supplied by a dynamo driven by a stationary engine. In a modification, Professor Jenkin uses trough-like conductors instead of wire ropes.



ST. GOTHARD TUNNEL.
Fig. 6. *Section of Air-Compressor*

Attention or acknowledgment	●	
Train or Engine entering Section	● ●	
Express Passenger Train	● ● ●	"Be ready" Signals.
Ordinary Passenger or Empty Carriage Train	● — ● ●	"Be ready" Signals.
Light Engine, or Engine and Break Van	● ● — ●	"Be ready" Signals.
Express Goods, Cattle or Fish Train	● ● ● ●	"Be ready" Signals.
Fast Goods Train	● — ● ● ●	"Be ready" Signals.
Ordinary Goods, Mineral, or Ballast Train	● ● ● — ●	"Be ready" Signals.
Bank Engine in rear of Train	● ● — ● ●	
Signal Given in Error	● ● ● ● ●	
Take off Slot:—Train Waiting	● ● — ● ● ●	
Send Staff:—Train Waiting	● ● — ● ● — ●	
Blocking Back Signal	● ● ● ● ● ●	
Section Clear, but Station or Junction Blocked	● ● ● — ● ● ●	
Imperative Obstruction	● ● ● ● ● ● — ● ● ● ● ● ●	
Shunt Train for Fast Train to Pass	● ● ● ● ● ● ●	
Stop and Examine Train	● ● ● ● ● ● ●	
Train Past without Tail Lamp *to box in advance*	● ● ● ● — ● ● ● ● ●	
Train Past without Tail Lamp *to box in rear*	● ● ● ● ● ● ● ● ●	
Approaching Train Separated	● ● ● ● ● ● ● ● ● ●	
Opening or Closing Switch	● ● ● ● ● ● ● ● ● ● ●	
Train Running Back	● ● ● ● ● ● ● ● ● ● ● ●	
Train or Engine Running away Forward	● ● ● - ● ● ● - ● ● ● - ● ● ● - ● ● ●	
Inspector's Signal for Testing Apparatus	● ● ● ● ● ● ● ● ● ● ● ● ● ● ● ●	
Testing Slots on Signals	● ● ● ● ● - ● ● ● ● ● - ● ● ● ● ● - ● ● ● ● ●	

"THE COMBINATION OF THE BLOCK AND INTERLOCKING SYSTEMS ON RAILWAYS."*

By Henry Arthur Dibdin, M. Inst. C. E.

The subject which we propose this evening to bring before you, may, at first sight, seem to be one which belongs wholly to the domain of practical railway management; but, when we reflect that our engineering profession, in its adaptation of the great forces of nature to the benefit of mankind is a very responsible stewardship, so to speak, and when we find, as but too often, that our application of steam to the mighty highways of this age is accompanied by a constant sacrifice of life, it is surely incumbent on the engineer to adopt all measures that avert what are conventionally called railway *accidents*, but which, nevertheless, in the greater part, occur from theoretically preventible causes.

We would premise that although (as is only to be expected) all appliances for regulating our railway travelling, from year to year, are in a transitionary state of improvement, they may always be classed—as regards signalling—under two chief heads, viz:—The Intelligence, or electric signals, and the Demonstrative, or visible semaphore signals. With the visible signals are classed the points, by which trains are diverted from one track to another, and, it may be remarked, should of course be worked in exact harmony with the signals.

These observations will lead us shortly to one of the main topics of our paper, namely, the Interlocking of Points and Signals, which has, for the last few years, formed a subject of the deepest solicitude to railway companies, and has cost them colossal sums of money in carrying out, but, no doubt, with the result of saving still greater sums, in compensation for accidents, which would have arisen a hundred-fold more had these precautions been neglected.

When railways were in their early infancy, and the whole subject was, as yet, an experiment, there was, probably, no inducement to furnish those signals which, in modern days, we have been forced to recognise as the whole and sole safeguard of our magnificent steam roads.

Nevertheless, only a few years' experience sufficed to prove how indispensable was some code of visible signals, however crude their nature. Thus, on looking at fig. 3, Page 185 we notice what formed the first signals on the Liverpool and Manchester Railway, in 1834, and which, like the Great Western signal (below it) of 1838, up to the present time, turned bodily round on an upright pivot, and was worked by a man at the foot. These signals, it will be observed, give two distinctive signs for "danger" and "all clear," but both possess the great drawback, in practice, of being seen by the engine driver (as he travels round the curve at a junction) from rapidly changing points of view. Thus he sees the board and disc, either, perhaps obliquely, or else gradually changing from full against him to all right, or *vice versa*, just according to what portion of the curve he may be on, which is, obviously, a very objectionable state of things. We come down, then, to what must be deemed the most superior of all visible signals, namely, the semaphore (as shown in fig. 4) and which was introduced on railways by Chas. Hutton Gregory, in 1841, although the plan of conveying messages by the up-and-down action of the semaphore arm had been used long before, both by the French and our own Government, and is, we believe, still used for that purpose in some places.

We do not suppose this simple and beautiful signal—as it now prevails over nineteen-twentieths of our railway system—will ever be supplanted. On looking to the right of fig. 5, this particular signal will again be observed—somewhat in perspective,—and explains itself; the disc arm at the left doing duty to the goods siding, (shown coming from the left) the main middle post arm relates to the main line, and the lower arm on the right hand is for the branch line.

Finding, however, that the visible signal, however improved, fell very far short of meeting the needs of railway traffic as it increased, and trains began to follow each other in more rapid succession, it became a matter of pressing importance to regulate the mixed goods and passenger traffic with safety, and hence was introduced the "time interval" or permissive block system, which, as doubtless many present will recollect, was generally effected by allowing a five minutes sand-glass to run out between the departures of any two trains on the same line. It soon became obvious that this "time interval" afforded no real safeguard in the event of the breakdown of the foremost train, or engine, and thus, with the practical introduction of Cook and Wheatstone's telegraph, in 1842, the surpassing value of the electric current, as a regulator, was apparent, and, after a while, obliterated every other method. The system grew by degrees into the highly-organised Block system, as we now know it, and substituted a definite space between each train on the line for the very inadequate and misleading "time interval."

Having thus glanced at the progress of matters up to the present time, we will now examine more closely the practical working of the Block system, and afterwards, that of the system of mechanical interlocking of the points and signals in the hands of the pointsman.

Above may be seen the Bell signal-code of the Block system, as in daily and hourly use on most railways, and which, as is familiar (we presume) to most present, conveys, by beats on a bell, the premonitory intelligence which is the forerunner of every species of train—very often for miles in advance of its progress—so that the necessary path may be cleared for that particular train on towards its destination.

This, it will be seen, is almost a speaking telegraph, and is, in itself, no small matter for a pointsman to retain in his me-

* A Paper read before the Liverpool Engineering Society.

mory, and act upon hundreds of times in a day; nevertheless, it has come to be absolutely indispensable to the every-day working of trains. These bell signals again, are supplemented frequently by the ordinary speaking telegraph, by which messages are transmitted for special purposes from one pointsman to another. And still further, there are, in most busy signal cabins, electrically worked dial-plates, with the names of the principal destinations of trains marked on them, so that each and every train for either place is announced from one signal-box to another without mistake, and there are, also, innumerable other contrivances for different purposes, so well as the "train register" books, involving thousands of entries per diem.

For those who never have been in a large signal-cabin, it is difficult to realise what a babel all this concentration of mechanism creates — there is the busy clicking of twenty dials, each carrying all-important intelligence—there is the silver clanging of twenty little bells, heralding coming trains—there is the never-ceasing and distressing racket of a hundred heavy iron levers, as they work the points and signals, and outside, may be, the clamour of shouting goods-guards, and the din of screeching engine whistles, whilst ever and anon, trains thunder along the tracks past the cabin, and it might well, we say, bewilder the most skilful and courageous of us were such a mass of complications placed suddenly in our hands to control; and it is well that a skilful, hardy race of men exists, as pointsmen, who, with clear head and stout heart, patiently work the great battle of the railway, from morning to night, and from night to morning, all the year round, and who have a heavy strain on both mental and physical faculties, and in whose hands lies very nearly the whole safety of railway travelling.

On again looking at fig. 5, it will be seen that we have assumed four block stations, or signals cabins on a line of railway, and marked A. B. C. D. A train, we will say, wants to proceed from A. The semaphore or visible signals are, of course—to begin with—at "Danger." A then gives B one beat on the electric bell, which B acknowledges by repeating it back to A. A then gives B the "Be ready" signal, as it is called, and, as we just now saw from the code, this "Be ready" indicates to the man at B—by the order and number of beats—the nature of the train at A. Therefore, B (the line, we assume, being clear) repeats A's "Be ready" back to him, and this, it is agreed, gives permission to A to let the train depart, which he does, by lowering his main signal outside to "All clear" as, say, in fig. No. 4, and he at the same time gives B two beats on the bell to shew that the train has left. B then, with another electric instrument, works a dial-plate in A's cabin to the words "Train on line," and this acts as a standing reminder to A, in case he wants shortly to send another train on, that he must not do so. B, it will be understood, has, meanwhile, gone through the same programme with C, and so has C with D—if there is nothing to arrest the train—and so on to its destination. But B does not release the warning dial-plate at A until the train has actually approached and passed his box, when he again works A's dial-plate to "Line clear," and thus it will be seen, a definite space is preserved between the trains. With this modification however, suppose the train from A happens to be a stopping passenger train, and draws up at the platform beyond C, it is very evident that it would be most undesirable to keep back and delay a train at B on this account only. C, therefore, permits B's second or following train to come on, of whatever nature it may be, giving him also No. 14 bell signal, so that B thence gives the driver a special caution as to the obstruction at C. At the same time, C's dial plate is, of course, kept standing at "Train on line" by D, and therefore C perceives that he must keep his home and distant signals at "Danger," and so brings B's train to a stop somewhere between these two signals; and, as will be understood, the same thing occurs with any other obstruction on either of the tracks, such as a breakdown, we will say at D. The Blocking back signal (6 beats) given each way, effectually retards the approach of trains within dangerous proximity (if it cannot be given in time so to act, this is another thing, and involves a class of accident no system, probably, will provide against) and then the line will stand blocked until the obstruction is cleared.

This, then, we know as the absolute block system, and it is, on the whole, a very perfect mode of working. The writer would, however, here point out how much still remains at in the discretion of the various pointsmen concerned; and how possible, nay, almost certain, that notwithstanding all these mechanical precautions, trains will be brought in collision, owing to some misapprehension of the bell or dial signals. In the case of the Tamworth accident, the pointsman, through mistaking the number of beats on the "Be ready" bell, made, with his point levers, a blind siding ready for, as he supposed, the arrival of a shunting goods train, instead of which the Irish Mail came thundering through, and went to wreck in the river, at the end of the blind siding. Recently, again, at the Bleamoor Tunnel, a pointsman, beginning with nervous mistake, wilfully gives the "All clear" to the rear station's dial-plate; and, while his own yet stands at "Train on line" (for one just left him) he suffers the second—the fast train—to pass him at full speed, and the foremost train having broken down in the tunnel, the succeeding express runs right in and both are wrecked. The Nine-Elms accident, near Waterloo terminus, on the South Western Railway, is another case in point, where an engine, having proceeded beyond the signal cabin for the purpose of shunting back into the locomotive yard, the pointsman took it for granted that this had been done, and gave the fatal "Line clear" to the rear station, which sent on a fast passenger train. It so happened that the driver of the single engine had most culpably stood still with his engine, to oil it, on the main line; and in the pitch dark night, and with the engine out of sight of the cabin, on rushes the express, and the morning's papers recount the woful loss of life that ensued.

These instances which might be multiplied indefinitely, and are taking place every day in a greater or lesser degree, while the record of hair-breadth escapes, by thousands in a year, would, of itself, form volumes.

But,—says some strenuous champion of the block system—"these accidents are not owing to the use of it, but to its direct and flagrant disregard." This, we think, is rather a "begging of the question," for reasons which will shortly be noticed. We will, however, meanwhile, briefly consider the great subject of the interlocking of points and signals, which has an equal, if not greater, claim on our consideration even than the Block. As all may not be familiar with this subject, the writer would, in the first place, ask attention to fig. 2, which shews all the combinations of the main signals which which can be effected at an ordinary junction of two lines of railway, and, as will be noticed, no two of the sixteen pairs, or couples of arms are alike. Out of these four arms, and the points, can be effected sixty-four different arrangements, of which only thirteen are safe. The dangerous phases are marked with a cross.

At great stations and junctions, the number of changes thus possible is almost incalculable, and in a signal-box with one hundred levers (now no uncommon thing) the changes which may be rung, so to speak, with these 100 levers, amount to some millions, and only about 1,000 of such combinations can be practically safe to the transit of trains; all the rest, if effected, would certainly bring about disaster and collision. For instance, it is evident (fig 1) that a train coming off the branch on to the main line would foul, either an up main or a down main line train. Under the interlocking, then, all such possible dangerous combinations are weeded out, so to say, by a most elaborate complicated plan of cross-bars, and quadrants, and locks, &c., in connection with the signal-levers, and so is mechanically prevented the possibility of the pointsman forgetfully exhibiting false or misleading signals to a driver of a train, or, it may be, making a track for him which must inevitably bring him into disaster with another train. Thus, so effectually has this been carried out, that it is no unusual thing to shift (in a large signal frame) at least 40 levers, before the particular one needed is found unlocked and free to be used. And such a frame as this will demand weeks and even months of anxious care, beforehand, to scheme all the locking into theoretical correctness, and so as also to comply with the rigorous requirements of the Board of Trade, which, it must be admitted, have proved to the last degree beneficial, in developing these and other important appliances for the safety of railways.

Assuming, therefore, that it is no longer, theoretically, in a signalman's power to give spontaneously, dangerous, or fatal signals to trains (which but, of course, was an almost certainty before the interlocking was done) the writer would now beg to lay before you the premises of the argument of this paper, namely:—

That although the Block and Interlocking are each perfect (or as nearly so as human prudence and skill can make them) yet, inasmuch as they are distinct in mechanism and operation from each other, therefore until they are combined, it will ever be in the pointsman's power or discretion to give signals and to work points in direct opposition to each other, and in antagonism to all fact and safety. And it must be remembered that the whole aim and object of the block and interlocking is to give one final and unerring sign, at each stage of the train's progress, the result of the combined judgment and permission of three, if not four, agents. Yet, we see that this final sign rests too often with an overworked and fallible human agent.

Suppose, now, that (as we recently noticed) C has a passenger train standing at the platform, and a fast express is signalled from B, there is, really, nothing to prevent C, if he be so forgetful, or nervous, or foolish, or wicked, as to give "Line clear" to B (as was literally done in the Bleamoor accident, just referred to) and he can take off all his visible semaphore signals to "All right" and thus he draws the fast train into the terrible disaster which awaits it, as on it comes, into the standing train at C. Or again, there may be no existing obstruction, but B, for instance, shall in like manner have given "Line clear" for a fast through-train from A, and then, totally forgetting that he has done so, amidst the turmoil of other working trains around him, and the badgering of impatient goods guards, or drivers. or, it may be, other pointsmens' bell-signals, he "loses his head," and may, either as the express thunders up unperceived by him through the steam of other engines, or in fog, or in darkness ; he may, we say, turn the express on to a branch line, or a siding where a goods train stands ready and whistling to come out ; or if at D, he might turn it on to a branch where a slow train had been shunted ; or he might have already brought the goods out of the siding, right into the teeth of the express at the last moment ; or, by merely shifting the main signals back to "Danger" for a second, and so liberating the points in front of it, he could "split the train," as it is called ; (as was done at Wigan, and spite of the locking-bar, could be done at any junction, to day.) He can, we say, do all this under the most perfect state of the Block and Interlocking, so long as they are uncombined and independent in their action. And hence, although the champion of the Block says it is only by flagrant neglect of its provisions that such catastrophes as the foregoing are possible, we say that this argument rather begs the question, and really points out its whole defect. *It should not be mechanically possible to disobey the regulations of the Block signal, and that signal—be its import what it may—must result from the co-operation of all the prime movers in the chain of circumstances, as before recited.*

It is not denied that these or similar considerations have forced themselves very seriously upon railway managers and engineers for some years past. Consequently, very numerous plans have been devised for meeting the difficulty in some form or other, and for combining, mechanically, the two systems of electric and semaphore signals, so that they cannot conflict. Though theoretically correct, it would appear, practically, that an overwhelming objection against all this is, that to carry it out is simply loading one series of mechanical complications on top of another, until the whole fabric drops to pieces by its own weight, and, therefore, there hardly seems much likelihood of the means being adopted. Be this as it may, the writer strongly contends then, that the optional powers at present possessed by the pointsman must be very considerably restricted before we can consider we have attained to a theoretically correct and safe mode of working trains. And this, we say, can only be done by the organised co-operation of all the elements at work, namely, the preliminary or electric warning signal, and the accepting or rejecting of that signal from the advanced section, and the visible-signal and point levers, and the train that finally follows, and which may either finish—or fail to finish—its passage. All these, we say, must act in perfect accord with each other ; and thus, no one step be taken but what is the result of the consent of each agent at work.

The writer thinks that this can only be answered by assuming a very considerable abridgment of the present Block system ; which, with its intricate code, and its train-dials and indicators, and its three-wire system, and other things which we have not time to discuss, should be swept away , and then, substituting for all this a partially automatic system of electric block, combined mechanically with the point and signal levers of the interlocking—all forming a circuit upon one electric wire, in which circuit the train itself forms an element of the first importance, and so fills what the writer deems to be the fatal gap in our present railway working—the train, having, hitherto, had no share or active control in the physical chain of events which regulate its transit. There would, of course, be no objection under this method to the use, as well, of independent dial-plates, and the speaking telegraph, if desired. It is now many years since the writer, imbued with these convictions, constructed the apparatus which he has the pleasure of now showing to you , and his object, when at first put into this practical shape, was, hereby, to so effect the safe working of single lines as it should be physically impossible for two trains to meet thereon, as in the disastrous event at Thorpe, near Norwich, when, as will be remembered, two passenger trains were (under some verbal misunderstanding at the stations) both despatched simultaneously from opposite ends of the single line, and shorly afterwards met midway with the most terrific consequences.

The principle of these instruments (now exhibited) would remain the same—but would have to be somewhat modified—for double-line working, and this the writer has never yet had leisure or opportunity for working out ; and so, also, the never ceasing duties of his avocation have entirely prevented his bringing the method into actual working, as yet, on any railway.

We will now—looking at the lower portion of Page 185.—illustrate a case of working for which these instruments were designed, and which serves to explain the argument for partly-automatic working, as just announced by the writer.

We have here a single line with two terminations, called for distinction, North and South, and our instruments are marked in accordance.

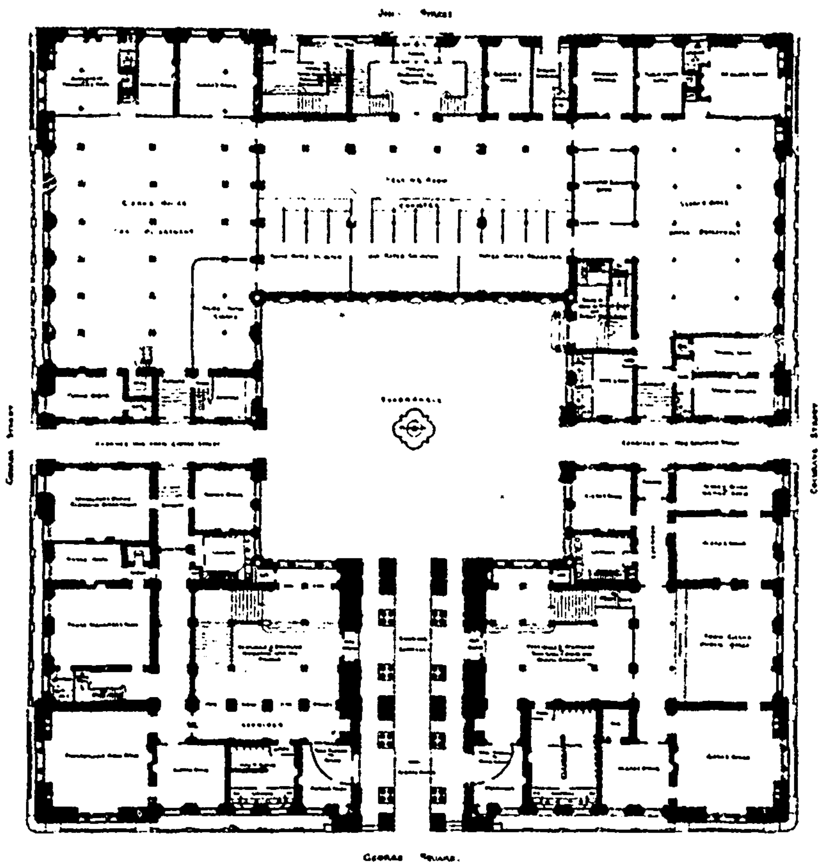
Suppose, therefore, that the man in the N. box wishes to send a train away to S., he gives, first of all, say 4 beats, to that station, as a preliminary to getting his own levers unlocked, for if he goes to them they are locked against him ; and, did the train really depart, it would only go into the siding at E. or F. Then, if no signals be off at S. or N., S. can give a reply which, properly effected, unlocks N's departure or main signal, and the train can depart. At the same time, it will be noticed that S. gives his permission in such a way, on the instrument, that it remains a self-locked tell-tale against him, and nothing that he can do can cancel that permission so given. What, then, revokes this self-locking ? We see that nothing short of the bona-fide arrival of the train at S. liberates the electric lock of the instrument, and once again the signals are put to their normal position, and the line can be again used in either direction. We see, also, that no bell-signals can be either given or taken whilst the train is in the section between N. and S. And, likewise, under the ordinary interlocking, the main arrival or departure signals being off, no second engine or train can possibly get on to the main line; and, as before stated, even were a driver to "run through" these main signals, in disobedience, he would only just drive into a blind siding, and might simply look to be suspended, instead of contributing to or causing some direful collision, as, but for this control, would be the case.

These instruments, be it observed, do not differ very essentially in mechanism from most other similar contrivances on the Block system already in use ; and, it is imagined, that the chief drawbacks or objections to such a plan of partly-automatic train signalling could be overcome by careful maintenance and inspection of the apparatus employed , such care, in fact, as it is at present bestowed on existing appliances; such contingencies also as the self-failure of the mechanism should be brought within very narrow limits. It is only right to observe that even the breakage of one single wire, anywhere, in this system, would have the effect of locking the line up completely at the section whereon it occurred. Nevertheless, if this happens on the present Block system, virtually, the same result ensues for a while, and it is not so long since the whole trunk line of the North Western was, at every 200 yards, furnished with loops on the Block telegraph wires, by the side of the railway, made so as to be purposely broken by the guard, in the event of a train coming to grief ; but, owing to frequent mischievous interference, this scheme has now been revoked. We think that means could be devised for removing this objection to the automatic plan, by the keeping in reserve of duplicate parts, &c.; and that, moreover, any such temporary disadvantage, from failure, would be more than counterbalanced by the general and constant gain in safety to human life—even regarding the matter from a purely economic point of view, which is, after all, we fear, the principal test in this utilitarian age of whether any invention be good or not. And, as regards the cost of introducing such a scheme, it is well known that a very few catastrophes to fast trains involve railway companies in far greater sums, for compensation, than would cover the whole cost of the Block system over hundreds of miles of railway.

GLASGOW MUNICIPAL BUILDINGS.

SECOND PREMIATED DESIGN.

Andrew T. Taylor, A.R.I.B.A., Architect, London, England,
And Union Buildings, St. Francois Xavier Street, Montreal



PLAN OF THE GROUND FLOOR

GLASGOW MUNICIPAL BUILDINGS.

The city of Glasgow, Scotland, having outgrown the present accommodation for the Municipal authorities and City Officials, and having long felt the inconvenience of having the public offices in different parts of the city, recently determined to erect a large and complete building in which all the city officials could be accommodated and which could embrace a new and more commodious Council Chamber, a large Banquetting Hall and Reception rooms for official occasions, and, in addition, a series of *galleries* which could be available for pictures and sculpture. Steps were accordingly taken by the Council, to obtain designs by open competitions for a building to cost £150,000 sterling. A large number of designs were sent in, but the result was unsatisfactory, as it was found that the sum was too small for the accommodation and style of building asked for.

The Council then reconsidered the whole matter and invited architects to engage in a second competition, increasing the sum proposed to be spent to £250,000 sterling. They wisely requested Mr. Charles Barry, ex-President of the Royal Institute of British Architect and son of Sir Charles Barry, the architect of the Houses of Parliament, to act as their adviser in the matter, associating with him their city architect, Mr. Carrick, who had devoted much thought and time to the scheme.

The competition was a specially interesting and important one, not only from the magnitude of the undertaking, but from the fact that a new principle was recommended by Mr. Barry, namely, that of having two competitions, a preliminary and a final one. The preliminary was to be open to every one and from the designs thus sent in, ten designs were to be selected and their authors invited to join in a final competition, elaborating their plans and fully thinking out the whole matter in all its parts and bearings. Each of the ten were to receive a honorarium, and the author of the design considered best to be appointed architect.

This method was adopted.

One hundred and twenty-five designs were sent in, from England, Scotland, Ireland, France and Germany.

Ten were selected, and in due course the designs for the final competition were sent in.

The accompanying design, of which the illustration (page 176) gives a perspective view, was not only one of the ten in the preliminary competition, but was placed second by the arbitors in the final competition, which decision was endorsed by the Lord Provost and Council.

The author of the design placed first was Mr. Young, of London, but as some of the arrangements of the design we illustrate, were considered superior to those in the successful design, the Council asked permission to adopt and embody these in the buildings to be erected, which was granted. The site is a fine one, as the buildings will form the whole of the East side of George

Square, and are bounded by streets on the remaining three sides.

As will be seen by the accompanying plans, the buildings were arranged round a Central Court' and the main entrance is placed under a hand some loggia.

The style of the building is Renaissance of a French character and suitable for a civic structure in which dignity as well as a certain amount of richness is seemly.

The architect of the design we illustrate, on pages 176, 177 181, (in association with another), is Mr. Andrew T. Taylor, M.R.I.B.A., of Union Buildings, St. François-Xavier Street, Montreal.

ELECTRICAL UNITS OF MEASUREMENT.

By Sir William Thompson, F. R. S. S. L. and E., M. Inst. C. E. *

The Lecturer began by observing that no real advance could be made in any branch of physical science until practical methods for a numerical reckoning of phenomena were established. The "scale of hardness" for stones and metals used by mineralogists and engineers were alluded to as a mere test in order of merit in respect to a little understood quality, regarding which no scientific principle constituting a foundation for definite measurement has been discovered. Indeed it must be confessed, that the science of the strength of materials, so all important in engineering, is but little advanced, and the part of it relating to the quality known as hardness least of all.

In the last century Cavendish and Coulomb made the first advances towards a system of measurement in electrical science, and rapid progress towards a complete foundation of the system was effected by Ampere, Poisson, Green, Gauss and others. As late as ten years ago, however, regular and systematic measurement in electrical science was almost unknown in the chief physical laboratories of the world; although as early as 1858 a practical beginning of systematic electric measurement had been introduced in the testing of submarine cables.

A few years have sufficed to change all this, and at this time electric measurements are of daily occurrence, not in our scientific laboratories only, but also in our workshops and factories where is carried on the manufacture of electric and telegraphic apparatus. Thus, ohms, volts, ampères, coulombs and microfarads are now common terms, and measurements in these units are commonly practised to within 1 per cent. of accuracy. It seems, indeed, as if the commercial requirements of the application of electricity to lighting and other uses of every-day life were destined to influence the higher region of scientific investigation with a second impulse, not less important than that given thirty years ago by the requirements of submarine telegraphy.

A first step toward the numerical reckoning of properties of matter, is the discovery of a continuously-varying action of some kind, and the means of observing and measuring it in terms of some arbitary unit or scale divison; while the second step is necessarily that of fixing on something absolutely definite as the unit of reckoning.

A short historical sketch was given of the development of scientific measurement, as applied to electricity and magnetism, from its beginning with Cavendish, about 100 years ago, to the adoption of the absolute system of measurement by this country in 1869, at the instance of the British Association Committee on Electric Standards. The importance in this development of the originating works of Gauss and Weber, was pointed out, as also of the eight years' labours of the British Association *Committee. This Committee not only fairly launched the* absolute system for general use, but also effected arrangements for the supply of standards for resistance coils, in terms of a unit, to be as nearly as possible 109 centimeters per second. This unit afterwards received the name of the ohm, which was adapted from a highly suggestive paper which had been communicated to the British Association in 1861, by Mr. Latimer Clark and Sir Charles Bright, in which some very valuable scientific methods and principles of electric measurement were given, and a system of nomenclature—ohmas, kilohmas, farads, kilofarads, volts and kilovolts—now universally adopted with only unessential modification, was proposed for a complete system of inter-dependent electric units of measurement. At the International Conference for the Determination of the Electrical Units, held at Paris in 1882, the absolute system was accepted by *France, Germany, and the other European countries*; and Clark and Bright's nomenclature was adopted in principle and extended.

Gauss' principle of absolute measurement for magnetism and electricity is merely an extension of the astronomer's method of reckoning mass in terms of what may be called the universal gravitation unit of matter, and the reckoning of force, according to which the unit of force is that force which, acting on unit of mass for unit of time, generates a velocity equal to the unit of velocity. The universal-gravitation unit of mass is such a quantity of matter, that if two quantities, each equal to it, be placed at unit distance apart, the force between them is unity.

Here mass is defined in terms of force and space, and in the preceding definition force was defined in terms of mass, space, and time. Eliminating mass between the two, it will be found that any given force is numerically equal to the fourth power of the velocity with which any mass whatever must revolve round an equal mass, fixed at such a distance from it as to attract it with a force equal to the given force. And, eliminating force between the two primative definitions of the universal-gravitation system it will be found that any given mass is numerically equal to the square of the velocity with which a free particle must move to revolve around it in a circle of any radius, multiplied by this radius. Thus, take a centimetre as the unit of length, and a mean solar record as the unit of time, and adopt 5·67 grammes per cubic centimetre as the mean density of the earth from Baily's repetition of Cavendish's experiment, and suppose the length of the seconds' pendulum to be 100 centimetres, and neglect the oblateness of the earth and the centrifugal force of its rotation (being at the equator only $\frac{1}{289}$ of gravity) the result for the universal-gravitation units of mass and force is respectively *15·36 French* tons, and *15·36* dynes, or 15·07 times the terrestrial surface weight of a kilogram.

The ultimate principles of scientific measurement were illustrated by the ideal case of a traveller through the universe who has brought with him on his tour, no weights, no measures, nor watch or chronometer, nor any standard vibrator or spring balance, but merely Everett's units and constants and a complete memory and understanding of its contents, and who desires to make for himself a metrical system agreeing with that which he left behind him on the earth. To recover his centimetre the readiest and most accurate way is to find how many wave lengths of sodium light there are in the distance from bar to bar of a plating which he can engrave for himself on a piece of glass. How easily this is done, supposing the grating once made, was illustrated by a rapid experiment performed in the course of the lecture, without other apparatus than a little piece of glass with 250 fine parallel lines engraved on it by a diamond, and two candles and a measuring tape of unknown divisions of length (only used to measure the *ratio* of the distance between the candles to the distance of the grating from either.) The experiment showed the distance from centre to centre of consecutive bars of the grating to be 32 times the wave length of yellow light. This being remembered to be $5{\cdot}89 \times 10^{-5}$ of a centimetre, it was concluded that the breadth of the space on which the 250 lines are engraved is $250 \cdot 32 \cdot 5{\cdot}892 \cdot 10^{-5}$, or ·4726 of a centimetre. According to the instrument maker it is really ·5 of a centimetre! Five minutes spent on the experiment instead of one, and sodium flames behind fine slits, instead of open candles blowing about in the air, might easily have given the result within one-half per cent. instead of 4½ per cent. Thus the cosmic traveller *can easily recover his centimetre and metre measure.* To recover his unit of time is less easy. One way is to go through Foucault's experimental determination of the velocity of light.

But, he must not be imagined as electrically-minded; and he will certainly, therefore, think of "*v*," the number of electrostatic units in the electro-magnetic unit of electricity; but he will, probably, see his way better to doing what he wants by making for himself a Siemens' mercury unit (which he can do easily, now that he has his centimetre), and finding (by the British Association method, or Lorenz's with Lord Rayleigh's

* A lecture delivered before the Institution of Civil Engineers, (*Eng.*)

modification, or both), the velocity which measures its resistance in absolute measure. This velocity, as is known from Lord Rayleigh and Mrs. Sidgwick, is 9,413 kilometres per mean solar record, and thus he finds, in mean solar seconds the period of the vibrator, or arbitrary-unit chronometer, which he used in his experiments.

Still, even though this method might be chosen as the readiest and most accurate, according to present knowledge of the fundamental data for recovering the mean solar second, the method by "v" is too interesting and too instructive in respect to elimination of properties of matter from our ultimate metrical foundations to be unconsidered. One very simple way of experimentally determining "v" is derivable from an important suggestion of Clark and Bright's Paper, referred to above. Take a Leyden jar, or other condenser of moderate capacity (for example, in electrostatic measure, about 1,000 centimetres), which must be accurately measured. Arrange a mechanism to charge it to an accurately measured potential of moderate amount (for example, in electrostatic measure, about 10 c.g.s., which is about 3,000 volts), and discharge it through a galvanometer coil at frequent regular intervals (for example, ten times per second.) This will give an intermittent current of known average strength (in the example, 10^5 electrostatic c.g.s., or about 1·300,000 c.g.s. electro-magnetic, or 1·30,000 of an ampere), which is to be measured in electro-magnetic measure by an ordinary galvanometer. The number found by dividing the electrostatic reckoning of the current, by the experimentally found electro-magnetic reckoning of the same, is "v," in centimetres per the arbitrary unit of time, which the experimenter in search of the mean solar second has used in his electrostatic and electro-magnetic details. The unit of mass which he has chosen, also arbitrarily, disappears from the resulting ratio. It is to be hoped that before long "v" will be known within 1·10 per cent. At present it is only known that it does not *probably* differ 3 per cent. from $2·9 \times 10^{10}$ centimetres per mean solar second. When it is known with satisfactory accuracy, an experimenter, provided with a centimetre measure, may, anywhere in the universe, rate his experimental chronometer to mean solar seconds by the mere electrostatic and electro-magnetic operations described above, without any reference to the sun or other natural chronometer.

The remainder of the lecture was occupied with an explanation of the application of the absolute system in all branches of electric measurement, and the definition of the now well known practical units founded on it, called ohms, volts, farads, micro-farads, amperes, coulombs, watts. The name mho, found by saying ohm to a phonograph and then turning the drum backwards, was suggested for a unit of conductivity, the reciprocal of resistance. The sub-division, millimho, will be exceedingly convenient for the designation of incandescent lamps.

The British Association unit has been found by Lord Rayleigh and Mrs. Sidgwick to be 9868 of the true ohm (10^9 centimeters per second), which differs by only 1·50 per cent. from 9870, the number derived from Joule's electrothermal measurements described in the British Association Committee's report of 1867, with 772 Manchester foot-pounds taken as the dynamical equivalent of the thermal unit from the measurement described in his Royal Society paper of 1849, and confirmed by his fresh measurement of 20 years later, published in his last Royal Society paper on the subject.

It is satisfactory that, whether for interpreting old results, or for making resistance-coils anew, electricians may now safely use the British Association unit as 9868, or the Siemens' unit as ·9413, of the ohm defined as 10^9 centimetres per second.

PHOTOGRAPHING SPEECH.—Deaf-mutes are taught to speak and comprehend by watching the movements of the lips. According to the *Photographic News* M. Wanerke has photographed the face of a man in which these movements were perfectly defined, so as to have the exact form corresponding to each sound. By means of these photographs inexperienced persons have been enabled to recognize the different articulations.

A TENDER, which will be a landmark in the history of electric lighting, has been made by the Telegraph Construction and Maintenance Company, to carry out an installation in Nottingham of 60,000 Swan lamps of 20-candle power. Five dynamos are proposed to be fitted, each weighing 45 tons, and each capable of maintaining 15,000 lamps. The total power employed or available will be 6,360 indicated horse-power. The cost of the installation will be £220,000, and the annual cost for maintaining the system is estimated at £46,608. Compared with gas at 2s. 6d. per 1,000 feet consumed at 60,000 at burners, each giving a light of 12 to 14-candle power, a saving of £93,750 per annum will be effected, or sufficient to pay a dividend of 23·18 per cent. The stability of the Maintenance Company is sufficient to warrant us in believing that the above estimate is calculated on fair bases.

ON A NEW FORM OF RESISTANCE WITH SPIRAL COILS OF WIRE.—*Electrical Review.*

By HENRY F. JOEL, C.E.

In most of the installations of the electric light an adjustable resistance is as much a necessity as a current measurer, switch, or such apparatus; but these several instruments help to make the electric light plant expensive. It has been the object of the writer to make a complete set of such necessary apparatus in the most simple, reliable, and economical manner, and the resistance now described forms part of such a set of apparatus.

A spiral of German silver, iron, or platinum wire is bent round a central block of wood or is otherwise fixed in position, in the centre of the spiral there is pivoted a metal contact arm, which presses on its outer end directly upon the top surfaces of the spirals; the pivot end of the contact arm is connected to one terminal, and one end of the spiral is connected to the other terminal, the other end of the spiral being insulated. It is obvious that, as the contact arm is moved round, more or less of the wire spiral resistance is inserted in the circuit.

This form of resistance possesses some important practical advantages, the spring of the coils of wire enables a good contact to be made without much friction, whilst the resistance can be adjusted to almost any degree of nicety, and at the same time the apparatus is simple and inexpensive.

In fig. 1, page 180, a complete spiral resistance, the contact arm is provided with a knob for convenience of moving, and a divided scale indicates the resistance to be introduced; a supplementary short circuit plug is shown; this is at times very useful.

Fig. 2 shows the wire coiled in the form of a volute spiral. In this form the contact arm has two pins fitted with rollers projecting downwards on each side of the wire coils, and the other end of the arm is slotted; when the contact arm is moved the pins act as guides, whilst the slotted end enables the contact arm to follow the convolutions of the spiral; this form of resistance gives a greater range than the circular form of fig. 1.

Fig. 3 shows a detail of the contact arm and spiral.

Fig. 4 shows an application of the spiral resistance to regulate the discharge of a number of accumulators, or any other electric generator, such as a dynamo-machine, and this arrangement also answers for keeping the resistance of a circuit constant should any of the lamps be turned out.

In this application the accumulators are shown at the top, connected on the one side to some electric lamps in multiple arc, and on the other to a solenoid coil. The spiral resistance is introduced between the two, a core is free to move in the solenoid, and when no current is passing is pulled over by a spring attached to one end; on the other end of the core a rack is fixed which gears into a pinion; on the same axis as the pinion a ratchet-wheel is pivoted, and this wheel by means of a spring pawl is connected to the contact arm. When the contact arm is moved the resistance is decreased or increased; with the ratchet-wheel and pawl it decreases the resistance only, but without the ratchet-wheel and pawls it acts both ways.

When the current passes through the solenoid the attraction of the core overcomes the spring, and the racks moves forward; should the current decrease in strength, the spring pulls the core back, and this moves the contact arm in the direction of the arrow, and thus decreases the resistance; the current is then again restored to the required strength, and the rack pulled back ready for further action.

This application of resistance coils in a spiral form should be of considerable service in many instances, and will help to surmount one of the difficulties in the way of the successful application of electric lighting, viz., keeping the circuit at a constant resistance.

RESISTANCE WITH SPIRAL COILS.

FIG.1.

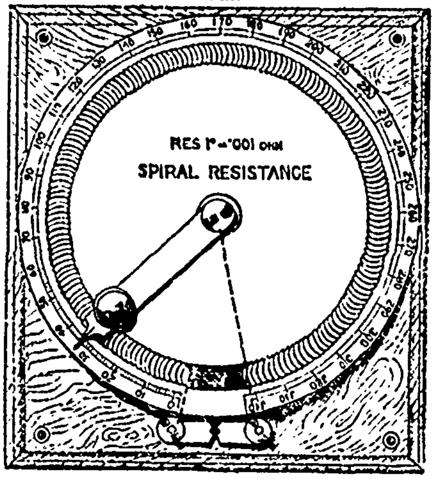
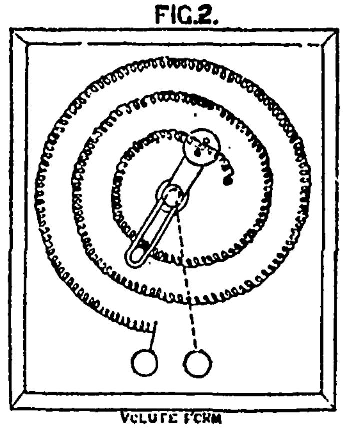


FIG.2.



VOLUTE FORM

FIG.3.

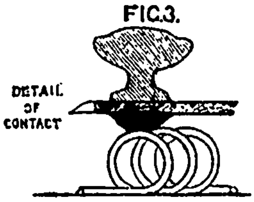
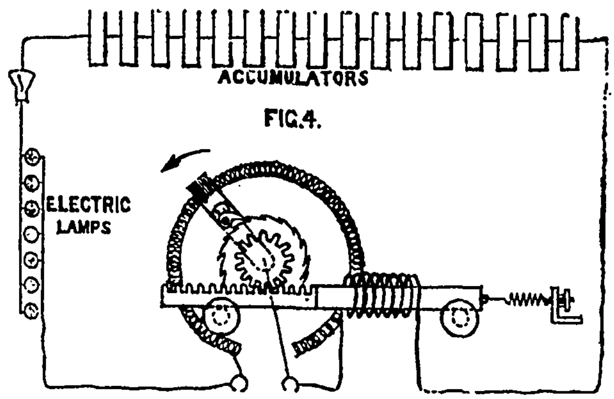
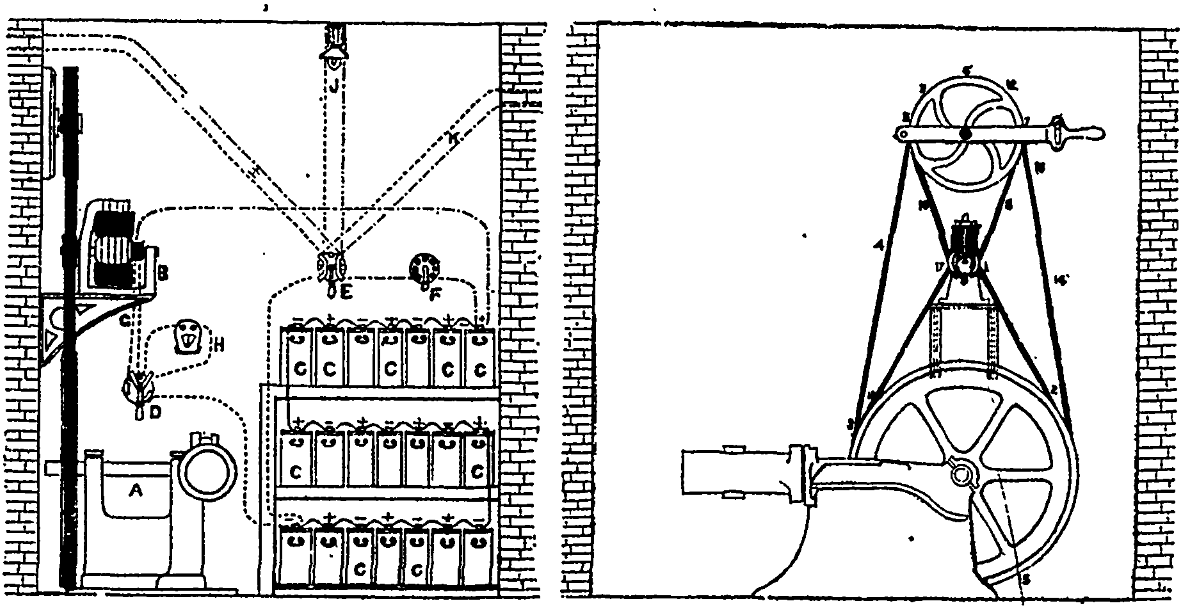


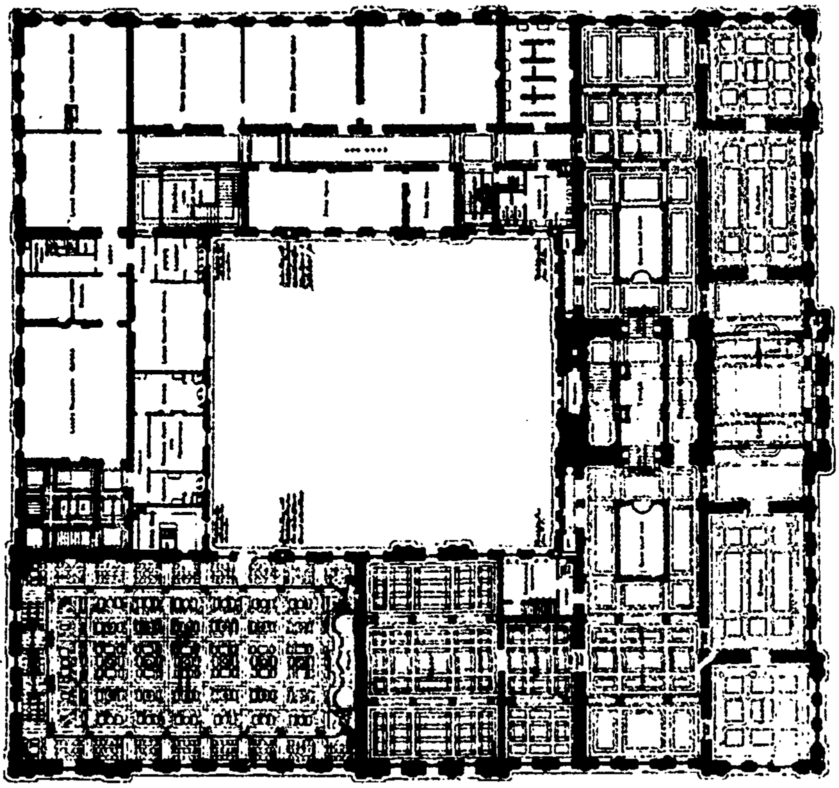
FIG.4.



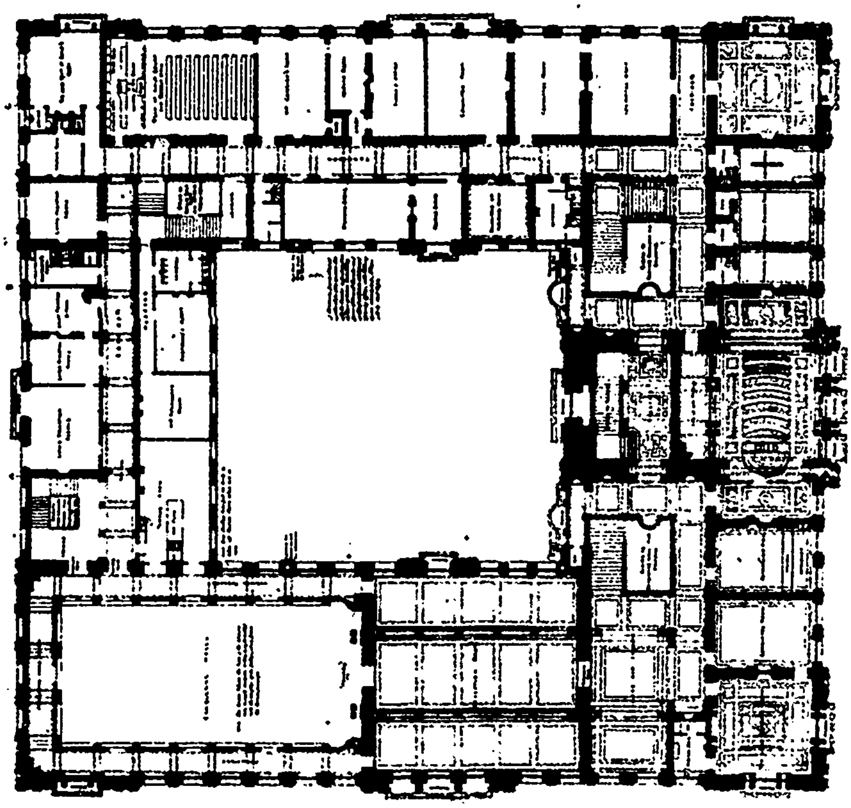
ELECTRIC LIGHT INSTALLATIONS.



GLASGOW MUNICIPAL BUILDINGS.



PLAN OF THE THIRD FLOOR



PLAN OF THE SECOND FLOOR

Andrew T. Taylor, A.R.I.B.A., Architect, London, England, And Union Buildings, St. Francois Xavier Street, Montreal.

ELECTRIC LIGHT INSTALLATIONS FOR OFFICES, &c.

At the offices of The Electrical Power Storage Company, Limited, 30 Swan incandescence lamps illuminate the whole suite of rooms pleasantly and thoroughly. All the lamps are suspended by tastefully-executed electroliers and wall-brackets, made by Messrs. Benjamin Verity & Sons, of Stanhope Street, Euston Road.

None of the wires are visible. Plug switches are provided for each room, and these, as well as all the circuit fittings and the gearing were made at the works of the company.

The engine-room in the basement of the Great Winchester Street Buildings measures only 13 feet long, 6 feet wide and 8 feet high, and therein stand the prime mover, the dynamo, the accumulator and necessary accessories, leaving ample room to walk round and examine everything easily.

The motive power is a one H. P. Otto gas-engine, running at 180 revolutions per minute; this drives a Siemens' S D_5 dynamo at 1,600 revolutions, by which a series of 23 one H. P. accumulators are charged. The charging is done during the day for a few hours, according to the demand, and little attention is required for the mechanism, as the office messenger starts the engine and oils the bearings, examines the deflections on the ammeter, and returns to his ordinary duties. When he considers that the current has been flowing a sufficient length of time, he once more enters the engine-room and stops the whole apparatus, which is always ready for immediate use. Every kind of noise and vibration had to be carefully avoided, and in order to comply with these conditions, the engine, dynamo, and brackets carrying moving parts, their bases, joining the wall and floor, were provided with felt and india-rubber packing.

The one H. P. Faure-Sellon-Volckmar accumulators occupy each an area of half a square foot, and they stand 12 inches high; these cells, when fully charged, can supply the whole of the lamps for nine hours and still leave the economical residual charge in the boxes, the engine being at rest all the time; in many cases it is found convenient to run the dynamo at the same time whilst the lights are fed by accumulators, and this method increases the period of lighting in exact proportion to the extra current from the dynamo.

One of the interesting features of this installation is probably in the gearing which transmits the power from the engine shaft to the dynamo spindle. This method of driving was devised by M. Raffard, of Paris, and it has been applied by the Electrical Power Storage Company in several installations where moderate power is used; it works very well indeed, and without the trouble often experienced in small strap and pulley transmissions.

The drawings on page 180 will sufficiently explain the details of this gear. The fly-wheel of the gas-engine has two V grooves cut in its rim, and in these grooves runs a cat-gut band 5-16 inch in diameter. The loose guide pulley and the pulley on the dynamo spindle are each provided with two corresponding V grooves. The numbers against the band show the mode of placing it on the three rotating parts; the pin of the guide-pulley is supported by a stretching lever, which permits of adjustment when the cat-gut becomes elongated through wear. Nearly the whole of the circumference of the dynamo pulley is taken up by the band, giving it a good grip and preventing slip, which is of the utmost importance considering that this pulley is only $5\frac{3}{8}$ inches in diameter. There is a perfect equilibrium in the tension of the bands, and consequently the friction on the dynamo bearings is practically nil, the armature of the machine maintains its central position and the wear is necessarily avoided. The whole pressure is taken up by the bearing and pin of the guide pulley, which runs at a very much slower speed than the armature, requiring, therefore, less lubrication, and the friction of the entire apparatus is considerably less than of any other mechanism at present known to transmit power at a high speed. This installation has been in successful operation since August, 1882.

In the drawings, A is the motor, B the dynamo, C Faure-Sellon-Volckmar accumulators, D switch, E current reverser, F resistance coils, G shunt wire, H ammeter, I lamp circuit, J ditto, K ditto. The positive wires are shown thus, • ——— • ——— •, and the negative, • • • • • • • *Electrical Review.*

TELEGRAPH EXTENSION.—A short while ago the construction of a telegraph line between Shanghai and Tientsin was autorized. This line is now to be etxended to Pekin. Telegrams are to be forwarded in French or English. Two mandarins have been appointed to keep a rigid surveillance over all telegrams.

RULES AND REGULATIONS FOR THE PREVENTION OF FIRE RISKS ARISING FROM ELECTRIC LIGHTING.

These rules and regulations are drawn up for the reduction to a minimum, in the case of electric lighting, of those risks of fire which are inherent in every system of artificial illumination, and also for the guidance and instruction of those who have, or who comtemplate having, electric lighting apparatus installed on their premises.

The difficulties that beset the electrical engineer are chiefly internal and invisible, and they can only be effectually guarded against by "testing," or probing with electric currents. They depend chiefly on leakage, undue resistance in the conductor, and bad joints, which lead to waste of energy and the dangerous production of heat. These defects can only be detected by measuring, by means of special apparatus, the currents that are either ordinarily or for the purpose of testing, passed through the circuit. Should wires become perceptibly warmed by the ordinary currents, it is an indication that they are too small for the work they have to do, and that they should be replaced by larger wires. Bare or exposed conductors should always be within visual inspection and as far out of reach as possible, since the accidental falling on to, or the thoughtless placing of other conducting bodies upon such conductors, would lead to "short circuiting," and the consequent sudden generation of heat due to an increased current in conductors not adapted to carry it with safety.

The necessity cannot be too strongly urged for guarding against the presence of moisture and the use of "earth" as part of the circuit. Moisture leads to loss of current and to the destruction of the conductor by electrolytic corrosion, and the injudicious use of "earth" as a part of the circuit tends to magnify every other source of difficulty and danger.

The chief dangers of every new application of electricity arise from ignorance and inexperience on the part of those who supply and fit up the requisite plant.

The greatest element of safety is therefore the employment of skilled and experienced electricians to supervise the earth.

I. THE DYNAMO MACHINE.

1. The dynamo machine should be fixed in a dry place.
2. It should not be exposed to dust or flyings.
3. It should be kept perfectly clean and its bearings well oiled.
4. The insulation of its coils and conductors should be practically perfect.
5. All conductors in the dynamo room should be firmly supported, well insulated, conveniently arranged for inspection, and marked or numbered.

II. THE WIRES.

6. Every switch or commutator used for turning the current on or off should be constructed so that when it is moved and left it cannot permit of a permanent arc or of heating.
7. Every part of the circuit should be so determined, that the gauge of wire to be used is properly proportioned to the currents it will have to carry, and all junctions with a smaller conductor should be fitted with a suitable safety fuse or protector, so that no portion of the conductor should ever be allowed to attain a temperature exceeding 150° F.
8. Under ordinary circumstances complete metallic circuits should be used; the employment of gas or water pipes as conductors for the purpose of completing the circuit should not in any case be allowed.
9. Bare wires passing over the tops of houses should never be less than seven feet clear of any part of the roof, and all wires crossing throughfares should invariably be high enough to allow fire-escapes to pass under them.
10. It is most essential that joints should be electrically and mechanically perfect and united by solder.
11. The position of wires when underground should be clearly indicated, and they should be laid down so as to be easily inspected and repaired.
12. All wires used for indoor purposes should be efficiently insulated, either by being covered throughout with some insulating medium, or, if bare, by resting on insulated supports.
13. When these wires pass through roofs, floors, walls, or partitions, or when they cross or are liable to touch metallic masses, like iron girders or pipes, they should be thoroughly

protected by suitable additional covering, and where they are liable to abrasion from any cause, or to the depredations of rats or mice, they should be efficiently incased in some hard material.

14. Where indoor wires are put out of sight, as beneath flooring, they should be thoroughly protected from mechanical injury, and their position should be indicated.

N.B.—The value of frequently testing the apparatus and circuits cannot be too strongly urged. The escape of electricity cannot be detected by a sense of smell, as can gas, but it can be detected by apparatus far more certain and delicate. Leakage not only means waste, but in the presence of moisture it means destruction of the conductor and its insulating covering, by electric action.

III. Lamps.

15. Arc lamps should always be guarded by proper lanterns to prevent danger from falling incandescent pieces of carbon, and from ascending sparks. Their globes should be protected with wire netting.

16. The lanterns, and all parts which are to be handled, should be insulated from the circuit.

IV. Danger to Person.

17. Where bare wire out of doors rests on insulating supports, it should be coated with insulating material, such as india-rubber tape or tube, for at least two feet on each side of the support.

18. To secure persons from danger inside buildings, it is essential so to arrange and protect the conductors and fittings that no one can be exposed to the shocks of alternating currents of a mean electromotive force exceeding 100 volts, or to continuous currents of 200 volts.

19. If the difference of potential within any home exceeds 200 volts, the house should be provided with a "switch," so arranged that the supply of electricity can be at once cut off.

THE CHAMBERLAIN GASLIGHT.—*Electrical Review.*

There is to be seen at 43 New Broad Street, E.C., a new gaslight, recently patented by Colonel Chamberlain.

It seems at present that there is but little chance of the electric light ousting ordinary coal gas illumination from the position it has occupied for so many years, but it may be that Colonel Chamberlain's process will accomplish to some extent that which electricity is doing but slowly. It is, however, scarcely within our province to speculate on that which is now produced on as minute a scale as were the first developments of lighting by electricity. As the matter stands Colonel Chamberlain not only shows the superiority of his new light over that of coal gas, but he also manufactures his gas on a miniature scale at the address given above.

This process has been the subject of elaborate tests made by Mr. Henry Hutchinson, C.E., F.C.S., and we cannot do better than describe Colonel Chamberlain's invention in Mr. Hutchinson's words. This gentleman says that Colonel Chamberlain's process may be briefly stated to consist of decomposing petroleum oil and water (four parts petroleum and one of water) in a small iron retort heated to redness by means of coke, coal, wood, or gas. The gas, as it issues from the retort, contains no other impurity than a small amount of tar and carbonic acid gas, which are got rid of in passing through a small purifier containing water, where it is cooled, condensed in volume, and deposits its tar, thence proceeding into suitable gasholders.

The gas is next diluted with three times its volume of "red hot" atmospheric air (but not cold air), and herein consists the greatest novelty of Colonel Chamberlain's invention, namely, the introduction of red hot air during the decomposition of the petroleum oil and the generation of the petroleum gas, in which condition the experimenter proved by numerous experiments the air must be admitted to the retort to bring about the necessary combination for producing a permanent and non-condensible illuminating gas.

In reference to the proportions of materials used, &c., he found, from a series of experiments, that by the use of 10 gallons of refined petroleum and two and a-half gallons of water, with the necessary quantity of "red hot air," 3,000 cubic feet of 18 to 20 candles gas, with a residual product of tar equal to half a gallon, could be relied upon. For comparison, and to show the great superiority of Colonel Chamberlain's gas, as compared with ordinary coal gas and water gas without petroleum, he shows their percentage compositions:—

COLONEL CHAMBERLAIN'S GAS.

Carbonic acid	= 2.1
Oxygen	= 10.0
Illuminating gases	= 21.4
Non-illuminating do.	= 20.5
Nitrogen	= 46.0
	100.00

COMPOSITION OF "COAL GAS."

Non-illuminating gases	= 93.25
Illuminating gases	= 6.46
Sulphur compounds	= 0.29
	100.00

"WATER GAS WITHOUT PETROLEUM."

(Non-illuminating gases.)

Nitrogen	36.0
Hydrogen	25.0
Carbonic oxide	35.0
Carbonic acid	4.0
	100.00

"Thus," says Mr. Hutchinson, "we see in comparison with coal gas, whilst the latter only contains about 6½ per cent. of available light-giving gases, Colonel Chamberlain's petroleum gas, on the other hand, gives light-producing gas equal to 21½ per cent.; and even if Colonel Chamberlain's gas were sold to the public at the same price as ordinary coal gas, this petroleum gas shows, and also confers upon the public, a clear gain of light-giving power equal to 15 per cent., and by the use of the 'New Douglas' burner will give a light of very great and unusual brilliancy, superior to any yet exhibited or known to the public."

In reference to the cost of Colonel Chamberlain's gas, from the numerous experiments carried on, Mr. Hutchinson thinks he may safely say, taking into consideration the increased illuminating power per foot of gas, as compared with coal gas, and the small cost of production, purification, &c. (the latter very costly and offensive process necessary in coal gas making), that from 10 gallons refined petroleum, with two and a half of water, gas of sufficient illuminating power is generated, when combined with red hot air, to give 3,000 cubic feet of 18 to 21 candle gas.

ESTIMATE OF COST OF 3,000 CUBIC FEET OF CHAMBERLAIN'S GAS.

Ten gallons petroleum oil, at 6d. per gal	5s.
Water	—
Air	—
Coal and labour	6d.
Interest on capital, wear and tear	6d.
Total for 3,000 cubic feet	6s.

Equal to 2s. per 1,000 feet of gas, having an illuminating power of from 18 to 20 candles.

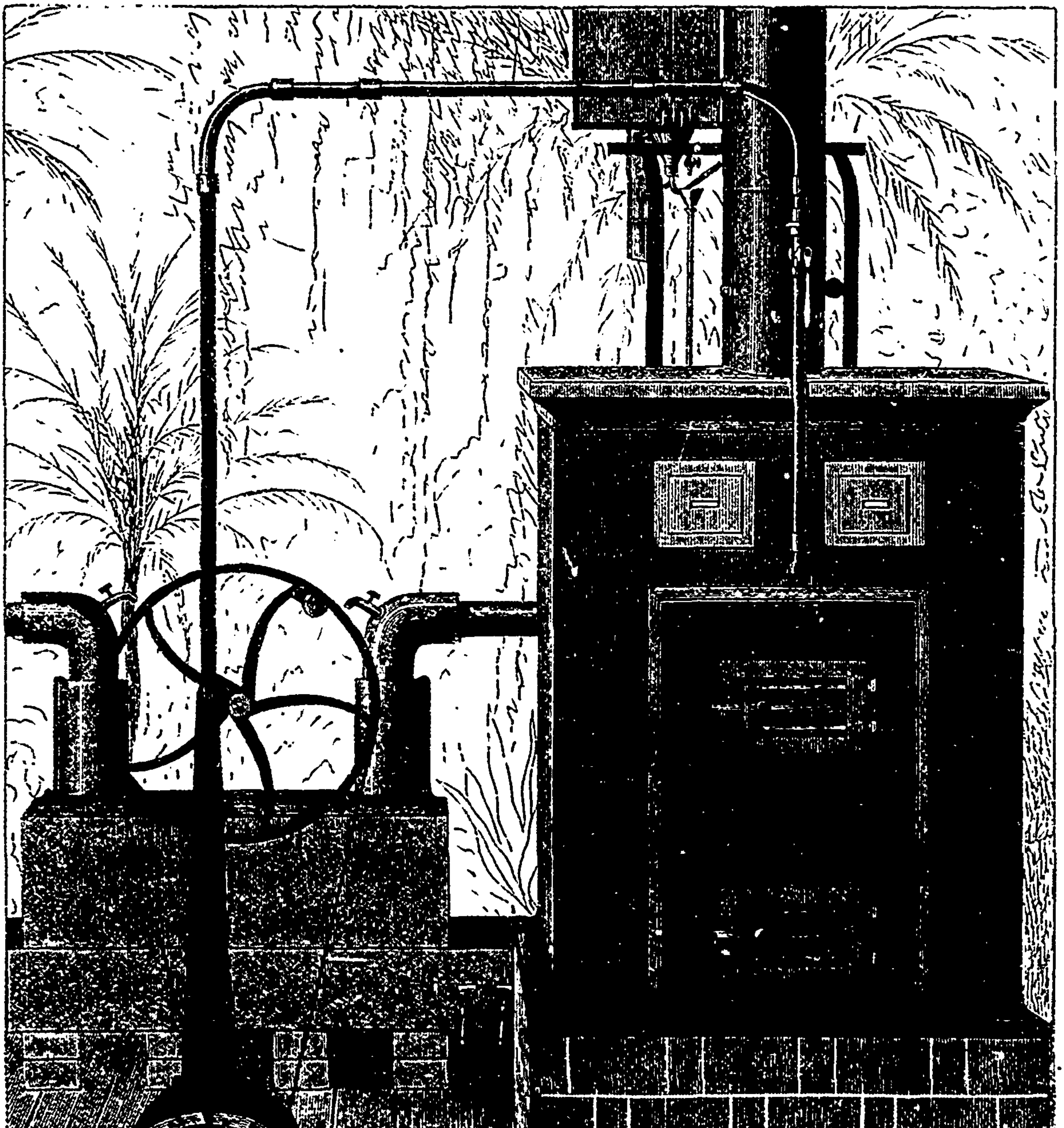
And deducting the value of the tar, which contains about half its weight of a valuable lubricating oil, as well as a small amount of brown colouring matter of great penetrating and staining power, with other valuable commercial properties, at 1s. 6d. per gallon only leaves 4s. 6d., as the actual cost of 3,000 feet of the petroleum gas, or 1s. 6d. for 1,000 cubic feet, which is a very small cost for a first-rate gas containing no impurities, such as sulphur and sulphur compounds.

Another important advantage of Colonel Chamberlain's gas lies in the fact that 800 cubic feet of it will go as far as 1,000 cubic feet of ordinary coal gas.

Mr. Hutchinson concludes after three weeks' intimate acquaintance with the details of this process of manufacturing the patent petroleum gas, by asserting that the patent is a very valuable invention, of great public utility, simple in its manipulation and free from danger, giving a pure gas of great illuminating power, and will fulfil a public want long felt, more especially by the higher classes of society, where an independent and domestic method of manufacturing good illuminating and heating gas is required.

If we mistake not, oil gases have been tried many times before, and therefore it would be premature to assert that Colonel Chamberlain's invention could be applied as successfully on a large scale for lighting districts as it is now for what

CHAMBERLAIN GAS LIGHT



might be termed home manufacture. That the gas will travel through long distances has yet to be proved, but, on the whole, the system appears to be highly promising. A general view of the apparatus for manufacturing the gas is shown in the drawing. The air is forced into the retort by means of a small "Roots" blower, seen on the left of the sketch.

BLOCK AND INTERLOCKING SYSTEMS ON RAILWAYS.

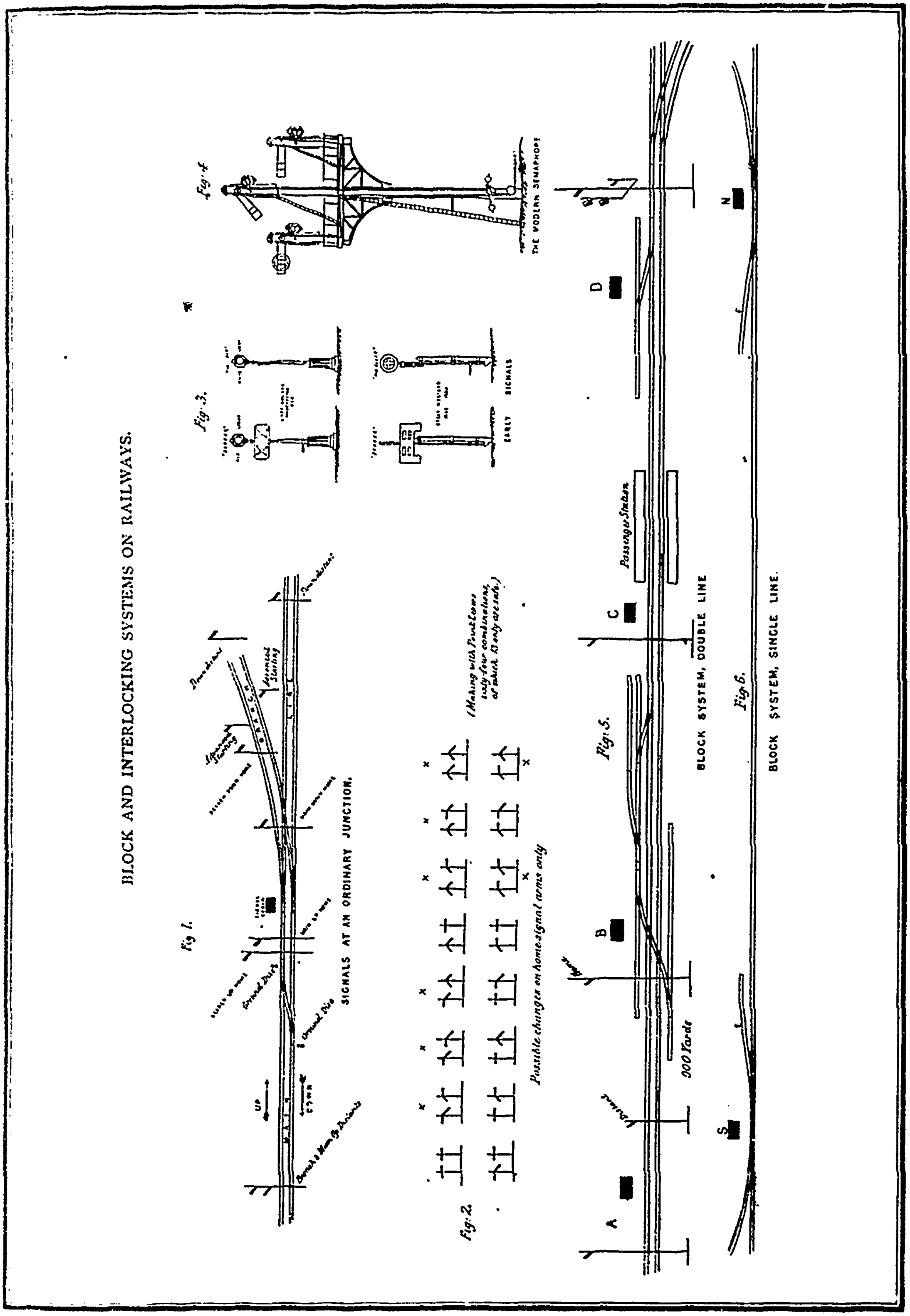


Fig. 1. SIGNALS AT AN ORDINARY JUNCTION.

Fig. 2. Possible changes on home-signal arms only (Making with Point Levers sixty-four combinations, of which 13 only are safe.)

Fig. 3. SIGNALS

Fig. 4. THE MODERN SEMAPHORE.

Fig. 5. BLOCK SYSTEM, DOUBLE LINE.

Fig. 6. BLOCK SYSTEM, SINGLE LINE.

"OUR BODIES," (*Knowledge.*)

By Dr. Andrew Wilson, F.R.S.E., &c.,

THE CIRCULATION OF THE BLOOD.

That blood circulates perpetually through our bodies, is, of course, one of the acknowledged truisms of our physical life. So tacitly, however, is the fact taken for granted, that very few persons seem to trouble themselves further regarding the mechanism which keeps this perpetual flow in motion. Possibly the most salient features of the blood circulation consist in the knowledge that the *heart*, by its incessant movement, is charged with the duty of sending blood through the body; and that the blood, secondly, flows, or is thus driven, through certain pipes or *bloodvessels*. The heart in this light is a kind of force pump; and if we add that it is a muscular force pump, we shall have found a rough and ready, but essentially correct, idea of the nature of the heart. As a *hollow muscle*, the heart no longer appears as a mysterious organ. It is hollow, to allow blood to pass through it; it is a *muscle* (or rather collection of muscles), that it may *propel* the blood through the body by its forcible contractions. For, after all, the same force by means of which we write a letter, or move our legs in walking, is that which drives blood through our bodies. The muscles of our fingers and arm *contract* when we write; the heart's muscular substance, in the same way, *contracts* when the heart "beats." The description of a heart as a "hollow muscle" is one also which applies with equal force to all hearts; and the heart of an insect or the pulsatile organ of a snail or oyster as fully conforms to this definition as that of a man.

We have already seen that the blood in the course of its circulation exists under a double phase. It goes forth from one side (*the left*) of the heart and from the lungs to nourish the body. It is then pure blood; it travels through pipes or tubes called *arteries*, and hence it is often spoken of as *arterial* blood. If we trace any arterial bloodvessel through its ramifications, we may see that it divides and subdivides, and finally spreads out into a network of fine, delicate walled vessels, known as the *capillaries*. So minute are these capillaries that, as a rule, they will allow only a single row of red blood corpuscles to pass along their interior at one time, like soldiers in single file. The diameter of these capillaries is, therefore, about the one three-thousandth of an inch. We can readily see that as the tissues of our frames are permeated by such a dense network of bloodvessels, they must receive not only a very large and constant supply of blood, but must have that fluid likewise brought into connection with the most minute parts or "cells." The fluid part of the blood strains through the capillary walls, and thus bathes the tissues in nutriment; and it is this fluid part of the blood which, in turn, is taken up by the *absorbent* vessels, as described in a former paper.

We may further observe that at no part of the circulation do the bloodvessels end abruptly, or like a street without openings. On the contrary, the special feature of the circulation is, that it is carried on in a set of closed tubes, which are everywhere continuous. If blood escapes from any bloodvessel at all, it must do so either naturally, that is, by straining through its walls, as already described; or it must escape through injury in the vessel. A wound of any bloodvessel, small or large, is thus really an opening into a system of close and continuous pipes.

The blood, then, which the *arteries* have carried to nourish the body, passes into the *capillaries*. The nutritive functions of any part part of the blood flow has been discharged when the tissues have received their quantum of blood through the capillary walls. If we trace the blood flow onwards — as we may do when the web of the frog's foot is microscopically viewed—we see that the capillaries gradually tend to become of larger diameter; and finally, by their union, we discover that the capillaries form *veins*. The name "vein" is familiar enough in common parlance. We know also, as a matter of everyday knowledge, that the name "vein" is given to the bluish looking vessels we see in the back of the hand, and still more plainly in the arm itself For the veins, as a rule, lie near the surface, whilst the arteries are deep seated.

If we grasp an object firmly in the hand, and tie a bandage say, in the middle of the arm, we notice that the veins grow larger and more prominent. Why is this? The reply is evident. We have by our bandage obstructed a flow of blood which is passing *up the arm towards the heart and lungs*. Hence the veins swell on the side of the bandage furthest from the heart. We cannot show experimentally in such a simple manner the fact that in the arteries the flow takes place in the opposite direction, namely, *from the heart and lungs to the body*. But, if we were to place a ligature round any artery — such as the radial artery, in which the "pulse" is felt, at the thumb side of the arm, about a couple of inches above the wrist—we should find the vessel to swell *above* the ligature, instead of below, as in the case of the vein. In other words, we should then be interrupting a flow of blood, which is passing down the arm, to nourish the hand.

We learn from these plain facts, that the *circulation* of the blood really merits that name. It is an incessant round, from the heart and lungs as pure blood, through the body, and back to the heart and lungs as impure or *venous* blood. The impurities, or waste matters, which it has received from the body in its course, are got rid of by lungs, skin, and kidneys, and this latter work constitutes that known as "excretion." The course of the circulation — fully wrought out by the immortal Harvey — is as follows. The heart is two-sided (right and left); and each side consists of two compartments — an *auricle* and a *ventricle*. The *right* side of the heart deals with *venous or impure blood* alone; whilst the left side is concerned only with *arterial or pure* blood. The impure blood is returned by the veins to the right auricle; thence it passes to the right ventricle, which pumps it into the lungs. This is one-half, so to speak, of the circulation. In the lungs the blood is purified. Then it is passed on to the left auricle of the heart; and thence to the left ventricle, which propels it through the arteries all over the body. No mixture of pure and impure blood, therefore, takes place in the heart; but in frogs and reptiles such a mixture actually takes place, because in these animals the heart is not completely two-sided, or double, as it is in birds, quadrupeds, and ourselves.

POISONOUS COLOURS IN GERMANY.

The following decree, concerning the prohibition of poisonous colours for the coloring of certain alimentary substances and articles of food, came into operation in Germany, on 1st April last.

1. The use of poisonous colors for the manufacture of food-products or articles of food intended for sale is prohibited. Those which contain the following materials or compositions are considered as poisonous colors within the meaning of this enactment:—antimony (oxide of antimony), arsenic, barium (except sulphate of baryta), lead, chromium (except pure chromic oxide), cadmium, copper, mercury (excepting cinnabar), zinc, tin, gamboge, picric acid.

2. The preserving and packing of food-stuffs or food-products intended for sale in wrappers colored with the above-cited poisonous colours, or in barrels in which the poisonous color is so employed that the poisonous coloring matter can pass into the contents of the barrel, is prohibited.

3. The employment of the poisonous colors enumerated in Art. 1 is prohibited for the manufacture of playthings, with the exception of varnish and oil-paints made of zinc-white and chrome-yellow (chromate of lead).

4. The use of colors prepared with arsenic for the manufacture of paper-hangings, as well as that of pigments containing copper prepared with arsenic, and of matters containing similar colors for the manufacture of materials of dress, is prohibited.

5. The putting on sale, and the sale, wholesale or retail, of food-stuffs and food-products preserved or packed contrary to the regulations of Articles 1 and 2, as well as playthings, paper-hangings, and dress-materials manufactured in contravention of the directions in Articles 3 and 4, are prohibited.

The metrical system is made compulsory in Havanna from July next.

Self Luminious Paint.—Boil for an hour 2¼ ounces caustic lime, recently prepared by calcining clean white shells at a strong red heat, with one ounce of pure sulphur (floured) and a quart of soft water. Set aside in a covered vessel for a few days; then pour of the liquid, collect the clear orange-coloured crystals which have deposited and let them drain and dry on bibulous paper. Place the dried sulphide in a clean black-lead crucible provided with a cover. Heat for half an hour at a temperature just short of redness, then quickly for about fifteen minutes at a white heat. The addition of a small quantity of pure calcium fluoride to the sulphide before heating it is made. It may be mixed with alcoholic copal varnish

RECENT EXPLORATIONS IN THE REGIONS OF THE GULF STREAM OFF THE EASTERN COAST OF THE UNITED STATES BY THE U. S. FISH-COMMISSION.*—*Science.*

INTRODUCTORY.

Although several extended surveys along the region of the Gulf Stream had been made by the officers of the U. S. coast-survey since 1844, no systematic dredging had been done along its course, north of Florida, until 1880. During the previous surveys, large numbers of bottom samples had been saved. Some of these were studied many years ago by Professor Bailey, and later by Mr. L. F. de Pourtalès. Many of the Foraminifera and other microscopic forms have been described by them. A few small shells from the same source were described by Dr. A. A. Gould in 1862. These investigation gave a general idea of the nature of the materials of the bottom and the depth, but many errors existed in the earlier surveys in the determinations of temperature, and in many cases the recorded depths were unreliable. The extensive surveys made by the Blake, since 1880, have been conducted with much better apparatus and greater accuracy.

The real character of the fauna inhabiting the bottom beneath the Gulf Stream, off our coast, was completely unknown until 1880, when numerous and successful dredgings were made, first, by Mr. Alexander Agassiz, on the coast-survey steamer Blake (J. R. Bartlett, U. S. N., commanding), and, later in the season, by the U. S. fish-commission party, on the Fish Hawk. The Challenger, on her celebrated voyage, made a line of dredgings from Bermuda towards New York; but, on approaching our coast, she turned northward, and went to Halifax. Her station nearest to our coast was about 160 miles off New York, in 1,240 fathoms. This is much further off the coast than any of the fish-commission dredgings, and outside the Gulf Stream slope. The few dredgings made by the Challenger off Halifax were partly on the shallow fishing-banks (Le Have bank), and partly in the deep water of the Atlantic basin. By mere chance, therefore, the Challenger missed the discovery of the exceedingly rich and varied deep water fauna fauna that is now known to occupy the Gulf Stream slope all along our coast In 1872 one haul was made by Messrs S. I. Smith and O. Harger, on the Bache, in 430 fathoms, south of George's bank, on this slope; but it happened to be on a comparatively barren spot. In 1877 the U. S. fish-commission party dredged on the northward continuation of the slope, about 120 miles south of Halifax, in 90 and 190 fathoms; but the bottom was of barren gravel, and the results meagre and unsatisfactory. In that region the cold currents are rapid, and the slope of the bottom is exceedingly steep, making the dredging very difficult. In 1880 Mr. A. Agassiz, while on the Blake, made several lines of dredgings off our eastern coast, crossing the Gulf Stream slope, The most southern of these were off the Carolina coasts, and the most northern stations were just south of George's bank. These dredgings extended from shallow water to 1,632 fathoms. The Blake was furnished with excellent apparatus for sounding and dredging, temperature determinations, etc. The officers of the Blake secured by this exploration a large amount of reliable physical data; and Mr Agassiz obtained very interesting collections, including large numbers of new forms of animal life, many of which have already been described in the bulletin of the Museum of comparative zoölogy.

Later in the season of 1880, the U. S. fish-commission dredging-party under the direction of the writer, made its first expedition to the Gulf Stream slope in the steamer Fish Hawk (Lieut. R. D. Tanner commanding). The region visited was about 75 to 80 miles south of Martha's Vineyard, in 65 to 192 fathoms. On Sept. 4, when this ground was first visited by us, a long day was spent in dredging and trawling, and with marvellous results. The bottom was found to be occupied by an exceedingly rich and abundant fauna, including great numbers of new and strange forms of animals belonging to nearly all the marine orders. Many fishes never before taken on our coast were secured. Thousands of beautiful and undescribed star-fishes of many species, with varied shaped and colors, encumbered our deck. Crabs and shrimps of strange kinds, some of them of large size, were taken by thousands. Numerous new and curious species of shells, some of them very beautiful; bushels of large and brilliantly coloured sea-anomones, several of them over a foot across, and most of them previously unknown, with sea-pens and corals of elegantly forms and colours,—were among the more conspicuous treasures secured on that ever memorable day. So successful were we, that it required the most diligent and devoted labour on the part of our entire party,—though aided by the officers and sailors of the steamer, who shared more or less in our enthusiasm,—from daylight in the morning till late at night, to preserve what we had secured, notwithstanding we threw away many thousand of duplicates. Some idea of the richness of the fauna, and of the abundance of life on the bottom in the region, may be gathered from the fact that it required above five barrels of alcohol to preserve the portion of the catch that we saved on this one day, and a similar amount was used by us on various subsequent trips in a single day. On our first day eight hauls were made, mostly with a large beam-trawl. There was a very heavy swell, due to a violent cyclone that had prevailed further south a few days before. Under these circumstances, the dredging and the care of the specimens were unusually tiresome. otherwise our enthusiasm would. perhaps, not have allowed us to retire, even at midnight. But a touch of genuine seasickness will dampen the ardor even of the most enthosiastic naturalists when hundreds of new and strange species are before them.

This first trip having been so successful, two others were made, later in the season, to other parts of the slope, in depths ranging from 85 to 500 fathoms. Each trip proved equally productive, and added many species to the long list of discoveries.

In 1880 the headquaters of the fish-commission were at Newport, R.I.; but in 1881 and 1882 they were at Wood's Holl, Mass., where a laboratory had already been fitted up in 1875. In 1881 and 1882 the exploration of the Gulf Stream slope was continued whenever the weather was sufficiently favorable to permit us to make a trip in the Fish Hawk without too much risk.

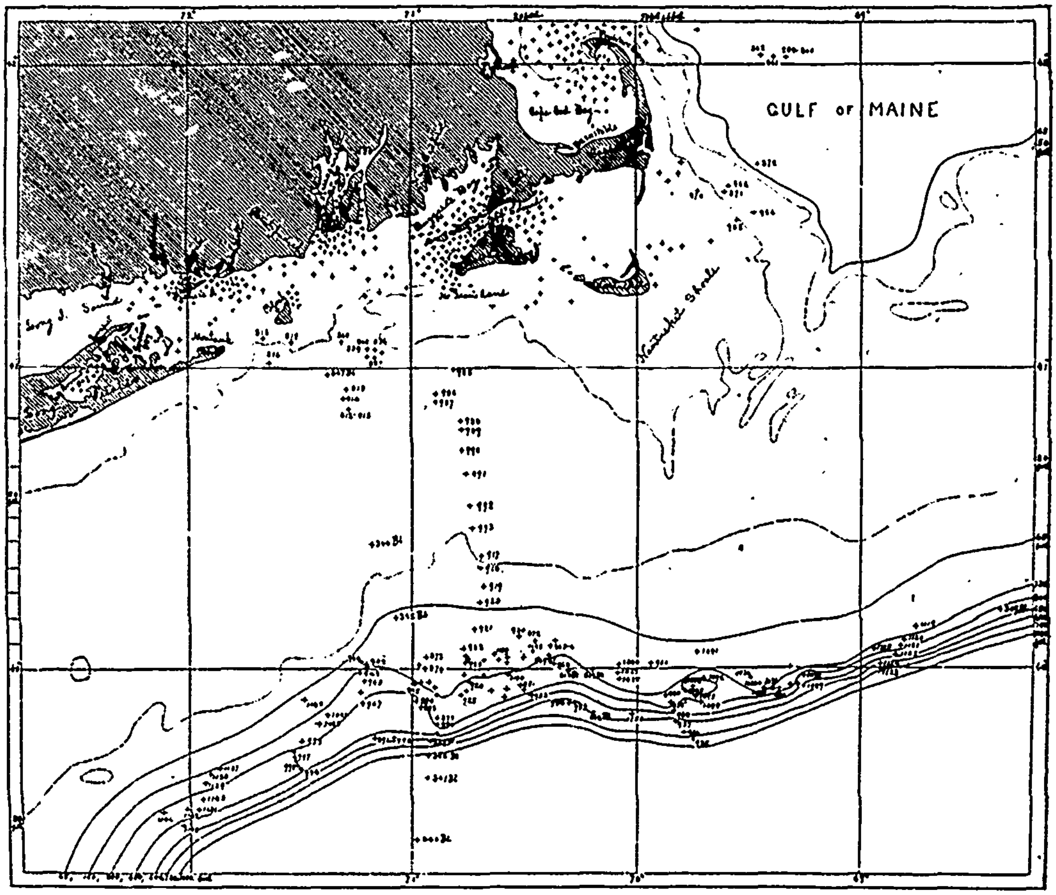
The steamer Fish Hawk, with which we have explored this regions the past three seasons, was built particularly for use in the hatching of shad-eggs in the mouths of shallow rivers, and was therefore not adapted for service at sea, unless in fine weather. A much larger iron steamer—the Albatross, of 1,000 tons—has recently been built for the use of the fish-commission, and is now being fitted up expressly for deep-sea service, for which she will be in every respect well adapted, and will have the best equipment possible for such investigations at all depths. The examination of the bottom beyond the depth of about 700 fathoms has, therefore, been deferred until the completion of the Albatross.

In addition to the three trips made in 1880, seven trips were made by us in 1881 from Wood's Holl, and in 1882 five trips. During these fifteen trips, on each of which a single entire day was usually employed in dredging, we occupied about 113 stations. At nearly all these stations we used a large beam-trawl of improved construction (fig. 1, page 188). In a few instances we used a large rake-dredge (fig. 2). On every trip fine surface-nets, or towing nets (fig. 3), were used to capture free-swimming animals, whenever the motion of the steamer was sufficiently slow to permit this mode of collecting. In these towing-nets, and in long-handled dip-nets, we secured a great variety of pelagic creatures, such as jelly-fishes, Salpa, Sagitta, various small Crustacea, and especially large numbers of Entomostraca.

Our dredgings in this region now cover a belt about 160 miles long, east and west, and about 10 to 25 miles wide. The most eastern stations are south-east of Cape Cod; the most western are south of Long Island. They are mostly between 80 and 110 miles from the coast-line of southern New England (see map, p. 444.) The depths are mostly between 65 and 700 fathoms. Probably no other equally large part of the ocean basin, in similar depths, has been more fully examined than this. In addition to the regular work of the party during the season, Capt. Tanner made a special trip to the Gulf Stream slope, off Chesapeake Bay, in 1880, and another off Delaware Bay in 1881. On both of these occasions valuable collections were made, and additional data in regard to the depth and temperature were obtained. He occupied seven stations, in 18 to 300 fathoms, in 1880, and eight stations, in 104 to 435 fathoms in 1881. These dredgings show the direct southward continuation of the inshore cold belt, and the warm belt outside of it, as well as the cold deep-water belt, with but little change in the fauna of each.

PHYSICAL FEATURES OF THE REGION.

The total number of species of animals already obtained by us from the deep water in this area is not less than 800. The number already identified or described, and entered on our



MAP I. — Southern coast of New England to the Gulf Stream slope, showing lines of depth and the positions of the principal dredging-stations of the U. S. fish-commission, 1871, 1874, 1875, 1880–82. The crosses (+) indicate dredging-stations, part of which are accompanied by their serial numbers corresponding to the records and published lists. Those bearing numbers between 309 and 347 were occupied by the Blake in 1880.

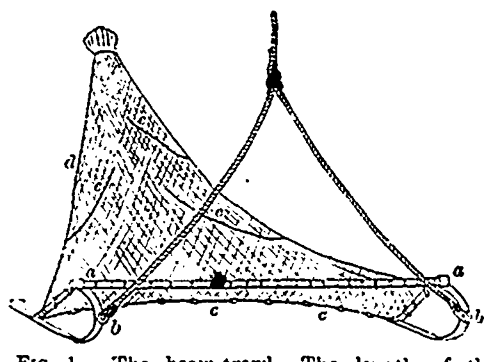


FIG. 1 — The beam-trawl. The length of the beam, *a*, *a*, varies from 12 to 15 feet in those used by us. The height of the iron runners, *b*, *b*, supporting the beam, varies from 24 to 30 inches; the length of the net, *d*, from 25 to 35 feet or more. The pockets, *e*, within the net, are to prevent the escape of fishes. The drag-rope, *c*, *c*, is weighted with lead sinkers.

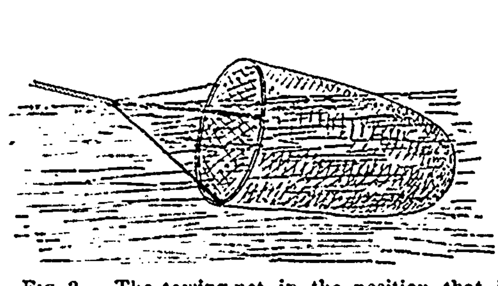


FIG. 3. — The towing-net, in the position that it takes while in use, half buried beneath the surface of the water. Those used by us are mostly 10 to 14 inches in diameter.

lists of the fauna, is about 650. This number includes neither the Foraminifera nor the Entomostraca, which are numerous, and but few of the sponges. Of this list, less than one-half were known on our coast before 1880, and a large number were entirely unknown to science. Of fishes there are, perhaps, 70 species. Of the whole number, already determined, about 265 are Mollusca, including 14 Cephalopoda, 90 are Crustacea, 60, Echinodermata; 35, Anthozoa; and 65, Annelida.

The apparatus used on the Fish Hawk has been better in many respects than most other vessels engaged in such work have had. Each year new improvements have been made. The 'trawl-wings,' first introduced by us in 1881, have been used with great success; for they have brought up numerous free-swimming animals from close to the bottom, which would not otherwise have been taken. The use of steel wire for sounding, and of wire rope for dredging, has enabled us to obtain a much greater number of dredgings and temperature observations than would have been possible under the old system of using rope, employed even on the Challenger. The use of steel-wire rope for dredging, first invented by Mr. A. Agassiz, and very successfully employed by him on the Blake, has proved to be an improvement of very great value in deep water. But its use there is an immense saving of time, and consequently a great increase in the value of the results. As an illustration of the rapidity with which dredging has been done by the Fish Hawk by using the wire rope reeled upon a large drum, I give here memoranda of the time required to make a very successful haul. In 640 fathoms, at station No. 1124, the large trawl was put over at 4.29 P.M.; it was at the bottom at 4.44, with 830 fathoms of ropes out, commenced heaving in at 5.17; it was on deck at 5.44 P.M., total time for the haul, 1 hour and 15 minutes. The net contained several barrels of specimens, including a great number and large variety of fishes, as well as of all classes of invertebrata,—probably more than 150 species altogether, many of them new.

At all the localities that we have examined, the temperature of the water, both at the bottom and surface, was taken, as well as that of the air. In many cases, series of temperatures at various depths were also taken. Many other physical observations have also been made and recorded. Lists of the animals from each haul have been made with care, and arranged in tables, so far as the species have been determined up to date.

South of New England the bottom slopes very gradually from the shore to near the 100-fathom line, which is situated from 80 to 100 miles from the main land. This broad, shallow belt forms, therefore, a nearly level, submarine plateau, with a gentle slope seaward. Beyond the 100-fathom line the bottom descends rapidly to more than 1,200 fathoms into the great ocean-basin, thus forming a rapidly sloping bank, usually as steep as the slope of large mountains, and about as high as Mount Washington, New Hampshire. This is well shown by diagram 1, which illustrates the relative slope at several lines of dredging, and the *actual* slope n'-o' along the line n-o. We call this the Gulf Stream slope, because it underlies the inner portion of the Gulf Stream all along our coast, from Cape Hatteras to Nova Scotia. In our explorations a change of position of less than 10 miles, transverse to the slope, sometimes made a difference of more than 3,500 feet in depth.

(To be continued).

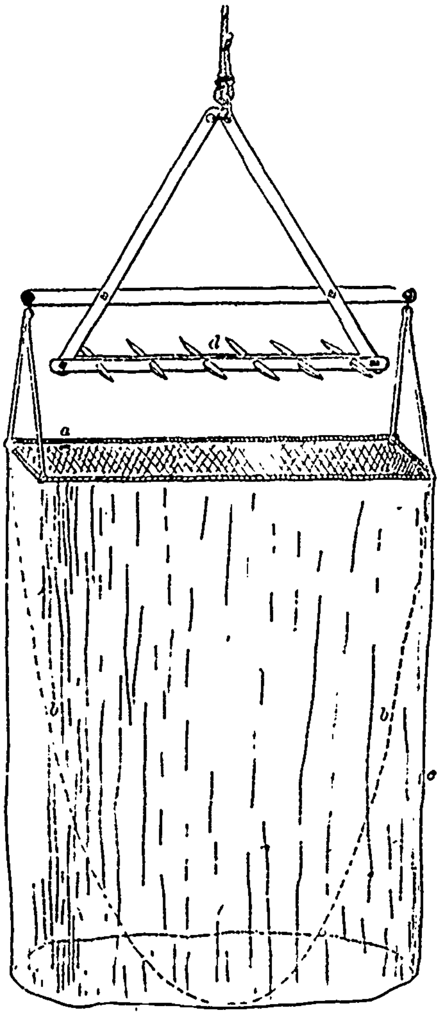


FIG. 2.—The rake-dredge rigged for use. The iron frame carrying the teeth, *d*, is about 3 feet wide; the teeth, about a foot long. The frame, *a*; carrying the net, *b*, is 4 feet long; *c* is a canvas bag to protect the net.

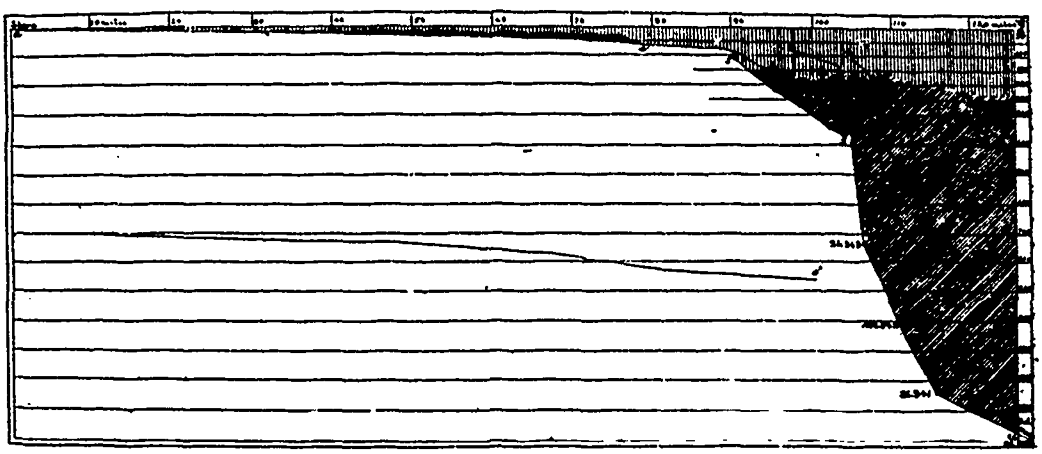


DIAGRAM 1.—To illustrate the relative slope or profile of the bottom, from the shore to the Gulf Stream slope, and across portions of the slope in several lines. Vertical to horizontal scale, 1: 300. The line n'-o' shows the actual slope along the line n-o. The vertical shading indicates the position of the comparatively warm water, both of the surface and of the Gulf Stream; oblique shading to the right indicates the cold water of the shallow plateau; oblique to the left, the cold water of the greater depths.

THE HEAT OF THE SUN.

BY ERNEST H. COOK, B.SC. (LOND.), F.C.S.

(Continued from page 147.)

The additions which the sun has received during these times must have caused a great change in the periods of planetary revolution and it is hardly possible to avoid the conclusion that if such is taking place, that some evidence of it would have been found ere this. Considerations somewhat of this nature induced the great German philosopher Helmholtz to discard the theory and to propose in its stead one founded on the heat given out by the contracting of the body of the sun and hence called the contraction theory. Speaking of this theory in a recent lecture at New York, Prof. Young of Vermont, says: "It is the one held by most scientific men and is one which I think will be found more than half true." Without entirely endorsing Prof. Young's words, there can be no doubt that we have in it a thoroughly competent cause to produce the effects.

Starting at the beginning, Helmholtz assumes the truth of Laplace's great conception known as the Nebular Hypothesis. This theory supposes, as is well known, that at one time millions of years ago, the whole of the matter composing the various members of the solar system together with any interplanetary substance which may exist was diffused in space in the form of highly rarefied gas. The only known cause capable of keeping such materials in such a condition is heat and it is thus further assumed that the whole of the heat in our system together with a large quantity which has been wasted in space (i.e. space beyond the confines of the orbit of Neptune) was stored up in the nebulous matter in the form of latent heat. This highly rarefied matter gradually radiated its heat into space, and in consequence began to diminish in bulk, and at the same time to increase in specific gravity. Planets and satellites began to form out of it, and the process of cooling and contraction continued until the system assumed its present condition. In this process, assuming the specific heat of the condensing matter to be equal to that of water, Helmholtz calculates that the heat given out would raise the temperature 28,000,-000° centigrade. What then has become of this immense amount of heat? All of it, except a very small fraction has been radiated into stellar space, and practically lost amid the vast recesses which exist between suns or between the satellites of suns. The small fraction has been intercepted by the matter of some of the planetary bodies and its energy, or some portion of it used up in rearranging the materials of the planet. In this way perhaps the vast store of energy which the deposits of carbonaceous matter in the earth possess, may have been derived from the condensation of the nebulous matter, and was employed at one time in keeping the molecules of that substance in a state of vibration. But the process of condensation having gone on from the remotest times up to the present does not stop here. Helmholtz supposes it to to be still going on, and in this way he accounts for the heat which we and our fellow worlds derive from the sun. According to this theory the central orb is radiating heat into space at the enormous rate indicated at the commencement of this paper and is being cooled by the loss thus experienced. In consequence of the cooling the materials composing the sun must occupy less space and consequently its diameter becomes less.

Moreover the more rapid the shrinkage the greater the amount of heat radiated. Or, in other words; knowing the amount of radiation taking place, the weight and volume of the radiating body and its specific heat, it is possible to calculate the rate of shrinkage necessary to keep up the energy expended. Without going farther the superficial reader would at once discard the theory as untenable. "Here, he would say, you have the sun emitting radiant energy at this enormous rate which has been demonstrably, not diminished during historic times and has propably continued for 20,000,000 years; and all produced by the shrinkage of his substance. Why long ere this he would have shruk into a cold dead mass."

But let no one imagine the celebrated German guilty of want of care in examining the subject. He has made the calculation indicated above, and he proves that a shrinking of the sun's diameter by $\frac{1}{10,000}$th of its present length (i.e. 88 miles) would produce an amount of energy capable of keeping up the solar emission at the present rate for 2,000 years. But if the sun be supposed to go on contracting, and its specific gravity to go on increasing until it equals that of our earth, then Helmholtz shows that the heat evolved would supply the sun with energy for no less than 17,000,000 years! In brief outline this is the celebrated theory of contraction. Simple in it assumptions, and quite competent to fulfil the demands made upon it, it is not a matter of surprise that it is held by many of the first thinkers of our time. Yet we cannot help thinking that two considerations weigh heavily against it. First, the researches of modern spectroscopy seem to indicate that we have in the sun an intensely hot nucleus surrounded by an atmosphere or shell of less intensely heated matter. Now if the heat is produced by condensation the whole body would be equally heated, and consequently no such partial separation would take place. Also the formation of a nucleus is difficult of explanation on such a theory for although the temperature of the nucleus may be greater, the actual *heat* in the solar atmosphere must be greater. Secondly as Siemens has pointed out, the heat being produced throughout the mass must reach the surface by conduction and convection. But we know of no substance capable of conducting the immense amount of heat which we find being radiated.

THE REGENERATIVE THEORY.

This theory, which I have so named because of its most characteristic feature, is at present literally and absolutely in its infancy. It first saw the light in March, 1882, having been proposed in a paper entitled the "Conservation of Solar Energy," read before the Royal Society of London, by Dr. C. W. Siemens, F.R.S, the great electrician, and president for the British Association for 1882-83.

It essentially differs from all the other theories, in that it supposes the action of the sun in sending out light and heat to be eternal. The preceding causes which we have considered, yield the sun energy enough to last him for millions of years. This one affords a cause which its author considers will last for ever. But if it is to last for ever, then it is a physical impossibility that anything should be used up or expended. Accordingly, the everlasting nature of the action is maintained by the energy being conserved and protected from loss. This is accomplished by supposing reciprocal action to go on using only the same materials, but under different conditions. The different conditions are those which obtain in or near the sun, and those of interplanetary space. In the one we have intense heat, and in the other equally intense cold, and I may here remark that it would be impossible to conceive of matter being placed in positions which afford conditions possessing a greater contrast. Matter is supposed to be subjected at different times to these different conditions, and its behavior under such conditions, produces, in the one case, the heat and light of the sun, and in the other, the materials necessary for maintaining this heat and light. Without further preface, I will endeavor to state Dr. Siemon's theory, in as nearly as possible his own words.

After briefly stating the various theories and offering certain objections to them, he says :– "The true solution of the problem will be furnished by a theory, according to which the radiant energy which is now supposed to be dissipated into space, and irrecoverably lost to our solar system, could be arrested and brought back in another form to the sun itself, there to continue the work of radiation."

(To be concluded in the next number.)

PROCEEDINGS OF SOCIETIES.

The Institution of Civil Engineers, (Eng.)—At the Meeting on the 10th of April, Mr. Brunlees, President, in the Chair, the Paper read was on "The Introduction of Irrigation into New Countries, as illustrated in North-Eastern Colorado," by Mr P. O'Meara, M. Inst. C. E.

The object of the Paper were stated to be three-fold :—first, to give an account of the development of irrigation in North-Eastern Colorado ; secondly, to enquire into the principles which should guide the introduction of irrigation into new countries ; and thirdly, to examine how far the methods being pursued in North Eastern Colorado were in accord with them. The developme t alluded to was influenced by most of the defects manifested in older countries, such as—inaccurate measurement of water, growth of ill-defined rights, excessive waste of water, etc., but there was a prospect of improvement through better legislation. The climate of Colorado was described as such, that agriculture was all but impossible without irrigation. Both were begun in 1860. There were 155,000 acres under cultivation in 1880, and it was estimated that in 1883 there would be 465,000 acres, with prospects of still further development. The amount of irrigation possible would be limited by the quantity of water obtainable, and by the area which each unit of it could be made to irrigate. It would amount to 9,750,000 acres under a hypothetical water-duty of 12 inches in depth for one season.

It was laid down that the duty of water in irrigation must vary with (1) the character and condition of the soil, (2) the rainfall, temperature, and evaporation, (3) the method of application, (4) the kind of crop, and, in some cases, (5) the depth of the water-line below the surface of the ground. As regarded (1), the influence of different soils, this must affect the duty of water, because, on the nature of the soil depended the quantity of water it would absorb, and the rate of filtration and of evaporation from within it. The Author gave details of experiments made by him to ascertain the amounts of water, and the times required to moisten two different typical soils in the Cache La Poudre Valley, and he drew some inferences from them. The formation of swampy lands and the prevalence of rust in wheat on some of the older farms were held to indicate, that the quantity of water required for beneficial irrigation became gradually less year by year for a few years after the commencement. (2.) The rainfall of the season should be added to the artificial irrigation, and account should be taken of the surplus water not absorbed by the soil, otherwise all estimates of water-duty must be misleading. The use of ordinary statistics of temperature and evaporation was at present vague and *unsatisfactory, owing to the absence of experiments on the drying of* soils. Nevertheless the question of evaporation was so important, that it was doubtful if any loss of irrigating power occurred in Colorado other than that which was due to it. (3.) Irrigation methods were conducted on two antagonistic principles, viz., to increase to the most profitable extent, in the one case, the quantity of water supplied to a given area, and in the other, the area irrigated by a given volume of water. The "Marcite" cultivation of Italy and the "asbestine sub-irrigation method" of California were cited as instances of these. Methods of irrigation were classed under four heads.– by sprinkling, by flooding, by distributing through furrows, and by distributing through pipes or drains under-ground. Sprinkling had been tried in Scotland on 7 acres of land by the Duke of Sutherland. The methods of flooding with compartments, and of distributing through furrows, were described in detail, as also the method of flooding without compartments, as practised in Colorado. This was characterized as extremely wasteful. It was shown from the experiments on dry soil, before alluded to, that 6 or 8 inches in depth, instead of 42·84 inches as at present expended, ought to suffice for cereals in Colorado. The experience of Professor Blount, of the State Agricultural College, was quoted to show that excellent crops of wheat could be grown with a rainfall of 4½ inches only, without irrigation As regarded (4) the water-duty for different crops, it was the degree of moisture required in the soil around its roots, and not the absolute quantity which the plant itself absorbed that had to be considered. The Author furnished, in a tabular form, a list of statistics, derived from various sources, in which he had endeavoured to include the essential elements He considered it, however, to be nothing more than an approximation, because of the incompleteness of almost every statement of the kind. In the column of "totals," the limits of water-duty appeared much narrower, because of the rainfall being added to the irrigation depth, than they would be otherwise. Countries where good crops were grown without irrigation were included in the Table, being considered to furnish a "natural duty of water," which should be useful for comparison with water-duties in place where irrigation was practised. Some remarks followed with respect to the peculiarities of certain crops–viz., rice, alfalfa, sugar cane, summer meadows, potatoes, cereals, and tea.

The Author then discussed the sources and works of supply, and the legislation of irrigation. The sources were stated to be two, viz., springs and rivers The supplies were made available for direct irrigation by canals, and for indirect irrigation, after storage, by reservoirs. The works of the "North Poudre Irrigation Canal," of a capacity of about 300 cubic feet per second, which had been carried out under the Author's charge, were described. Those most worthy of remark were a crib dam, 30 feet 6 inches high, some shelf-work, tunnels, and "gulch" bridges. Details were also given of a larger canal, the "Northern Colorado." These works showed a considerable departure from the practice of older countries, owing to the abundance of timber, and to the preference of Americans for economy and rapidity in construction over durability. The principal supplies of water in Colorado came from the snows of the Rocky Mountains. The rivers rose, reached their maximum and fell again, frequently before the end of the irrigation season. Hence measurements of the snow remaining on the mountains were of importance to agriculturists. The construction of reservoirs was dealt with as a means of reducing risk in cultivation in countries where the rivers failed in the crop-season. Reservoirs were distinguished as of three kinds :—"river-bed" reservoirs for equalizing the flow, "main" reservoirs which received the entire volume of a canal, and "detached" reservoirs which received a portion only. A serious error in the construction of some reservoirs in Colorado was pointed out. The gauge first used for measuring water in Colorado was the Max Clark's gauge, and the improved system at present in use, with the formula of Francis :—

$$Q \quad 3{\cdot}33\,(l - 0{\cdot}1\,n\,h)\,h^{\frac{3}{2}}.$$

were described and commented on. A short account of the legislation affecting irrigation in Colorado followed. The legal definition of an "inch of water" was given in full. Those laws were such, that any holder of land in the State was entitled to take and use the waters of the rivers, and any one could construct reservoirs and store unappropriated water. A fruitful crop of litigation had, as a matter of course, been developed in the State ; and some cases were still pending. A series of laws were passed in 1879 to determine the order and priority of existing and future claims, to fix the price of water, and to control its distribution. The Author finally directed attention to the Report of the State Engineer of California on similar laws, concurring generally with the principles advocated therein, and suggesting a free exchange of water-rights, and the condemnation of such reservoir sites as were used for direct irrigation only.

American Society of Civil Engineers.—Mr. F J. Cisneros, who recently visited the Isthmus of Panama presented an informal statement of the progress of the work upon the Panama Ship Canal. He stated that the purchase of the Panama Railroad by the Canal Company seemed to promise most excellent results, and suggested that proper methods in the management of the railroad, and lower charges for both freight and passengers, would certainly increase its revenue.

In reference to the Canal he said that the line had been completely staked, cross sections taken and the location made and stakes set for definite work for a large portion of the line. The line is entirely cleared and grubbed from kilometro 40 to the mouth of the Rio Grande, and is rapidly advancing at other points. The Valley of the Chagres has been surveyed, and it has been found that the high water lines above the high dam will cover an area of about 6750 acres, and that the volume of water stored will be about 1,000,000,000 cubic metres. Actual work upon the Canal has been commenced at six points.

The contractors, Messrs. Slaven & Co., for dredging the Canal from Colon, have their first herculean dredge in place, and will commence work directly. The Canal Company have been working with two French machines, at the rate of 1000 cubic metres per day for each machine. The Franco-American Trading Co. have contracted for the excavation of about 10 kiloms. of the Canal beyond the Bay of Panama. Their machines are being built at Lockport. There are now about 6000 men on the work, chiefly Jamaicans, Carthegenians, and a few Martiniqueans

Many dwelling houses, machine shops, &c., have been constructed. The machinery is both French and American, and the eleven American excavators are working with great economy. Borings have been made along the whole line, and have extended to the bottom of the Canal giving in a general way the following results. From Colon to kilom. 10. material easily dredge. From Mamey to Obispo, mostly clay with occasional seams of rock. From Obispo to Emperador about 7 kilms. of hard trap of Conglomerates. From Emperador to Paraiso, about 8 kilms. clay for about 15 meters, then indurated clay followed by schist and reaching rock near the bottom of the Canal From Paraiso to Pedro Miguel 10 to 12 metres clay followed by rock. From Pedro Miguel to the sea, mostly clay and mud with the exception of a few seams of rock.

Considerable work has been done at the Port of Colon including the commencement of a break water.

THE NEW YORK AND BROOKLYN BRIDGE.

From "Engineering News and American Contract Journal."