BRÜCKNER'S CYLINDERS FOR ROASTING SILVER ORES.

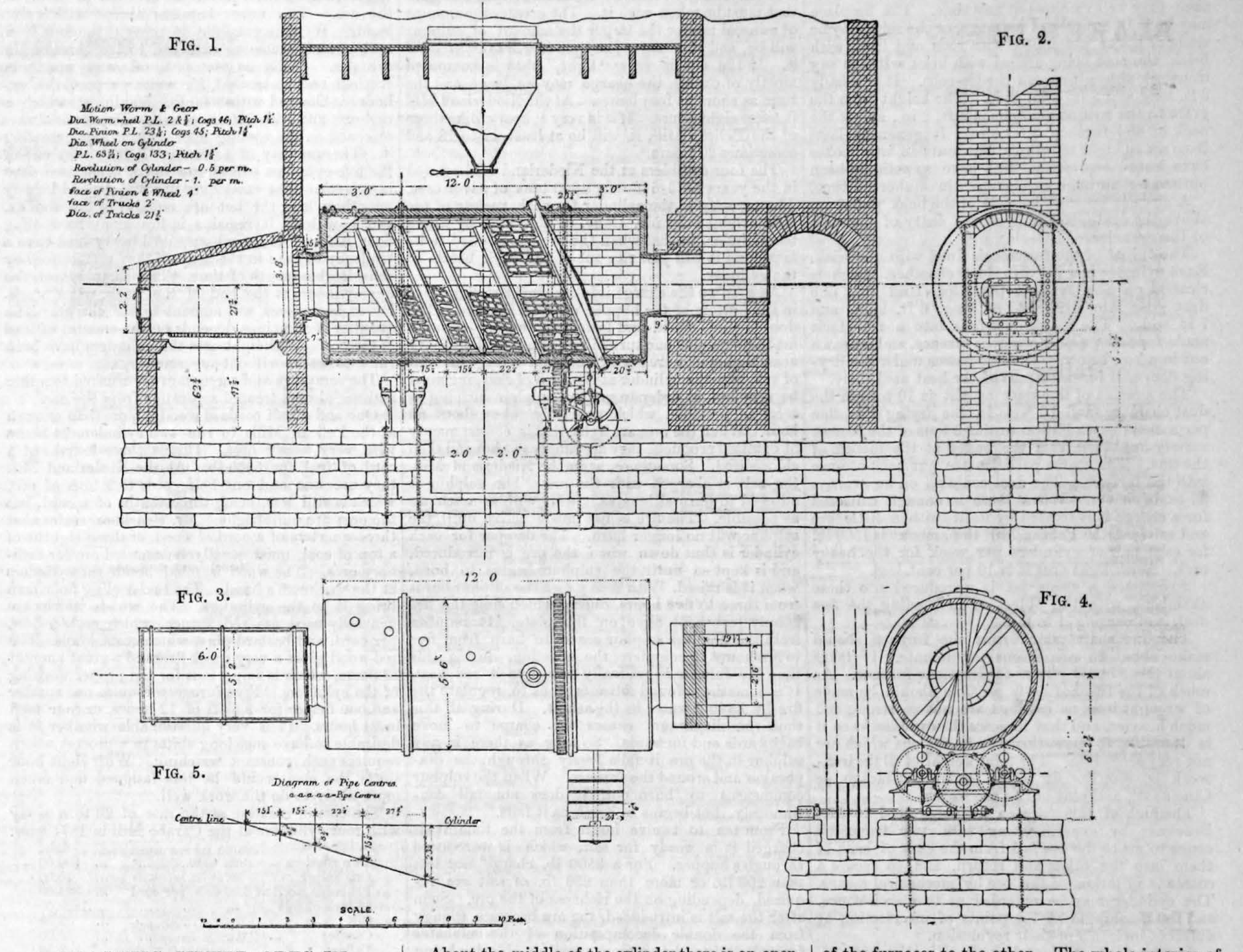


FIG. 1. FIG. 2. FIG. 3. FIG. 4. FIG. 5.

ROASTING SILVER ORES IN COLORADO.

By J. EGLESTON, PH. D.

IN the roasting of silver ores by the Reese River process (roasting and amalgamation), the great desideratum is to find some means of economical treatment. A great many furnaces have been constructed for this purpose, and have for the time being, more or less solved the difficulty. Most of them have, however, gone out of use in a very short time, either because they claimed too much or cost too much to work. One of these furnaces, however, the Brückner cylinder, which was introduced into Colorado in 1867, is likely to be of permanent value. It was introduced for roasting gold ores, and rendered the extraction of 90 per cent. of the gold possible, but it is now almost exclusively used for silver ores, and has rendered a real service in the working of that metal in Colorado. There are thirteen of them in the territory, which were used in the extraction of nearly one-half of the silver produced there in the years 1855-6.

It consists of an exterior cylinder of boiler iron 12 ft. long and 5 ft. 6 in. in diameter, the ends of which are closed, leaving an opening in the centre of each, 2 ft. in diameter. This opening has a flange which projects several inches on the outside. One of these openings connects with a fireplace, and the other with a flue leading to the dust chambers.

In the first furnaces constructed the cylinder was closed with a head at right angles to it, having the flange fitted on at right angles to the head. The ends of the cylinder are now made conical, which simplifies the construction of the interior of the furnace. Both of these methods of construction are shown in the above illustration.

About the middle of the cylinder there is an opening for the introduction of the charge, which is closed by an iron door. Two bands with square projections are bolted on the outside, near the ends, each one of which turns on two friction rollers which support the cylinder. The one near the flue fits into the wheels, which are provided with flanges for the purpose, and prevent any tendency that it may have to slip out of place. The one near the fireplace simply runs on the friction rollers. Between these two bands, and nearest the flue, is a circle of gearing, which is cast in one piece and carefully turned, so as to secure an even revolution. It fits into a spur-wheel, which gives the motion to the furnace. The gearing should be compound, so as to allow of two speeds which are required at different stages of the process, and should be so arranged that where there are a number of cylinders, any one of them may be stopped at pleasure without interfering with the others.

In order to provide against the possibility of settling, each journal box of the friction rollers is held in position by adjustable screws, so that it can be moved laterally or perpendicularly.

Passing through the cylinder from side to side are six pipes, which make a diaphragm in the form of a grate. They are inclined at an angle of 15 deg. to the axis of rotation, making at the same time an angle of 30 deg. to 35 deg. to the plane of this axis, as is shown in Fig. 4. The tubes of the diaphragm pass through to the outside, so that air constantly circulates through them. It was expected that the cooling of the air and the formation of a scale would protect them from the action of the sulphurous vapours; this has proved not to be the case. The object of the diaphragm is to force the charge to continually move backward and forward from one of the furnaces to the other. The whole interior of the cylinder is lined with one layer of ordinary red brick laid flat and set in mortar, made of one part fireclay and two parts firebrick thoroughly mixed and beaten.

At the Pelican Mill the lining is anchored by means of irons bolted for that purpose to the iron casing of the cylinder. The brick is cut upon one side in order to form a complete arch in the interior of the furnace. At the Niederland Mill the brick is put in without shaping, and each half cylinder wedged from the diaphragm, so that no anchorage is necessary. The neck bricks are moulded for the purpose.

The time that the lining will last depends upon the care with which it is put in. It will generally last a year and a half if the work is well done. In the early construction of the furnace the ends were closed by rectangular pieces, and the lining was made conical to reduce it to the proper size. This was found to complicate the construction and necessitated frequent repairs. The ends of the cylinder are now made conical and the lining made of the same thickness throughout. The weight of the cylinder is thus considerably reduced, and repairs to the lining are much less frequently necessary.

In the first furnaces constructed the cylinder was set on a foundation of masonry and the rollers supported on timbers. This construction caused so much trouble that it is now supported on a cast-iron frame which is carefully adjusted before it leaves the shop, thus greatly simplifying the erection of the furnace at the works. The projecting flanges fit loosely into the firebox at one end and into the flue at the other.

Over the lower part of the flue end a piece of sheet-iron is placed inclined so as to throw any ore which might tend to escape through the opening between the cylinder and the flue, back into the furnace. Exactly opposite to the opening a door is placed in the flue so that the working of the furnace may be examined at any time. The fireplace may be built entirely of masonry, or the sides may be made of boiler plate tied with rods and lined with brick, the roof being arched with brick without any ironwork above it except the tie-rods. It is usually 6 ft. long and 3 ft. 2 in. wide. The height from the grate to the roof at the door is 2 ft. 2 in., and at the neck of the furnace 3 ft. 8 in. It generally lasts from six to eight months. The outside iron boxes have lasted two years, but have sometimes been burned out through carelessness in a shorter time.

A circular opening is made in the back part 6 in. above the grate, to admit of the entry of the neck of the cylinder.

The throat of the furnace is lined with firebrick. Each cylinder has its own dust chamber, which is cleaned on Sunday. At the Niederland Mill fine dust goes into a flue 40 ft. long, 6 ft. high, and 7 ft. wide. The coarse dust falls into a receptacle made for that purpose near the furnace, and is drawn out in a box below. The flue passes under the drying floor and furnishes part of the heat used there.

The amount of fine dust caught is 10 tons in the dust chamber, and 10 tons in the drying kiln flue per month. In addition to this 5 tons of the coarser variety are taken from the boxes at the mouth of the flue. The coarse particles are put back at once into the furnace. The dust contains on an average 32 oz. of silver. When there is enough collected for a charge it is treated by itself with a little ore and salt. At the Pelican Mill the amount is 1500 lb. for each pair of cylinders per week for the heavy ores. With light ores it is 10 per cent. less.

Sometimes a steam jet is introduced into these chambers, with the object of moistening the fine dust, and causing it to fall.

The line shaft which runs the furnace should make about 23 revolutions per minute. It takes about three horse power to drive one furnace. As much of the furnace as is possible should be made of wrought iron, as castings are not so strong and much heavier, and they increase the expense when it is desirable to erect furnaces in regions which are not very accessible. The total weight of all the ironwork is 1600 lb. It is all made at Chicago or Cincinnati, and sent out to the works.

The idea of this furnace was suggested to Mr. Brückner by experimenting with two truncated cones to make the ore fall from the ends of each of them into the other and return, and so secure a constant agitation of the ore by mechanical means. The cylinder may be regarded as two such cones, and the diaphragm as the points of intersection at different intervals of their revolution.

Any kind of ore may be treated in the furnace, but the higher the percentage of sulphur and galena the smaller the quantity that can be turned out in 24 hours. Many of the ores of Colorado are very refractory, containing large quantities of lead, zinc, and sulphur. They are very difficult to treat owing to the tendency which they have to form either fusible compounds, to clinker, or at least to cake, and thus form masses which are not affected by the salt, and must be re-treated. The greater the amount of sulphur in the ores the longer the time it takes to treat them. The difficulty is greatly increased with the tendency of the ore to cake. All ores must be crushed fine before they are charged.

As soon as the previous charge has been withdrawn from the furnace it is ready for a fresh charge. It is at a dull red heat from the previous charge, or is brought into that condition, revolving at the rate of one-half to one turn a minute. It is then brought into position with the charging door up, and stopped. The ore which is stored in bins in the story above is charged from a hopper through a long flexible conduit, which is brought directly over the charging hole and the charge introduced. The weight of the charge is very variable, and depends upon the nature of the ore.

At the Niederland Mill, in Carabo, where the ore contains 5 per cent. of galena, 4 per cent. of blende, and 2 per cent. of copper pyrites, or a total of 11 per cent. mineral matter, the charge is 3700 lb. as a maximum.

At the Pelican Mill, where the ore contains 15 to 16 per cent. of galena and pyrites, and sometimes as high as 15 per cent. of blende, or 30 per cent. of mineral matter, the charge is rarely higher than 3500 lb., and sometimes considerably less. These ores are very difficult to treat on account of the very large quantity of blende. The size of the charge is, however, not necessarily an indication of the capacity of the cylinder, for the time taken to treat it is exceedingly variable, depending upon the care that must be taken with it. The greater the amount of mineral matter the larger the amount of sulphur will be, and the longer the time it will take to treat it. If the ore is very "light," that is composed mostly of oxides, the charge may be large and the time as short as four hours. At the Niederland Mill it takes eight hours. If it is very "heavy" like those of the Pelican Mill, it will be at least 12 to 13 and sometimes 20 hours.

The four cylinders at the Niederland Mill roasted in the years 1875-6 nearly 4000 tons of silver ores. The capacity of the cylinder for each variety of ore is determined by Mr. Cone, of this mill, by filling the cylinder, so that when the ore has swelled to its maximum it will just run out of the back nozzle of the cylinder.

As soon as the charge is introduced a sliding valve in the bottom of the hopper cuts off the ore. The door is then closed and fastened, and the cylinder made to revolve one turn in two minutes. For heavy ores, that is for ores which contain a large amount of sulphur, the cylinder at the time of charging must be very hot, in order to get the sulphur burning as soon as possible, which generally takes about an hour. When the ores are light, that is, consist mainly of oxidised products, they are simply got hot and then chlorodised. Sometimes, as in the Niederland Mill, the salt is charged with the ore. The sulphur is allowed to burn as long as it will, with as much air as possible. The fire is not made active until the sulphur will no longer burn. The damper for each cylinder is shut down when the ore is introduced, and is kept so until the sulphur begins to burn, when it is raised. With heavy ores the sulphur burns from three to five hours, during which time the fire is only just kept alive on the grate. It requires from the time the sulphur ceases to burn from five to six hours to complete the roasting, during this time the furnace is gradually raised to a red heat. It is sometimes found advantageous to regulate the fire by having water in the ashpit. During all this time the diaphragm causes the charge to move backwards and forwards. So long as there is any sulphur in the ore it falls freely through the diaphragm and around the furnace. When the sulphur commences to burn out, it does not fall continuously, but begins to break as it falls.

From ten to twelve hours from the time it is charged it is ready for salt, which is introduced through a hopper. For a 3500 lb. charge not less than 200 lb. or more than 250 lb. of salt are required, depending on the richness of the ore. Soon after the salt is introduced, the ore becomes spongy from the double decomposition of the sulphates formed during the previous roasting, chlorine being given off.

When it is chlorurised, there is no smell of sulphurous acid. There must be a clean smell of chlorine given off for about half an hour before the charge is done. Samples are taken from the door in the back of the flue, and sometimes by opening the door of the cylinder, and allowing a certain quantity to drop into the car as it revolves. The chloruration varies from 85 to 95 per cent., according to the ore, and the care with which it is treated.

When the same ore is treated it is not always assayed. In some works the workman is allowed to judge by the eye and the smell as to whether the chloruration is properly done, which is a very bad practice. It should always be assayed with hyposulphate of soda at different stages of the process.

When the charge is finished, which is generally in from four to 13 hours after the charge is introduced, an iron wagon is run underneath the cylinder and the charging door removed and the cylinder is allowed to revolve with the fastest motion with the door open. The charge falls into the wagon and is carried to the brick cooling floor. At the Pelican Mill this wagon is 5 ft. 6 in. long, 34 in. wide at the top, and 29 in. at the bottom. In some works the ore is dropped into a hopper beneath the furnace, at the bottom of which there is a screw or endless chain which carries the ore out into an iron trough cooled with water. This avoids a considerable waste of time in cooling the ore and some labour. It takes from one to one and a half hours to discharge the cylinder.

Before chloruration the Colorado ores are greyish, and after the chloruration they are a brownish red. The whole art of chloruration consists in putting in the salt at the proper time, while there is still some sulphur in the ore. It is then said to have a velvety look and must be entirely free from lumps. The temperature should never be so high as to sinter the ore. This never happens except with green hands. It is impossibile to prevent the ore from caking and becoming attached to the sides of the cylinder. This is scraped off and must be crushed and re-treated, for which purpose the cylinder is charged with 3000 lb., 500 lb. of which is raw ore, and with 160 lb. of salt. The ore is always screened on the cooling floor before amalgamating it. The quantity of screenings is such that one of the five cylinders will be run upon them two days in a week. The exact quantity will depend largely upon how long the hot ore remains in the wagons, and how long it remains in heaps on the cooling floor before it is spread out. All heavy ores have a tendency to cake in the heaps if they remain for any considerable length of time. The scrapings of the five cylinders at the end of the week, when working on heavy ores, will amount to one charge. The quantity of scrapings depends on the amount of lead in the ore. With light ores the cylinders have been run two weeks without any scrapings.

The scrapings and screenings are crushed together and are always treated separately from the ore.

One and a half cords of wood is more than enough at the Pelican Mills to run two cylinders 24 hours with very heavy ores. This is three-fourths of a cord of fuel for 3500 lb. At the Niederland Mill they use one and one-half cords to 5 tons of ore, which is still less, being three-tenths of a cord, but the ores are quite light. Mr. Brückner states that three-quarters of a cord of wood, or three-eighths of a ton of coal, must usually be counted on for ordinary ores. The wood is piled beside the cylinders at the workman's hand. The two cooling floor men bring it to the cylinders. The woods which are generally used are red spruce, which costs 5 dols. per cord, and bastard pine, which costs 4 dols. The red wood gives a very quick fire, and a great amount of flame, which is important for the proper working of the cylinders. Five furnaces require one roaster and one helper for a shift of 12 hours, or four men in 24 hours. It is very questionable whether it is desirable to have such long shifts in a process which requires such constant watching. With eight hour shifts the men would be less fatigued and much more likely to do the work well.

The cost of roasting at the rate of 20 tons a day with four cylinders at the Carabo Mill in 1871 was:

	dols.
Two roasters	200.00
One helper	75.00
104 cords wood at 3.50 dols. per cord ...	364.00
26 tons of salt	1820.00
Oil	2.50
Candles	5.50
Tallow	1.50
Black lead	1.00
One-third power and general expenses ...	287.00
Cost of roasting 520 tons	2756.50
,, ,, 1 ton	5.03

This is very much less than roasting with a reverberatory furnace. The expenses for roasting light ores in Georgetown with two cylinders, having an average capacity of 7 tons in 24 hours were,

	dols.
One man for two cylinders 12 hours at 3.25 dols.	6.50
7 per cent. of salt, or 980 lb., at 3 cents per pound	29.40
1½ cords of wood at 5 dols. per cord ...	7.50
Total for roasting 7 tons of ore	43.40
or for 1 ton of ore	6.20

The expenses for labour and fuel are small, but vary somewhat in different localities. The roasting is very uniformly done, occupies less time than in a reverberatory furnace, and costs less.

The only repairs required are to the throat and the diaphragm. The throat must generally be repaired once in six weeks or two months. In Colorado the castings are made from old iron taken from all kinds of machinery and furnaces, which has been frequently melted, without much regard to quality, and is very hard and poor. They cost 8 cents per pound. They are so bad that it is the intention now to have the castings sent from the east. The time that a diaphragm will last depends upon the quantity of sulphur in the ore. It will usually last from four to five months with very heavy ore. With light ores one set will last a year. When a tube of the diaphragm breaks, the cylinder is still run for the week, and new tubes are put in on Sunday, when the works stop for repairs. A great deal of importance was placed at first on having the diaphragm in good order. It was found that the scale which should protect it would not always form, and the tubes were constantly giving out and being replaced by new ones. Mr. Cone, of the Niederland Mill, never having had a complete set in his cylinders, put in new diaphragms complete; but they were rapidly worn out, and as they broke the stumps were in the way, and he now finds that the furnace works better without them, and since he has definitely abandoned the use of diaphragms he finds that the furnace works just as well, and there is a great deal less dust in the dust chambers. The rotary motion of the cylinder appears to be quite ample to insure sufficient movement in the ore to have it thoroughly oxidised.

The cost of one cylinder complete, including all the machinery and ironwork with the royalty, is about 2000 dols. in Cincinnati, so that a single furnace delivered in Colorado will not cost less than 2500 dols. to 3000 dols., depending on the accessibility of the district where it is to be erected. The royalty on the cylinders has been reduced several times. In the year 1874 it was 1000 dols. When the furnace was first introduced, insufficient experiments were made, and like most good things more was claimed for it than could be accomplished. This put a check on the introduction of the cylinder for a short time only.

The advantage of the cylinder is that it does its work well and uniformly, and that the ore is always under full control of the workmen; that it uses a small quantity of fuel and labour; that the percentage of chloruration is high, and may be carried to 96 or 97 per cent., if sufficient care is taken; that it does not require special labour, as the process is easily learned by any one; the men are usually anxious to learn it, as they consider the position a responsible one, and that the machinery is simple, not likely to get out of order, and easily repaired when it is deranged.

LITERATURE.

The Drainage of Lake Fucino, executed by the Prince Torlonia. An Abridged Account, Historical and Technical. By MM. ALEXANDER BRISSE, Engineer-in-Chief of the work, and LEON DE ROTROU, late Resident Chief of the Administration. In French and English. The English Translation by V. DE TIVOLI, Jun. With an Atlas of Plates. Rome: The Propaganda Press.

THE modern drainage works of Lake Fucino, undertaken in 1854 and just brought to a conclusion, successfully in an engineering point of view, and chiefly through the energy and liberality of Prince Alexander Torlonia, are without doubt in many respects the most interesting that have hitherto been undertaken. And this not on account of their extent, nor because of the difficulties encountered in their execution, but for the reason that the drainage of this lake was an undertaking first conceived by Julius Cæsar, and carried out subsequently by other Roman emperors; not successfully indeed, on account of a dishonest contractor, rather than of an incapable engineer. But these ancient drainage works were of a vast and unique character, the traces of which were almost lost, until the new scheme was carried out, and exposed the old works. The book, containing the full record of both these undertakings ancient and modern, may be regarded as the literary monument of these great schemes, and the authors have done their work faithfully and well, while the atlas of plates, admirably executed by Italian engravers, leaves nothing to be desired. The letter-press is somewhat curiously disposed, so that the French and English versions occupy opposite pages, an arrangement which may be open to some objections, inasmuch as it doubles the bulk of the volume, and forms a combination useless to the reader. This is a small fault, however, to find with a volume full of interest almost on every page.

Lake Fucino was the largest in Central and Southern Italy, and was situated in the province of Aquila, about 33 miles east of Rome, and 96 miles north of Naples. It covered the greater part of a large table land in the sous prefecture of Avezzano, a table-land surrounded by spurs from the main Apennine chain, so that its waters could find no outlet for discharge into the neighbouring rivers. The level of the lake in 1861 was 2094 ft. above the sea; the area of the basin is about 173,000 acres. As evaporation and absorption were the two only means by which the waters of the lake could disappear, its levels were variable, rising rapidly in wet, and falling gradually in dry seasons, the range being as much as 30 ft., when the depth of the lake was about 74 ft. These frequent variations were of course a cause of constant disquietude to the inhabitants around its shores, for the fertile lands in its vicinity were always liable to be flooded to the destruction of the crops, and this evil was felt all the more keenly in the past time, because the Marsi, who inhabited the very mountainous country about the lake, had no other cultivable land. The lake was endowed by the Marsi with the dignity of a god; this people, nevertheless, came to realise the probability that such a deity could well be spared, and appreciating more highly the active powers of Julius Cæsar than the malignance of the lake, they besought him to see what could be done for their aid. With this resolution commences the most interesting chapter of Roman engineering of which complete records exist. About the same time that the petition of the Marsi arrived, Julius Cæsar was considering the momentous question of feeding Rome, a question likely to be pressed rudely upon him before long, on account of the increasing population and the rapid decline of agriculture in Italy. The drainage of the Fucino lake would afford him a vast area for growing food, and it fell in as a natural part of a grand scheme he had formed. This scheme included a ship canal through the isthmus of Corinth, for the quick passage of the corn fleets from the East, a new and capacious port at Ostia, a direct road over the Apennines joining Rome to the Adriatic, the reclamation of the Pontine Marshes, and the draining of Fucino. Had Cæsar lived, doubtless this great scheme, which must have brought joy to the Great George-street of Rome, would have been realised. But the dagger of Brutus prevented the grand project from being even commenced, and the successor of Julius Cæsar, frightened at the extent and at the cost—failing indeed to realise the importance of the scheme—did nothing, and left the Marsi without aid. Neither Tiberius nor Caligula paid attention to the matter, though the troubles foreseen by Cæsar were pressing hard upon Rome, and dearths were becoming frequent. But when Claudius succeeded, his advisers, anxious to retain popularity, brought forward these old projects, and two of them, the drainage of Fucino and the port of Ostia, were decided upon.

Business instincts being practically identical with those of to-day, financiers, engineers, and contractors came forward with many schemes to carry out the work, provided they received the reclaimed land in payment, but the chief secretary of Claudius, a man named Narcissus, seeing his way to profit in the undertaking, persuaded the emperor to undertake it on his own account, and the proposition having been accepted, Narcissus undertook the general superintendence of this work as well as those at Ostia. From which two results followed: first, that the Fucino drainage was a failure, and, second, that Narcissus realised about 3,000,000*l*. But that the works were a failure was not due to want of skill on the part of the engineer, nor indeed to want of funds, only to the dishonesty of the chief contractor. With regard to the engineer, let us give honour to an unknown individual in the words of MM. Brisse and Rotrou: "What remained of the works showed that the engineer who conceived the plan must have been a man of rare merit, for not only had he overcome with as much ability as simplicity, the very great difficulties of such an undertaking, but everything showed that he had based it upon data, the precision of which is truly astonishing if we consider that in those days science and the means of execution were still so far from the degree of perfection which they have reached in these days." The levels of discharge from the lake and the outfall into the river were taken with the utmost care. The former was 59.712 ft. below the level of the surrounding country, and 69.182 ft. above the bed of the river; and as the outfall was 41.487 ft. above the Liris, a total fall of 27.703 ft. was obtained, giving a gradient of 1.5 per 1000 along the whole length of the tunnel (6114 yards). An area of 11.9 square yards was originally given to the tunnel, but in execution this was not maintained; the position of the works show clearly that it was not the intention wholly to remove the lake, but only to reduce its area very considerably. Between the lake inlet and the point of discharge the drainage tunnel did not follow a straight line, but was formed in three sections, making very obtuse angles with each other, this course having been selected with great judgment, as it reduced considerably the amount of rock tunnelling, it shortened the total length of the working by striking the Liris at a nearer point, and lay in the lower ground so that the depths of the working shafts were greatly lessened. There were forty of these shafts in all, a greater number than was originally contemplated by the engineer, but which were rendered necessary as the work proceeded. They were all square in section, and many were sunk through solid rock to very considerable depths, the deepest being on the Campi Palentini section. Special and very interesting reference is made to one that the engineers reopened and used during the recent operations.

"In the course of the Torlonia works, it was found necessary to re-open one of the ancient shafts in the Campi Palentini, sunk through a bank of clay and sand for more than 280 ft. The shaft had not been touched since the Romans had filled it up. The timbering with which it had been lined though carbonised by its long stay (18 centuries) underground, was still in its place without having shifted in the least; so that it was easy to get acquainted with its exact position and dimensions. The sides of the square, each measuring 14.16 ft., were supported in the middle by strong cross beams, which thus divided the aperture into four equal compartments each 5.16 ft. square. These were used merely for hoisting up the rubbish excavated in the tunnel in skips or buckets, which had a cylindro-conical shape, and were made of copper strengthened with broad bands of soft iron. The capacity of these buckets was not very great, only about 1.4 cubic feet. They were suspended by means of hooks to ropes set in motion by men working at the bar of a vertical capstan mounted on a wooden framework close to the mouth of the shaft. Each shaft had two such capstans, so that two buckets could ascend and descend simultaneously, or perhaps it was so arranged that while one bucket was loading at the bottom of the shaft, the second was being raised, the third emptied of its contents, and the fourth descending empty, so that the capstans were always at work."

But besides the shafts there was also a very extensive system of auxiliary works, consisting of a series of inclined galleries, which varied according to the uses they were put to. In the Campi Palentini, where the shafts were deepest these galleries dipped towards the river to the nearest shaft, and generally stopped on reaching it; they were employed to ventilate the shafts while the latter were being sunk. Some, however, were continued beyond their intersection with the shafts down to the tunnel, giving access to the latter and facilitating the removal of spoil. Sometimes they were driven at different heights in the same vertical plane, and occasionally three were met with, one above another. In such cases connecting shafts were driven between them to improve ventilation, the number and extent of course varying with the position of the tunnel; altogether the length of these auxiliary works was double that of the main tunnel. Three-fourths of the whole whole work was driven through solid rock, and the remainder through difficult ground, and they speak alike of the skill of the engineer who planned them, of the dishonesty of the chief contractor who carried them out, of the wonderful perseverance showed during their execution, and of the enormous outlay incurred. Some very interesting evidence exists of a serious accident which occurred through flooding at one part of the works, involving an extensive deviation of the original line.

The head works in the lake comprised a trapezoidal basin with the narrow end towards the tunnel; the entrance was fitted with gates working in grooves, and raised by capstans placed above the entrance in the thickness of the masonry. In front of this basin there was a second, hexagonal in shape, and divided from the former by a wall, on which there was another construction jutting into the hexagonal basin, and establishing a communication between both. The sluice for regulating the outflow had been first placed there, but was removed, and the hexagonal basin became useless. Finally a masonry channel led the water from the lake into the tunnel.

After 30,000 men had been employed during eleven years upon the works, the contractor announced that the water could be let into the tunnel, and the event was celebrated by a great festival, compared with which the inauguration of modern engineering triumphs are poor and meagre. It was found, however, on the opening day that the bottom of the inlet basin was about 17 ft. too high, and only a small part of the lake could be drained. The necessary alterations were made and a second fête celebrated the new attempt. An unfortunate incident occurred on this occasion. A platform for Claudius and his suite was erected over the inlet works that they might better see the rush of water into the tunnel, but unfortunately the sluices were swept away and the emperor and his attendants were nearly lost. Shortly after this Claudius died, and Narcissus, so far as is known, had not the opportunity to carry out any more contracts.

The cost of this work was about 14,000,000*l*. The imperfect manner in which the tunnel had been made soon caused it to become choked, and after the death of Claudius it fell into disuse. Trajan (115 A.D.), however, made some efforts, and Hadrian far greater ones, towards restoring and rendering useful the great work. The latter constructed large and improved collectors at the lake, lowered the point of inlet, and cleared the tunnel, thus preventing inundation in the lake and reclaiming a certain portion of the banks.

With the fall of the Roman Empire the scheme was entirely abandoned, and until 1240 it remained untouched. At that time Frederic II. of Swabia, Emperor of Germany, gave orders to repair and clear the tunnel, but it was done very imperfectly. In 1600 a great inundation called prominent attention to the subject, and the inhabitants called in Domenico Fontano, the architect and engineer of Sixtus V., to report on the possibility of reopening the work. The attempts made, in accordance with this report, were unsuccessful. Towards the end of the 18th century many suggestions were made for the necessary works, and in 1791 the Government assisted Ignacio Stile, a Neapolitan engineer, to commence restoration, under the charge of Abbé Lolli, who had long been engaged in examining and considering the question. Political events, however, prevented any practical results from being achieved. We must reserve for another occasion a review of the various attempts made in the same direction during the present century, and which terminated with the completion of the scheme by the Prince Torlonia.

BELL'S ARTICULATING TELEPHONE.

ATTEMPTS have been made for many years past to transmit musical or articulate sounds to a distance by means of electrical communication, and some of the early experiments of the late Sir Charles Wheatstone were accompanied with so much success that it was hoped that a time would come when an instrument might be constructed not only to register graphically certain audible sounds, but to produce upon a diagram a set of signs by which the sounds of the human voice could be recorded; in other words, that it might become possible to construct an automatic reporter, and in the Loan Collection of Scientific Apparatus at South Kensington may be seen several instruments bearing upon these researches, and in which the vowel sounds are recorded by a series of distinctive curves.

In the year 1860, Philipp Reis, of Friedrichsdorf, near Homburg, following the researches of Wertheim, Marian, and Henry, upon the production of sounds by electricity, invented the telephone which bears his name, and which also may be seen at South Kensington. The telephone of Reis is of two parts; a transmitting instrument and a receiver. The former consists essentially of a stretched membrane which, by vibrating in unison with the impulses it receives from musical sounds played near it, transforms those impulses into a series of electrical currents by a simple make-and-break arrangement, and these currents acting on the receiving instrument, which may be hundreds of miles distant, reproduce the corresponding notes, so that a tune played at one station can be distinctly heard at the other.

The receiving instrument is founded upon the well-known phenomenon discovered by Page in the year 1837, that a distinct sound accompanies the demagnetisation of an iron bar placed in an electromagnetic helix. It consists of a soft iron bar about the size of a knitting needle surrounded by a helix of wire which forms part of a voltaic circuit with the transmitting instrument, and for intensifying the effect both instruments are provided with sounding boards or resonators. From the above description it will be seen that if a note which makes, say, one hundred vibrations per second be sounded in the neighbourhood of the transmitting instrument, its membrane will make one hundred corresponding vibrations, making and breaking the voltaic current one hundred times, and producing one hundred demagnetisations in the receiving instrument for every second of time, so that exactly the same note that was sounded in the transmitter will be audible at the distant station. It is obvious that the duration of and time between two notes must be identical at both ends of the conducting wire, and thus is reproduced automatically and without a possibility of error the elements which make up melody, viz, correctness of note combined with measure of time.

Following Reis in Germany, Elisha Gray in America constructed, in 1874, his far more perfect electric telephone, in which the transmitting instrument consists of a vibrating reed, which is at once a note producer and a rheotome or contact breaker. It is tuned like the reed of a harmonium to its proper note, and when adjusted can only transmit to the receiving instrument the number of currents per second corresponding to the vibrations producing its note. Elisha Gray's receiving instrument is electrically similar in principle to that of Reis, but consists of a horse-shoe electro-magnet mounted upon a wooden sounding box or resonator with a heavy armature attached to its poles. The transmitting instrument is provided with a key-board similar to that of a harmonium, and each note has its corresponding key and vibrating reed.

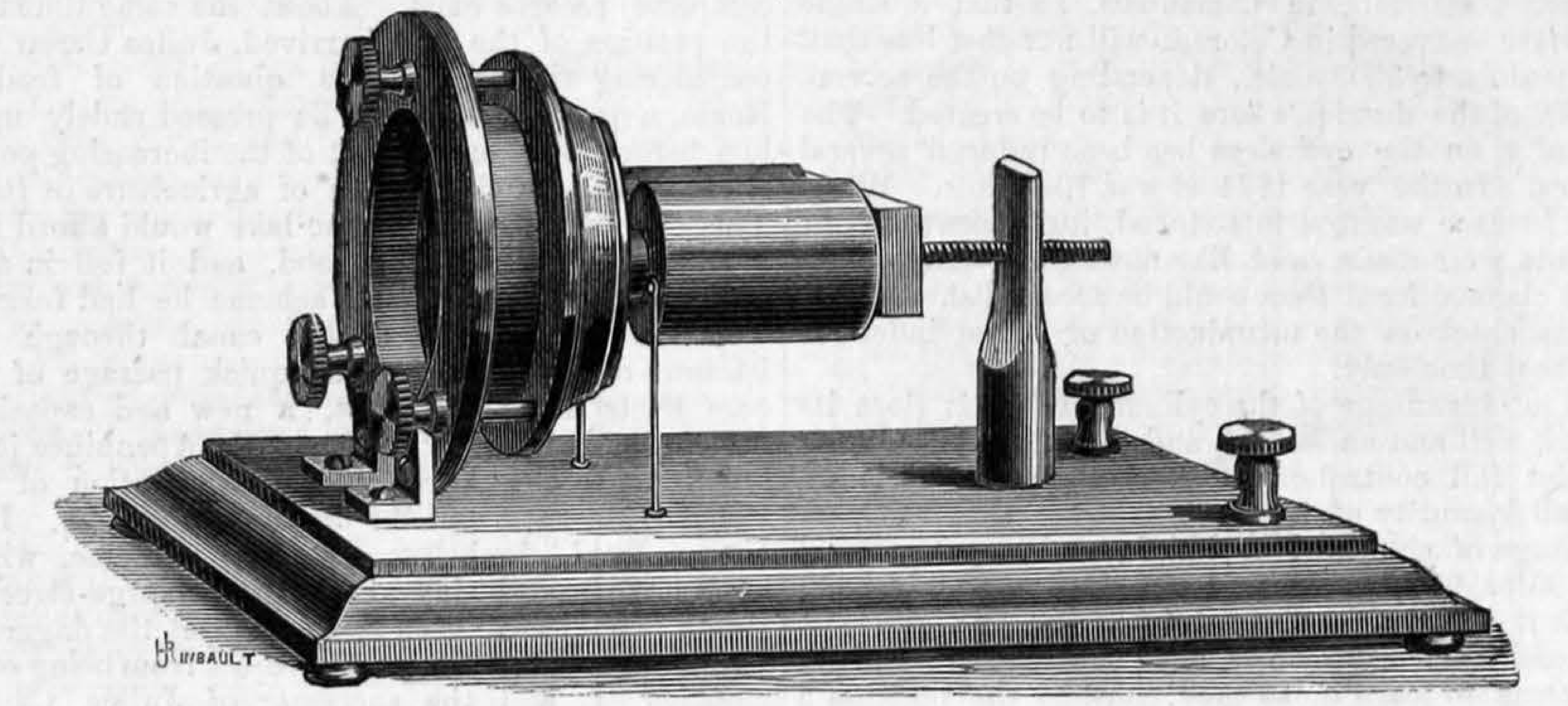


FIG. 1.

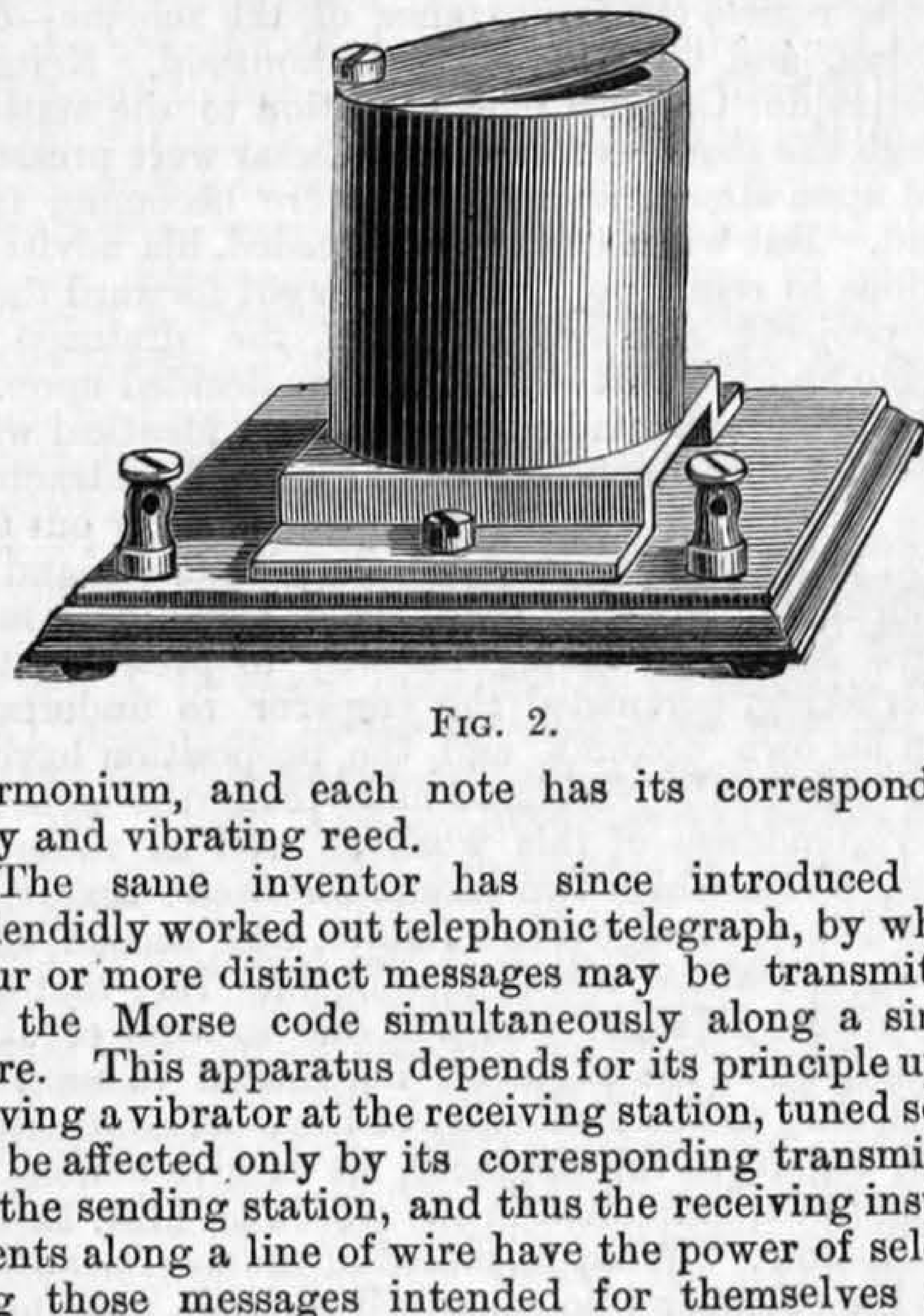


FIG. 2.

The same inventor has since introduced his splendidly worked out telephonic telegraph, by which four or more distinct messages may be transmitted in the Morse code simultaneously along a single wire. This apparatus depends for its principle upon having a vibrator at the receiving station, tuned so as to be affected only by its corresponding transmitter at the sending station, and thus the receiving instruments along a line of wire have the power of selecting those messages intended for themselves and letting all others pass. This has also been accomplished by a Danish engineer, M. Paul Lacour, who employs vibratory tuning-forks for transmitting the impulses, and a series of corresponding tuning-forks, each arm of which is enclosed in a magnetic helix for the selecting instrument. This selecting instrument can be used either as a receiving telephone, or by being employed as an intermediate relay, may transmit the signals to ordinary telegraph instruments.

We give above illustrations of the transmitting and receiving instruments of Mr. Graham Bell's articulating telephone, by which the sound of the human voice may be transmitted by electricity along a telegraph line and heard, as a voice, at the other end.

The articulating telephone of Mr. Graham Bell, like those of Reis and Gray, consists of two parts, a transmitting instrument and a receiver, and one cannot but be struck at the extreme simplicity of both instruments, so simple indeed that were it not for the high authority of Sir William Thomson, one might be pardoned at entertaining some doubts of their capability of producing such marvellous results.

The transmitting instrument, which is represented in Fig. 1, consists of a horizontal electro-magnet attached to a pillar about 2 in. above a horizontal mahogany stand; in front of the poles of this magnet —or more correctly speaking magneto-electric inductor—is fixed to the stand in a vertical plane a circular brass ring, over which is stretched a membrane, carrying at its centre a small oblong piece of soft iron which plays in front of the inductor magnet whenever the membrane is in a state of vibration. This membrane can be tightened like a drum by the three mill-headed screws shown in the drawing. The ends of the coil surrounding the magnet terminate in two binding screws by which the instrument is put in circuit with the receiving instrument, which is shown in Fig. 2. This instrument is nothing more than one of the tubular electro-magnets invented by M. Niclès in the year 1852, but which has been reinvented under various fancy names several times since. It consists of a vertical bar electro-magnet enclosed in a tube of soft iron, by which its magnetic field is condensed and its attractive power within that area increased. Over this is fixed, attached by a screw at a point near its circumference, a thin sheet iron armature of the thickness of a sheet of cartridge paper, and this when under the influence of the transmitted currents acts partly as a vibrator and partly as a resonator. The magnet with its armature is mounted upon a little bridge which is attached to a mahogany stand similar to that of the transmitting instrument.

The action of the apparatus is as follows: When a note or a word is sounded into the mouthpiece of the transmitter, its membrane vibrates in unison with the sound, and in doing so carries the soft iron inductor attached to it backwards and forwards in presence of the electro-magnet, inducing a series of magneto-electric currents in its surrounding helix, which are transmitted by the conducting wire to the receiving instrument, and a corresponding vibration is therefore set up in the thin iron armature sufficient to produce sonorous vibrations by which articulated words can be distinctly and clearly recognised.

In all previous attempts at producing this result, the vibrations were produced by a make-and-break arrangement, so that while the number of vibrations per second as well as the time measures were correctly transmitted, there was no variation in the strength of the current, whereby the quality of tone was also recorded. This defect did not prevent the transmission of pure musical notes, nor even the discord produced by a mixture of them, but the complicated variations of tone, of quality, and of modulation which make up the human voice, required something more than a mere isochronism of vibratory impulses.

In Mr. Bell's apparatus not only are the vibrations in the receiving instrument isochronous with those of the transmitting membrane, but they are at the same time similar in quality to the sound producing them, for the currents being induced by an inductor vibrating with the voice, differences of amplitude of vibrations cause differences in strength of the impulses, and the articulate sound as of a person speaking is produced at the other end.

Of the capabilities of this very beautiful invention we cannot give them better than in the words of an ear witness, and no less an authority than Sir William Thomson, who in his opening address to Section A at the British Association at Glasgow, thus referred to it:

"In the Canadian Department I heard 'To be or not to be . . . . . there's the rub,' through an electric telegraph wire; but scorning monosyllables,

GRAIN ELEVATOR AT CANTON, MARYLAND, U.S.A.

CONSTRUCTED FOR THE NORTHERN CENTRAL RAILROAD OF NEW JERSEY, BY MR. W. B. REANY, ENGINEER, PHILADELPHIA.

(*For Description, see Page* 524.)

Fig. 1.

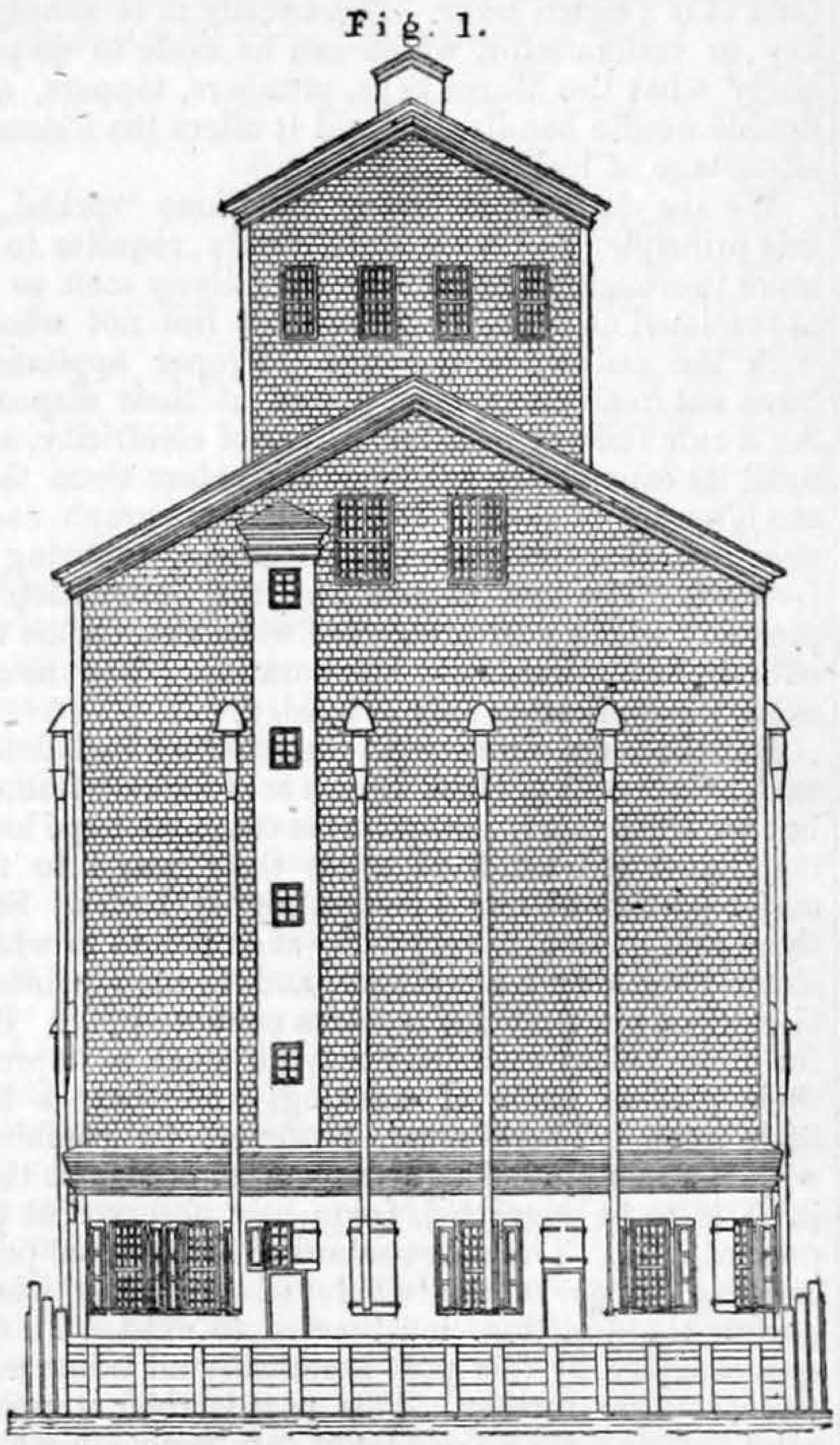
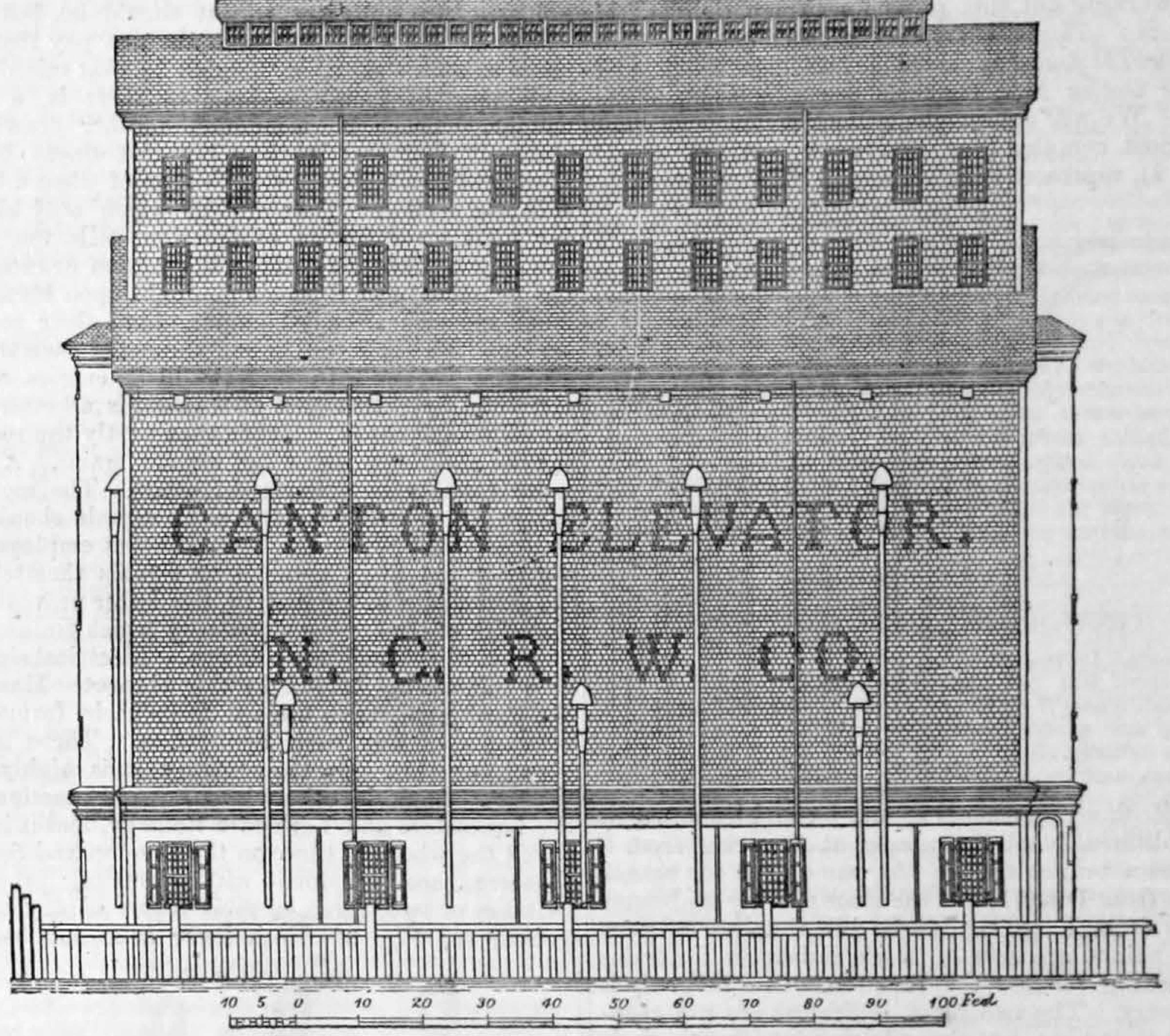


Fig. 2.



the electric articulation rose to higher flights, and gave me passages taken at random from the New York newspapers: 'S. S. Cox has arrived' (I failed to make out the 'S. S. Cox'); 'the City of New York;' 'Senator Morton;' 'the Senate has resolved to print a thousand extra copies;' 'the Americans in London have resolved to celebrate the coming 4th of July.' All this my own ears heard, spoken to me with unmistakable distinctness by the then circular disc armature of just such another little electro-magnet as this which I hold in my hand. The words were shouted with a clear and loud voice by my colleague judge, Professor Watson, at the far end of the telegraph wire, holding his mouth close to a stretched membrane, such as you see before you here, carrying a little piece of soft iron, which was thus made to perform in the neighbourhood of an electro-magnet, in circuit with the line, motions proportional to the sonorific motions of the air. This, the greatest by far of all the marvels of the electric telegraph, is due to a young countryman of our own, Mr. Graham Bell, of Edinburgh and Montreal and Boston, now becoming a naturalised citizen of the United States. Who can but admire the hardihood of invention which devised such very slight means to realise the mathematical conception that if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of its current must vary continuously and as nearly as may be in simple proportion to the velocity of a particle of air engaged in constituting the sound."

RAILWAY JUNCTION WORKING.

IN Captain Tyler's report to the Board of Trade upon railway accidents for the year 1875, we find, under Class E, a list of those collisions which occurred at junctions, and which called for the usual investigation on behalf of the Board of Trade. They are fourteen in number, and they were the occasion of death to one person, a railway servant, and of injury to 114 others, seven of whom were servants of the companies concerned. "In every case there was negligence or mistake on the part of officers or servants. In five cases there was want of block telegraph working. In four cases there were defective signal or point arrangements, or want of locking apparatus. In three cases the accommodation was insufficient for the traffic. In one instance there were either insufficient brake power, or insufficient establishment respectively." So says the report.

For the previous five years the number of accidents classed under this head stand respectively 18, 19, 32, 20, 22. For the year 1875, and in the aggregate for the whole term, they occupy the third position in the eleven classes under which the whole of the investigated accidents are enumerated. It is thus the *third*, as "collisions within fixed signals at stations or sidings" is the *first*, source of danger with which railway management has to grapple.

A junction will, under any circumstances, prove more dangerous than an ordinary, open, free piece of line. It is so, because at this point trains cross each other's tracks, and pass from one line to the other; but we fail to see why, apart from the danger attending the use of points, a junction should not be worked with as much safety to the traffic passing over it as is any other portion of the line. Given a properly equipped signal-box, provided with efficient locking apparatus and block signals, there should be no difficulty and no danger more than attends other portions of the line. The error in working such points lies, not in the apparatus, nor in the men, but in the manner of working them. The extract which precedes these remarks appropriates no less than five of the fourteen accidents to want of junction block working. The conclusion is no doubt within the mark, for a careful perusal of all the cases coming within the class would rather indicate that no less than nine might fairly be attributed to it. It is in a proper application of block signalling to junction working that the existing danger attending such points is to be mainly overcome. In the reports upon the several accidents we have the remark, "There does not appear to have been any system of junction block working in force," occurring more than once, and we find under the Portobello (G.W.R.) accident of the 5th of November, the signalman "was not required by his regulations to block back to the next cabin whilst allowing such an obstruction near his cabin" . . . . "under improved arrangements for shunting the goods trains directly across, instead of see-sawing them up and down the lines, and a better mode of block working, such mistakes would not be made, and there would be less delay to the traffic."

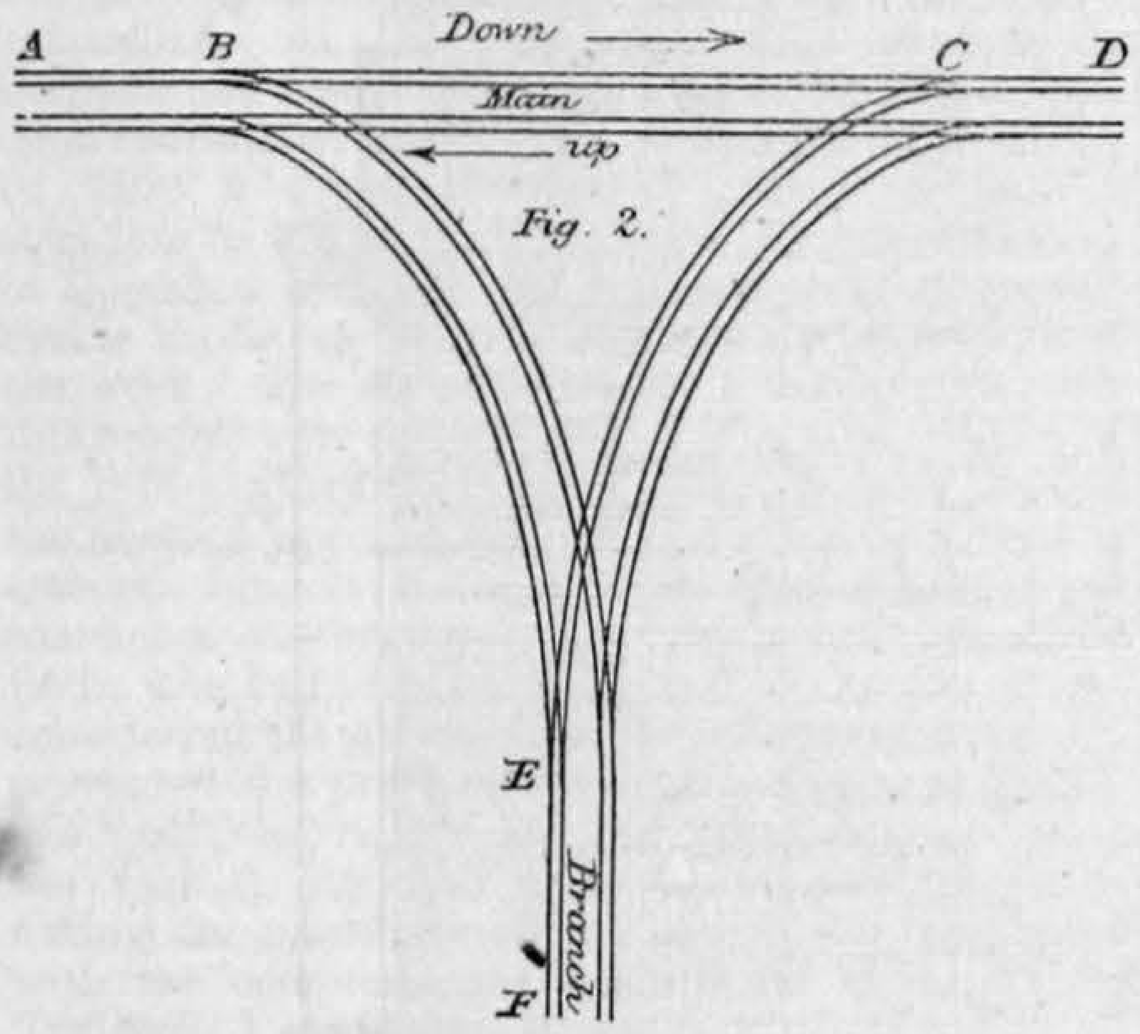
The essence of block signalling lies in the fact that by it trains are kept apart by a certain and defined interval of space. Why is it this does not apply at junctions as well as on the straight road? Take now for instance a simple junction such as is shown in Fig. 1. We will assume the main line A B C and

the branch section B D are worked under the block, and that A and C are stations. The rule prescribes that not more than one train shall be in any one section upon the same line of metals at one and the same time. We have a train running from C towards A, and another has to come from D to couple with it at A. Now where is the virtue of allowing the train from D to draw up to B until that from C has passed B? Or, if the main line train is late, of allowing that from C to draw up to the junction till that from D has passed it? It is clear that in either case, if it does so, it must wait until that which first enters the section B A is clear of it. Why then not keep it back at D or C, as the case may be, until the other has passed? The danger lies in these two trains meeting at the point B. If they are kept apart by the space B D or B C, it is clear the danger no longer exists.

Take now a down branch train. It must cross the up main line. Here the danger lies in its coming into collision with an up main line train at the junction point. But if we keep the up main line train back at C till the down branch train has cleared B we remove all danger.

But this means delay! It means delay, but it means safety, and safety or freedom from accident means economy. In the nine cases to which we have alluded, 64 persons, including railway officials, are reported to have been injured. Now casting aside all sentiments of humanity, and reducing the question to one of a merely commercial character, what did the injuries to these 64 persons cost the companies? It is questionable if the establishment of such a system as we have propounded would have cost one quarter the amount of these damages. Why then delay it? Every day which witnesses the absence of it, is a day of risk to the traveller and to the shareholder alike.

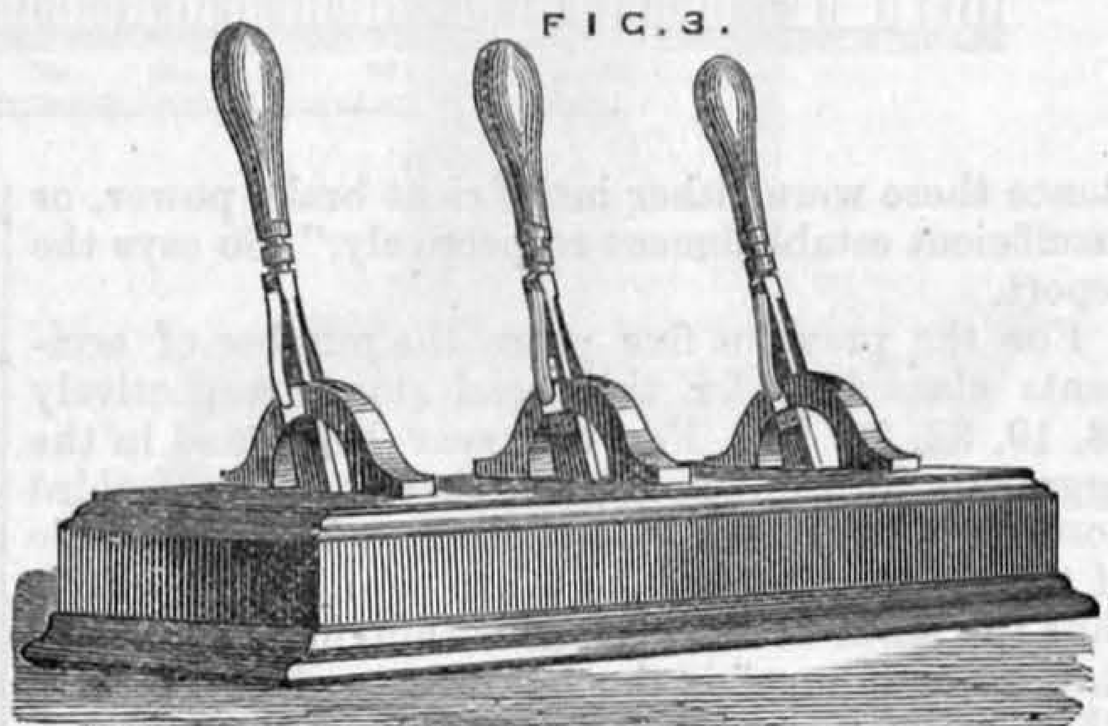
In working out this principle the rule to be laid down is: *That the junction sections of every road which will be fouled by the coming train shall be regarded as one section until the train has passed the fouling point.* We will take a triangular junction as perhaps the most complex for this work. A B C D (Fig. 2), represents the main road. E F the branch.



The block arrangements should be supplemented by an additional block instrument at A worked from B for down branch trains; the same at D for branch trains from D to C; and the same at F for up branch trains from F to E. There will thus be between these points two sets of block indicators for trains proceeding *towards* the junction. One bell only is necessary. The two block indicators are not absolutely necessary, but there is an advantage in their employment which will appear further on. The block indicators for the branch trains will be maintained at danger, so that no branch train may leave either A D or F without permission from B C or E respectively; and B and C will each, regarding E as their branch, keep their signals for trains coming from that point also at danger. We will now follow a train through from the direction of A to F. It is a branch train. Previous to its arrival at, or departure from A, B is advised of its approach, and the number of beats on the bell tells him its character. The branch signal is at block and it cannot leave A till it is set to clear. Previous to clearing it B has to protect it from any up main line train, as the down branch will cross those metals at B. B, therefore, places the block indicator at C at danger, and notifies by the bell that the road is blocked or *obstructed.* C acknowledges this, having first put on his out-door signals in conformity with the block. *Now* B is at liberty to admit the down branch train, and he accordingly gives A the clear signal, and on the arrival of the train there it is allowed to proceed. On its leaving A the block signal is put on behind it, and E is advised of its approach. E's main line is from B to F, C is his branch, and E's branch signal worked to F is for trains proceeding from F towards D. This signal E keeps at danger except when cleared for a branch train. E C being E's branch, his signal worked to C will also be at danger. The coming train is, therefore, already protected against any train which might cross its metals at E. It enters the B E section and is protected at B. B then clears his up main road at C. The train has now entered E F, is protected at E, and cleared at B. It will be observed that during this time there has been no stoppage of any up main train from F. For this there was no necessity, as it would run parallel with the down branch train. It has been stated that the block signals at E, worked from B and C, stand normally at danger; the main line A D, is thus kept clear, that is, it is only obstructed when trains are within any of its sections.

Assuming now that there is but one block instrument for trains from A to B, D to C, and F to E, it remains to keep that instrument always at block, and only to clear it when the road has been prepared for it. At the same time, although the block signals stand against trains which might foul it coming from other points, it might be advisable to more strictly impress the existence of the block by a bell signal representing an obstruction. But there is always this objection to such a form of working. The line is shown to be obstructed where it really is not obstructed —that is when there is nothing in the section—and nothing crossing, or about to cross the points. It is not clear why it should be, but it is nevertheless a fact, that men do not pay that respect to such a signal as they do to that raised for, and maintained only so long as there is, a real danger. There is, moreover, another drawback about it, and that is that the instrument being always at block gives no indication of when a train is in the section. That system which only blocks for a train, or for an obstruction, tells the man working it there is a train in the section or crossing the junction, and it leaves no doubt upon his mind. Both systems alike, of course, have their record books which show the in and the out of each train; still it is not well to trust to book entries or to mere memory, the signal instrument is a better and an additional check. Hence then partly the reason for the additional signal for branch trains. A still more forcible one, however, exists. The method adopted in working electric block signals should be as nearly as possible analogous to that employed in working the line, or out-door signals themselves. Improvements as applied to the latter prevent the lowering of conflicting signals by which trains may be allowed to come into collision. Electrical signals as a rule are far behind in this respect. Many of the block systems in use are from their formation incapable of any such application. There is no reason for this. On the contrary it is highly desirable it should be otherwise. Several junctions on the Lancashire and Yorkshire Railway, and it is believed the whole of those on the London and South-Western, are provided with electrical junction switches of two, three, or more levers as may be required, see Fig. 3. Each lever or switch handle

FIG. 3.



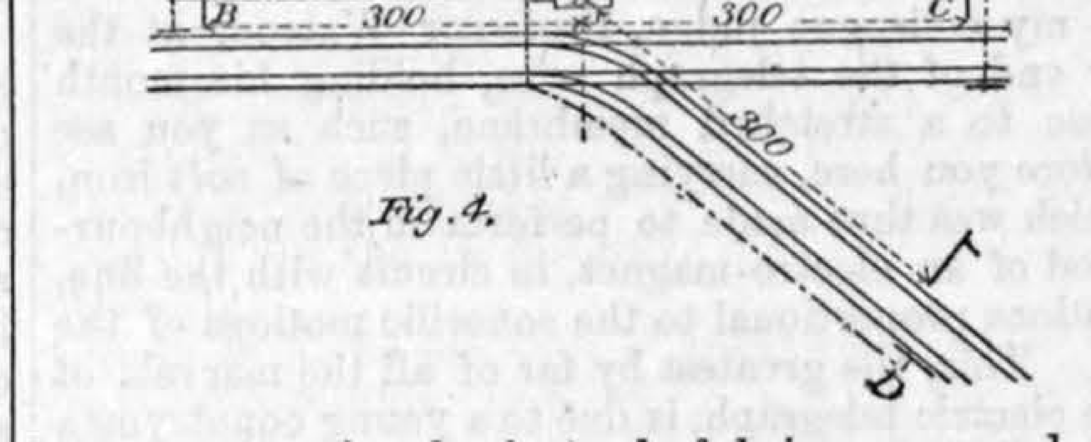
interlocks by means of a movable bar beneath, much in the same manner as those of a locking frame. Thus, in the example before us (Fig. 2), B would be provided with a four levered switch, one lever of which would work the block signal for down main trains, another that for down branch trains, a third that for up branch trains, and the fourth that for up main line trains. These levers would be so arranged that it would be out of the power of the signalman to at one and the same time give the clear signal to either of the signal boxes in communication with him, for trains which could come into collision with each other. C and D would be similarly provided.

There is room for much improvement in electrical block signals. They remain, with the exception of Preece's, Tyer's, and Walker's, in form and manipulation pretty much the same as when first drafted for the work. Originally an ordinary speaking telegraph instrument, they are practically the same still. The dial is coloured, or it may be lettered; or the needle may carry a card, but it is worked like a needle instrument, and its indications are by the needle. Mr. Preece was the first we believe to conceive the idea of moulding block signals after the fashion of those used upon the line, and he has carried this not only to the block signal itself, giving it the form of the semaphore, having but two indications—blocked and clear—but also to the method of working the signals. Thus a switch—a miniature lever—is used to raise the arm or to lower it precisely in the same manner as the lever in the frame actuates the line signals. Although in Walker's and in Tyer's we have for the signal instrument a miniature semaphore arm, it is still worked, in the one case by a key, such as is known in telegraph circles as a Morse key, and in the other by a buffer or plunger. There would no doubt be some difficulty in making these keys and plungers, the old-fashioned double and single needle handles, or the pedals of Spagnoletti's to interlock, but there does not appear any reason why these instruments should not be worked by a switch such as is employed by Mr. Preece. In form it is a signal lever. Electrically it is simply a key or commutator, which can be made to do precisely what the Morse keys, plungers, tappers, and double needle handles do, and it offers the immense advantage of locking.

We are desirous of seeing junctions worked on this principle, and we believe it only requires to be more thoroughly understood by railway men to be appreciated as it ought. The fault lies not wholly with the railway authorities. Proper appliances have not in all cases been placed at their disposal. As a rule railway men know little of electricity, and until its capabilities are fairly set before them they are ignorant of them. It is for the telegraph engineer and others interested in the science to bring it forward. The loss of life and the destruction of property which year after year witnesses, claims the efforts of all towards its amelioration. The means exist, its application only is needed.

But there are numerous junctions, we had almost said, as innocent of block signals as of locking frames; but we trust this is not quite the case; we hope locking frames at least have made their way into the major portion of our junction signal boxes. Still there are, no doubt, very many such points to which electric signals are a stranger, and to such points it is evident our previous remarks cannot apply. But for these points electricity may do much to improve their present mode of working, and that at but little cost. There must, however, be combined with it a more judicious arrangement of signals than is, it is to be regretted, frequently observed at the present date. The old standard or home signal-post, carrying upon it the whole of the arms which govern the junction, must cease to exist. To the spot occupied by this post practically all trains may come, but no further. This post is their stopping point. It is clear no one point can be chosen which shall so protect all the junction points that a train stopping at it from any direction shall not foul either one road or another. It is, therefore, wholly wrong on principle and in moral effect. The practice is, in some instances of recent construction, being superseded so far that the branch is protected by a separate post, which keeps the branch trains, some 20 yards perhaps, clear of the junction points. But we must go further to find the protection we desire.

Let A (Fig. 4) be a junction box, and let the



home or stop signals, instead of being arranged at the junction points, be fixed some 300 yards away as shown at B, C, D. It will be understood that these signals are the stop signals which supersede the junction standard; the distant signals are at their usual positions, some 500 to 800 yards beyond these points. Now it is clear if we succeed in keeping trains at this distance from the points, there will be no danger of their fouling the crossing. Moreover, there is a certain margin left for careless driving and those other contingencies conducive of accident. But each signal is 300 yards from the box, and there will arise occasions when they will be hid from the signalman's view, and any trains standing at them will also be hid from his view. Here electricity may prove serviceable. Every train will naturally draw up at the signal-post whenever the signal is on against it. It may be directed that it shall do so. If, then, a treadle of such proportions that at least one wheel of any carriage, truck, or engine, composing the train, shall press upon it during the stoppage or passage of any train coming in that direction, be laid parallel and in connexion with one of the metals, we shall have by it a means for working a commutator, or key, by which a current of electricity may be brought into action, and so be made to work an indicator and bell combined, fixed in the signal-box, so as when a train is waiting to make the indications represented by Fig. 5. The word "waiting" would be attached to a movable index and would only be exhibited during the time the treadle was depressed. The arrangement of the bell would be such of course as to give one, two, three, or four beats; as it may be assumed, a continuous ringing kept up during the time the train might be kept outside the junction, would be anything but conducive to the signalman's equanimity.

Fig. 5.

The difficulty of stopping an "empty engine" precisely at the spot where the treadle is placed may be advanced as an argument against such an arrangement; but to this we answer that some better arrangement of the signals is absolutely needed; that the further these can, with reason, be placed from the junction points, the greater will be the safety; and, finally, that engine-drivers are as amenable to reason as other people, and as fully alive to the fact that these adjuncts operate as much for the preservation of their own lives as for those of the passengers, and will, therefore, readily conform to any rules which may be needed to give effect to them. Add to this that any failure in the apparatus would merely result in a free use of the engine whistle, and we have every confidence that the means proposed would be found to materially reduce accidents of this class.

In order to facilitate traffic on lines worked under the block system, it is now becoming the practice to provide junctions with what are termed *advance signals*. These are signals for trains *going from* the junction. They are usually placed a sufficient distance from the junction points to admit of a train of any reasonable length standing between it and the junction points. Referring our readers again to Fig. 4, such signals might very well be applied to the posts situated as at C and D. The advantage of them may be illustrated by the following example. Suppose the C section is blocked. Ordinarily this would have the effect of keeping any train for that section in the B section. If now there is a branch train following, so long as the C section is blocked it cannot come on, for it is kept back beyond the B section, but if we move up the main line train beyond the junction points, holding it by the advance signal at C, then we can bring on the branch train and get clear of it. So that not only does the branch train gain by such an arrangement, but inasmuch as, when the branch train is disposed of, there is room for another main line train, all trains in the rear of it gain a step. In fact by its means a block on the main line is not transmitted to a branch train following, nor is a block on the branch transmitted to a main line train following it. It is desirable that all such advance signals should be provided with a means by which the signalman may know whether the train is held there or not. Under Class E of the report from which we have quoted occurs a case in point. We allude to the collision which occurred at the Gas Factory Junction of the Blackwall Railway, on the 13th of December. During a dense fog the signalman had put forward a train under his advance signal, and apparently forgot it, for after a time, another train approaching, he lowered his standard for the same section and sent in a goods, which came upon that held by the advance signal. In his remarks upon this accident the Government inspector is in accord with us, for he says, after referring to the fact that the signalman by whom the mistake was made had never during 18 years' previous service had any fault found with him, that "some means should be adopted, either by a recording instrument in the cabin, or a fogman employed in thick weather, for indicating to a signalman in a such a case when a train which he cannot see is standing at, and when it has proceeded forward from, his advance signal." The means is to be found in the treadle arrangement already referred to.

It is only by the adoption of a system of working such as has been described in the early portion of this article, and by the application of arrangements such as have been referred to later on that any approach to immunity from danger at such points is to be obtained. Improved locking gear and continuous brakes under the control of the engine-driver are invaluable accessories, but the primary object to be obtained is to secure all conflicting lines being held and treated for a given space on either side of the conflicting point as a block section, in which but one train may be admitted at one and the same time. If this can be achieved, in it will lie the first and chief contribution to security in junction working. But it must never be forgotten that railway working is almost entirely dependent on human aid, and human aid is and ever will be unreliable—human, electrical, or mechanical—one and all may fail. It is not, therefore, desirable to rely upon any *one* means only, but by a combination of the whole to reduce the chance of failure to its lowest possible minimum.

PROPOSED NEW BRIDGE ACROSS THE THAMES.

YESTERDAY week at a meeting of the Court of Common Council held at the Mansion-house for the despatch of business, the Lord Mayor presiding, an important report was brought up from the Special Bridge and Subway Committee by Mr. H. A. Isaacs, the chairman. It stated that on the 10th of February last, in order to meet the wants of and to relieve generally the continually increasing traffic of the City, it was referred to them to consider a report as to the advantage and the approximate cost of making the approaches to and of erecting a bridge over or a subway under the Thames, east of London-bridge, and of the best means of carrying out the same. All references in relation to additional accommodation for traffic between the north and south sides of the Thames, eastward of London-bridge, were transferred to them. They proceeded in the matter, and the architect prepared and laid before them a plan showing the principal thoroughfares near the north and south side of the Thames from London-bridge to Wapping, which they carefully examined and considered, and they took steps for obtaining returns of the vehicular traffic over London-bridge to and from the districts which would be likely to be advantageously affected by the construction of a bridge over or a subway under the Thames eastward of London-bridge. From these it appeared that the average number of vehicles of all kinds passing daily over London-bridge from north to south was about 7800, of which the proportion of goods traffic was estimated at about 4000; the average proportion going from the north-east to the south-east of London at 1570, the estimated proportion likely to use London-bridge being 380, and the proportion likely to be benefited by a new means of crossing the river being estimated at 1190. It further appeared that the average number of vehicles of all kinds passing daily over London-bridge from south to north was about 7600, the estimated proportion of goods traffic being about 3800; the average proportion going from the south-east to the north-east of London being estimated at about 1570, the number likely to use London-bridge about 400, and that likely to be benefited by a new means of crossing the river 1170. Those results had, however, been arrived at upon the assumption that the goods traffic from both the north-east and south-east of London would go direct between the extreme points of destination, and not diverge into the City to deliver and load, and that the new means of crossing and the approaches would be as con venient as those of London-bridge. The committee had also obtained a return of the number and character of the vessels passing up the river westward of St. Katherine's Docks, from which it would be seen that the total number of vessels passing up the river during six consecutive working day was 144, two of which had masts 40 ft. high, eight 45 ft., 13 50 ft., 11 55 ft., 32 60 ft., 39 65 ft., 13 70 ft., seven 75 ft.; eight 80 ft., one 90 ft., and one 95 ft. Having carefully considered those various returns, they visited the different localities on the north and south sides of the river eastwards of London-bridge, and after a vey careful inspection of them, it appeared to them that the most eligible site for a bridge over or a subway under the Thames would be that approached from Little Tower-hill and Irongate Stairs on the north side and from Horsleydown Stairs on the south side of the river. They then proceeded to consider the references upon the designs submitted by the following persons: (1) Mr. Frederick Barnett, who submitted plans for a low level bridge, the centre of which would consist of two swing bridges on turn tables in the centre, one at each end of a pier, leaving waterway on each side for large vessels when the swings were open; (2) Mr. G. Barclay Bruce, Jun., who sent in plans and a model for a roll bridge, the bridge or platform moving over rollers from shore to shore by steam power; (3) Mr. Sidingham Duer, who submitted plans for a high level bridge with hydraulic lifts at each end; (4) Mr. T. Claxton Fidler, who sent in plans for a high level suspension bridge, apppoached on the north side by a gradient of 1 in 40 from the end of the Minories, and on the south side round a spiral approach of about 400 ft. in diameter; (5) Mr. John Keith, who submitted a plan for a subway from the Minories to the Bermondsey New-road; (6) Mr. Edward Perrett, who submitted plans for a high level bridge approached on the north side of the river by a level viaduct from the top of Little Tower-hill and on the south by a level road to be formed, each abutment of the bridge being provided with two hydraulic lifts; and (7) Mr. Edmund Waller, managing director of the Thames Steam Ferry Company (Limited), who submitted the plan of the company for a steam ferry from Irongate Stairs to Shad Thames. They were attended by all the parties, who were generally heard in relation to and explanation of thei respective designs and schemes. They also examined the designs submitted to them by the following persons, which had not been referred to them by the Court—namely, a design by Mr. T. Chatfield Clarke for a low-level bridge, 100 ft. east of London-bridge, the northern approach being from Fish-street-hill and the southern from Tooley-street; a scheme by Mr J. Pond Drake for a swing bridge, 50 ft. wide with a headway of 14 ft. or 16 ft. above Trinity high water mark; and a plan by Mr. C. T. Guthrie for a railway ford with double or single line of railway of nearly uniform level. Only four of the parties gave any estimate of the expense of carrying their designs into execution. Mr. Bruce's estimate was 134,381*l*., and working expenses 10,000*l*.; Mr. Duer's, 136,500*l*., and working expenses, 1872*l*. per annum; Mr. Keith's 163,346*l*., and for land and approaches, between 300,000*l*. and 400,000*l*., and Mr. Perrett's 260,000., with 80,000*l*., for land and 4000*l*. per annum for working expenses. The Committee had very fully and carefully considered that most important subject, and, after mature deliberation, they had arrived at the conclusion that, provided the requisite funds could be obtained for the purpose, it is desirable that a bridge over or a subway under the Thames should be constructed eastward of London Bridge, and that the most eligible site will be that approached from Little Tower Hill and Irongate Stairs on the north side and from Horselydown-lane and stairs on the south side of the river. They recommended that it should be referred back to them to consider the best means of carrying the same into effect and of procuring the requisite funds for the purpose, and they further suggested that they should be authorised to advertise for designs and to offer premiums for those most approved. Appended to the report were various traffic returns.

NOTES FROM THE SOUTH-WEST.

Clifton Extension Railway.—In the Court of Appeal, on Tuesday, before Lords Justices Baggallay and Brett, the case of the Attorney-General *v* the Great Western Railway Company and the Midland Railway Company was heard. In August, 1876, the Master of the Rolls granted an injunction to restrain the defendant companies from opening for passenger traffic a portion of the Clifton Extension Railway until after the expiration of the period for which the Board of Trade had directed, or might direct, the opening to be postponed. The defendants appealed. Mr. Davey, Q.C., for the companies, asked to have the hearing of the appeal advanced; Mr. J. Rigby, for the Attorney-General, assented. Their lordships ordered that the appeal should be in the paper on the first day in the Hilary sittings on which appeals are taken.

Briton Ferry Tramways.—The Briton Ferry Local Board of Health has decided not to oppose the substitution by the local tramway company of steam for horse power on its line.

Lighthouse in the Bristol Channel.—At the last meeting of the Bristol Chamber of Commerce it was resolved that a memorial should be presented by the chamber to the Board of Trade, appealing against the decision of the Trinity Corporation to erect a light at Bull Point instead of a lighthouse on Morte Stone, and that application should be made to the other ports in the channel to concur in or present a similar memorial.

Launch of the Flamingo.—Another vessel has been added to the Royal Navy by the launching at Devonport Dockyard of the Flamingo, a composite screw gun-vessel. She was commenced in December, 1875, and is of 774 tons burthen, and 750 horse power; and her dimensions are as follows: Length between perpendiculars, 157 ft.; extreme breadth, 29 ft. 6 in.; breadth moulded, 28 ft. 6 in.; depth, 14½ ft. The Flamingo was built in No. 3 building slip, and the launch, which was under the direction of the chief constructor, Mr. A. Moore, was a successful one. The Flamingo was immediately afterwards taken in tow, and placed in the basin of the dockyard. The Condor, sister ship to the Flamingo, building in No. 2 slip, is approaching completion, and will be launched on the 28th of January.

Trade at Cardiff.—The foreign coal trade of this port has improved a trifle although tonnage is scarce and freights are rising. Several large companies have completed contracts for quantities exceeding their usual limits, and this seems to indicate a revival in the trade. The iron trade has slightly improved.

Ebbw Vale Steel, Iron, and Coal Company.—The Ebbw Vale Steel, Iron, and Coal Company held a special meeting to-day (Friday) at Manchester, to confirm the following special resolution: "That the nominal capital of the company be reduced from 2,383,200*l*, being 74,475 shares of 32*l*. each, to 1,712,925*l*. divided into 74,475 shares of 23*l*. each, by the extinction on each of the said 74,475 shares of paid-up capital to the extent of 9*l*., to the intent that the present liability of 3*l*. per share on each of the said 74,473 shares shall be preserved, notwithstanding such reduction."

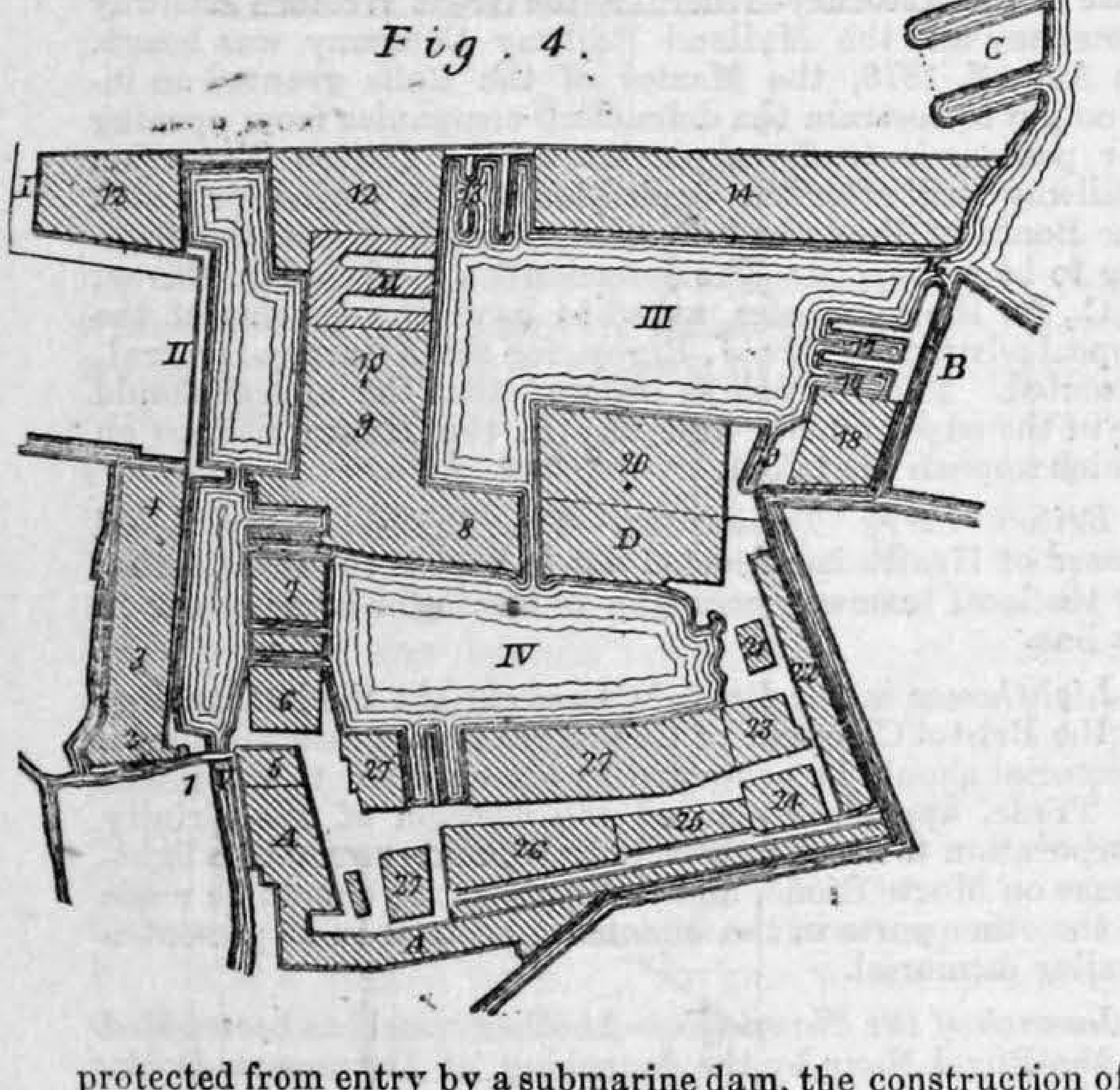
Neath Tramways.—The proposed introduction of steam upon the Neath and district tramways was discussed on Monday by the Neath corporation. A resolution that the council should approve of an application of the tramways company to the Board of Trade for the necessary powers was carried by the mayor's casting vote, an amendment that the council should remain neutral for a twelvemonth during the trial of an engine, being lost.

PATENT LAW REFORM.—The Society of Arts' memorial to the Lord Chancellor on Patent Law Reform has already been signed by over 800 persons, including, it may be said, most of those whose names are best known in connexion with the subject.

THE ARSENALS OF ITALY.

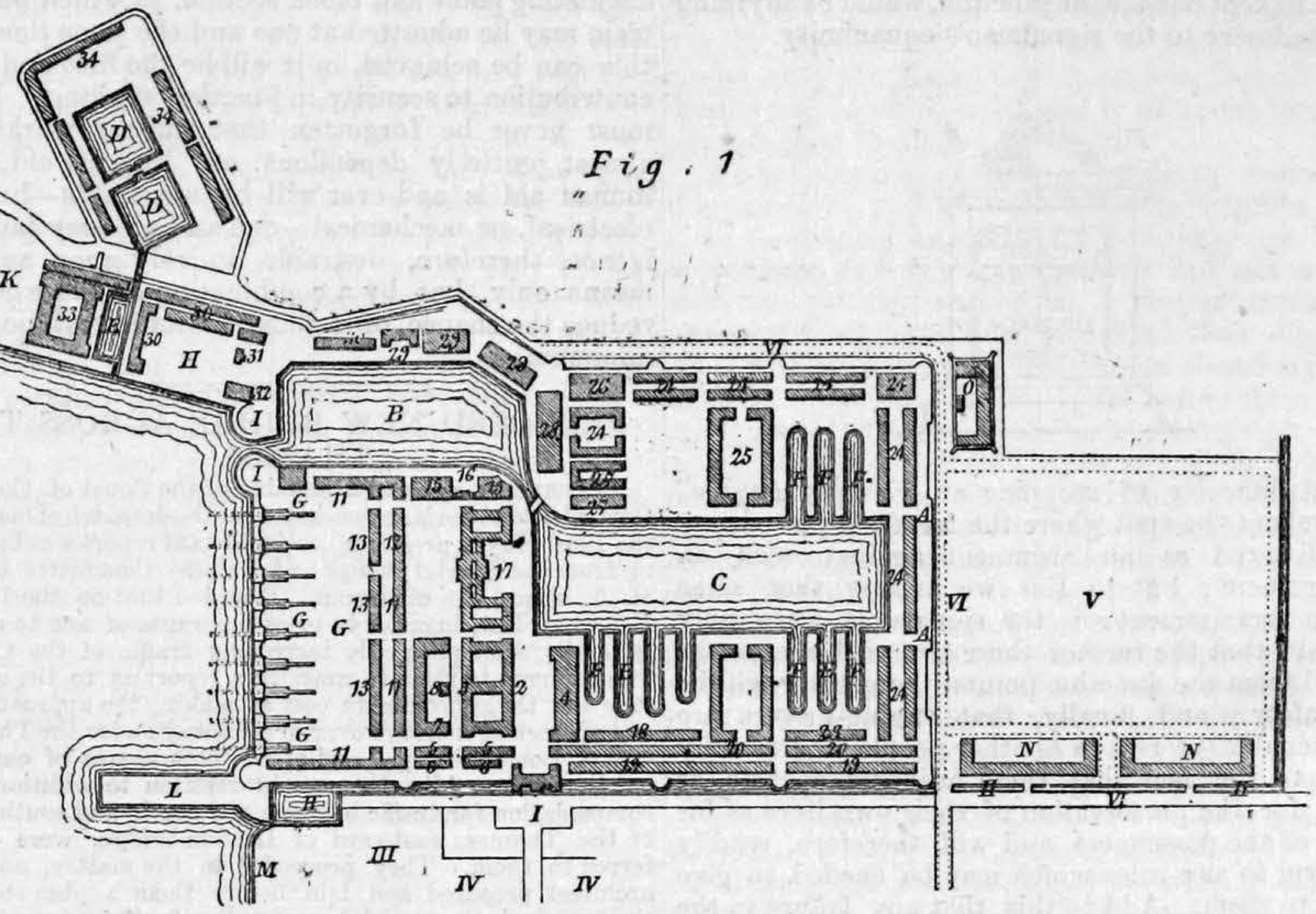
THE *Mémorial du Génie Maritime* has published recently some interesting information upon the military arsenals of Italy, and of these articles an extended abstract has appeared in the *Revue Maritime et Coloniale*. We think the subject of sufficient value to justify us in referring to it in some detail, in the following order.

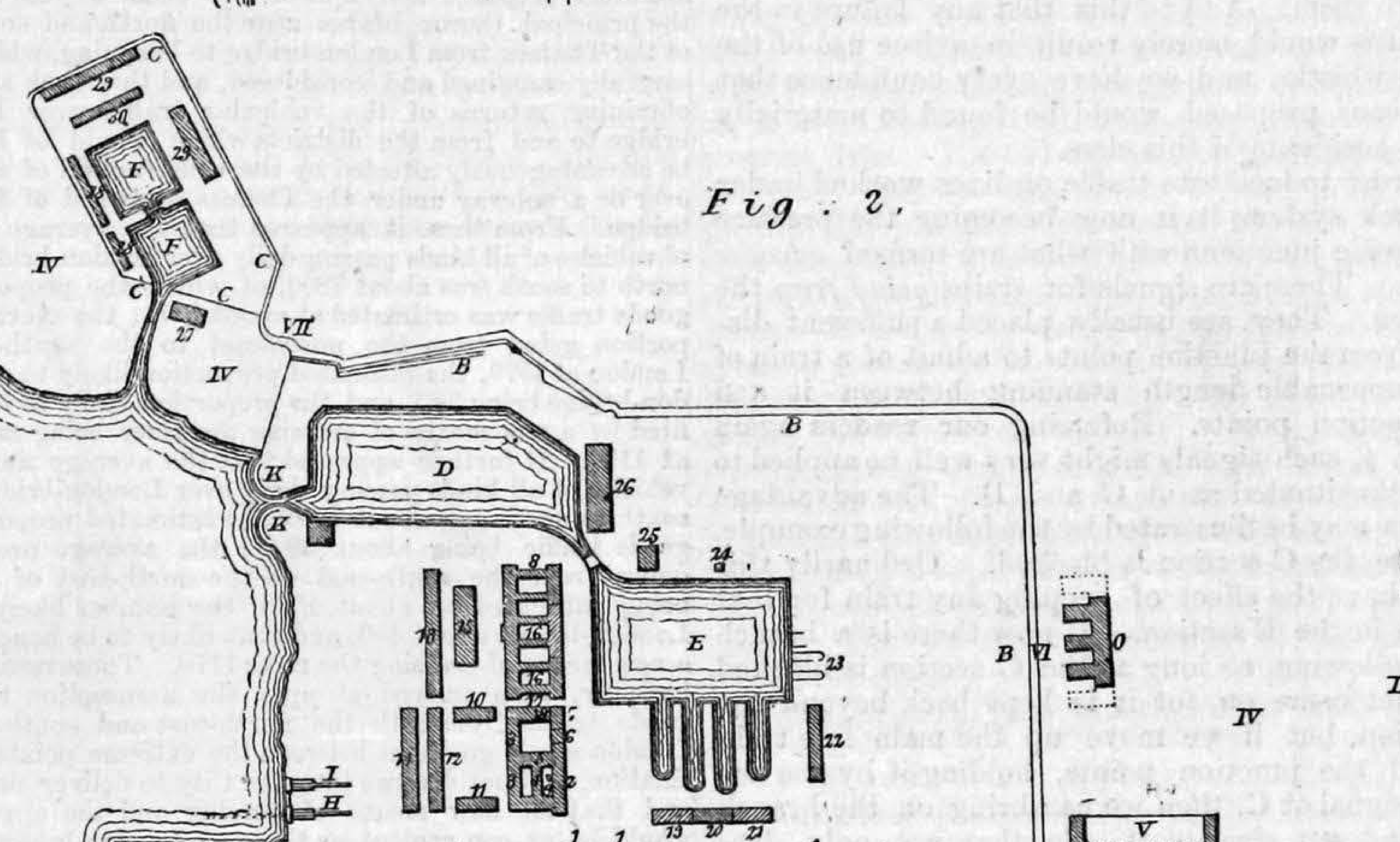
I. SPEZZIA.—When the Piedmontese Government determined upon the establishment of a navy, it became necessary to provide an arsenal, where construction and repairs could be carried on, under complete shelter from all hostile attacks. The Count Cavour decided to locate this arsenal at Spezzia, and the constructive work was immediately commenced. Operations were pushed on so rapidly that to-day, after an expenditure of about 50 millions of francs, the arsenal of Spezzia may be ranked among the most important of the maritime establishments. The accompanying diagram, Fig. 1, shows the plan as originally designed, and how far the work has been completed. But the illustration shows only that portion devoted to the arsenal itself. The State establishments include a much greater area, extending almost over the whole of the shores of the Gulf of Spezzia, and Count Cavour wishing to supplement, in case of war, the Government workshops, with the large private establishments, caused to be built, among the earlier works, the San Bartolomeo ship construction works, with the intention of ceding it to a public company. The death of Cavour and the territorial aggrandisement of Italy, which brought to it the private works of Livourne, of Naples, of Sorrenta, &c., prevented the carrying out of this project, and San Bartolomeo is now ceded to the War Department in connexion with the defence works undertaken on the other side of the harbour, and on the surrounding heights. These works are considerable; the harbour itself is entirely

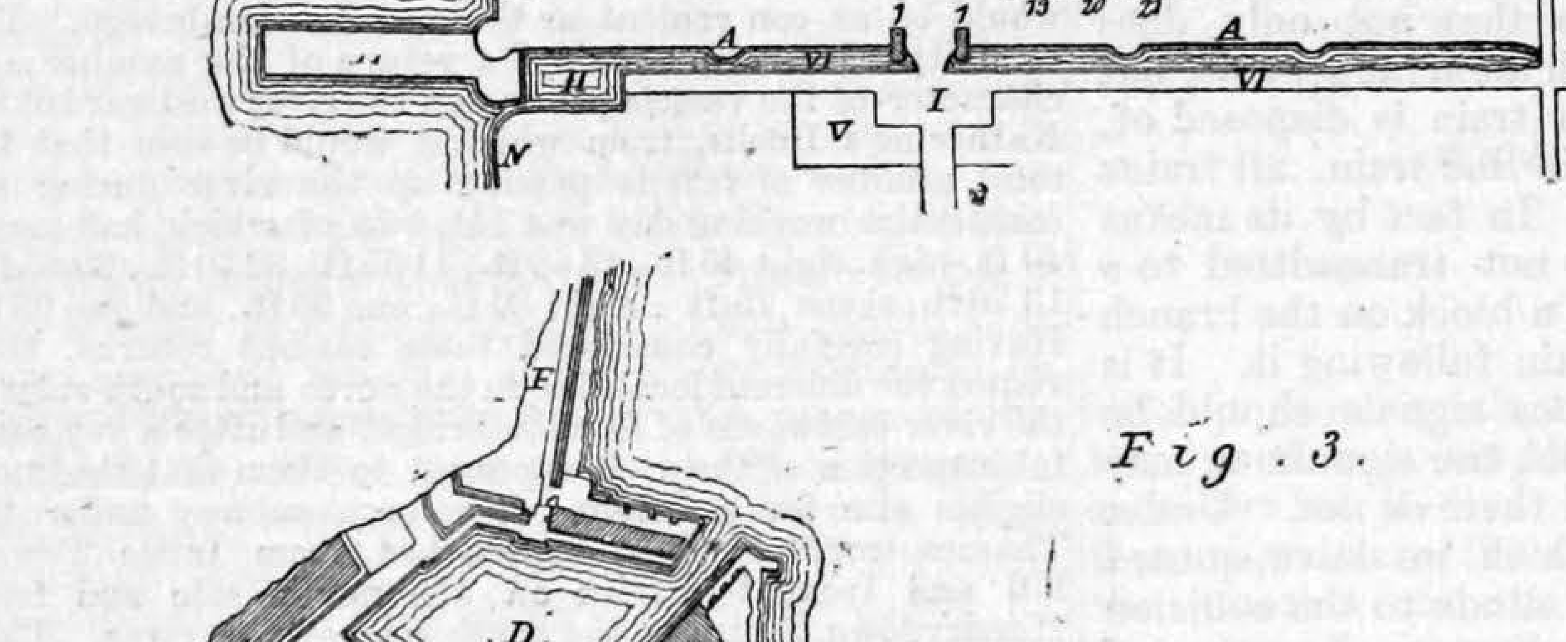


protected from entry by a submarine dam, the construction of which is being actively pushed forward. This dam, laid between the points of Santa-Maria and Santa-Theresa, is 157 ft. wide at the base and 33 ft. at the summit, its mean height is about 42 ft., and its surface level is 39 inches below low water. In the middle of this dam there will be placed an armour-clad fort, and there will be two ship entrances, that of Santa-Maria 650 ft. wide, and that of Santa-Theresa 1300 ft. in width. The island at the entrance to the harbour will be defended by a large fort now being built; it will contain three powder magazines belonging to the War and the Marine Departments. The arsenal, properly so-called, will be surrounded by a road, and on two sides by a wide fosse, but the enclosure works are finished only on two sides; to the west large excavations are necessary, including considerable rock-cutting, to divert the high road, which connects the arsenal with the small artillery establishment of San-Vito. It is intended that there should be nine building slips, but two only are completed. Awaiting the completion of these, two small slips have been made for the construction of gunboats of the Staunch type According to the original plan, the arsenal should include ten basins, but four only are constructed, the depth of these being 32 ft. 9 in. The two large ones are 443 ft. long and 80 ft. 3 in. wide at the top, and 56 ft. 8 in. at the invert; the two smaller ones are 360 ft. 9 in. long, and 72 ft. 9 in. and 55 ft. 9 in. wide. The basins are emptied by means of two turbines, driven by two 150-horse power engines, taken from some old gunboats. A small pump is also kept constantly at work to remove infiltrating water. Although these basins are founded on very bad ground, they have not cost more than 40,000*l.* each. Nearly all the reserve vessels, especially the armour-clads, are kept at Spezzia.

The drawing, Fig. 1, shows the original design for the arsenal, and the letters and figures upon it have the following reference: I. is the chief entrance; II. is the surrounding canal; III. Land belonging to the Navy Department; IV. Land belonging to private owners; V. The Place d'Armes; VI. The road around the arsenal. A. Wall enclosing arsenal; B. Fitting-out basin; C. Basin for construction and repairs; D, D. Artillery basins originally intended for timber ponds; E, E. Provisioning docks; F, F. Repairing docks; G, G. Building slips; H. Artillery depôt; I, I. Anchor and chain depôts; K. Coal depôt; L. Mole; M. Battery; N. Casernes; O. Prison. 1. Main entrance and offices; 2. Coppersmiths' and construction offices; 3. Boiler shops; 4. Machine shops; 5. Framing and caulking shop; 6. Coal stores; 7. Carpenters' and pattern shops, &c. 8. Steam saw mills; 9. Wood store for cabinet-makers; 10. Painters' shop; 11. Timber stores; 12. Hand saw mill; 13. Ironwork shops; 14. Stores; 15. Masting shops; 16. Inclined plane; 17. General stores; 18. Pumps; 19. Rope stores; 20. Forges; 21. Steam hammer; 22. Pumps; 23. General shops; 24. Foundry; 25. Cisterns; 26. Sails and fittings; 27. Direction bureau; 28. Armament stores; 29. Salle d'Armes; 30. Artillery repairing shop; 31. Corps de garde; 32. Food stores; 33. Artillery shops.







The arsenal is connected by a railroad to the establishment of San-Bartolomeo, and a small locomotive has been finished for general service, though it has been little employed. The system of cranes and appliances for moving heavy loads is very imperfect. About 2000 workmen are employed, of whom 1700 are occupied on ship work.

Fig. 2 shows the arrangement of the arsenal as existing to-day. A. Wall surrounding arsenal; D. Fitting-out basin; E. Basin for construction and repairs; F. Artillery basin; G. Repairing docks; H, H, I. Building slips; K. Chain and anchor depôt; L. Mole; M. Battery; N. Caserne; O. Hospital; 1, 1. Offices; 2. Naval bureau, engine-rooms, &c.; 3, 3. Forges; 4. Locksmiths; 5. Erecting shop; 6. Pumps; 7. Model room; 8. Carpenters; 9. Boiler shops; 10. Steam hammers; 11. Foundry; 12. Wood stores; 13. General stores; 14. Fitting shop; 15. Ground occupied by the contractors of the arsenal works; 16. Special stores; 17. Boiler shop; 18. General fittings; 19. Framing shop; 20. Pumps; 21. Caulking and painting shops; 22. Temporary shop for iron shipbuilding; 23. Small building slips; 24. Masting shears; 25. Military bureau; 26. Harbour and port bureau, sail stores, &c.; 27. Artillerists' quarter; 28. Artillery shops and gun foundry; 29. Gun-carriage shops and stores; 30. Shop and stores for torpedoes.

The buildings are all of one story, excepting the construction offices, which contain the moulding lofts and the large bureau for harbour manager, &c. The sheds lately con-

GRAIN ELEVATOR AT CANTON, MARYLAND, U.S.A.

CONSTRUCTED FOR THE NORTHERN CENTRAL RAILROAD OF NEW JERSEY, BY MR. W. B. REANY, ENGINEER, PHILADELPHIA.

(*For Description, see next Page.*)

Fig. 12.

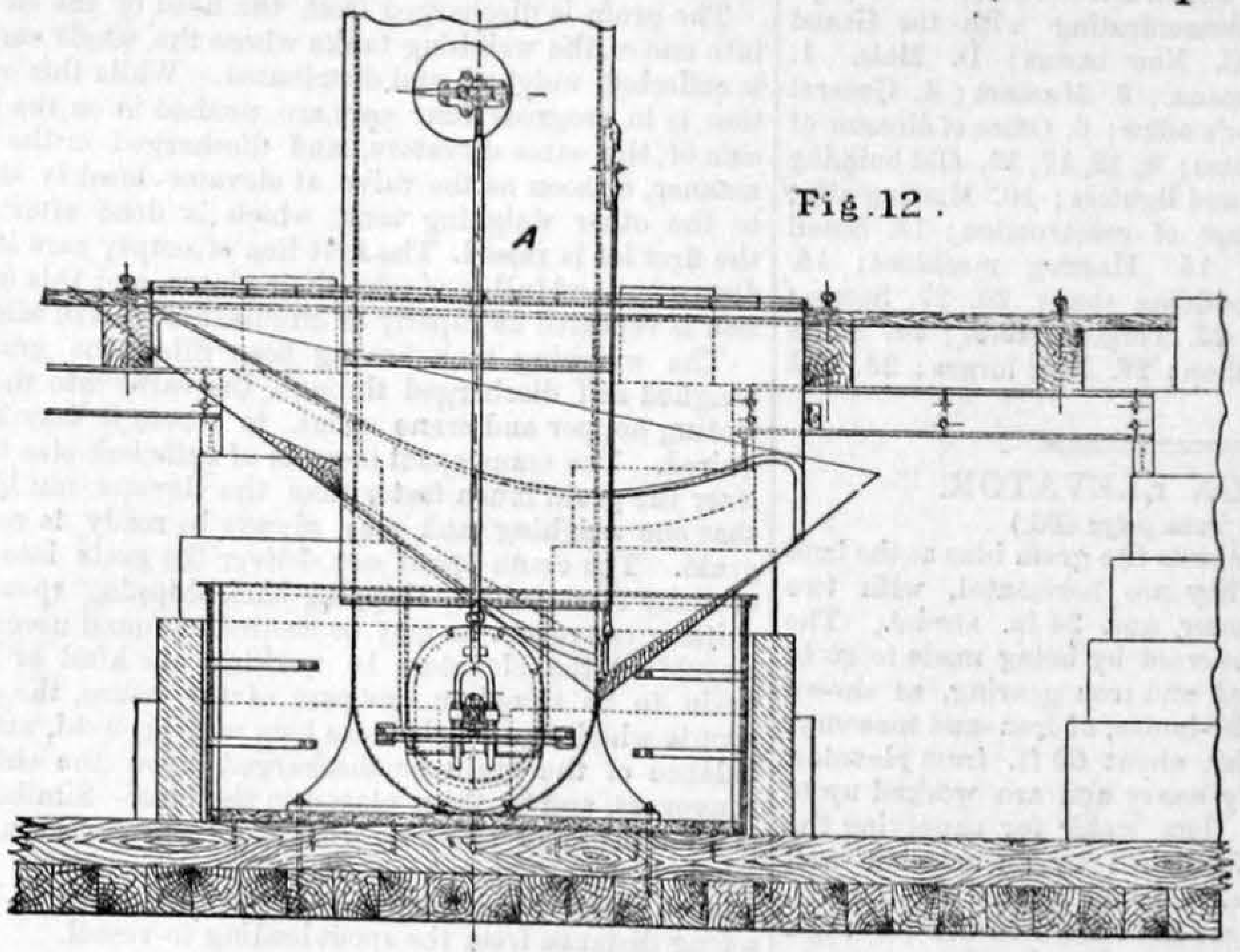


Fig. 14.

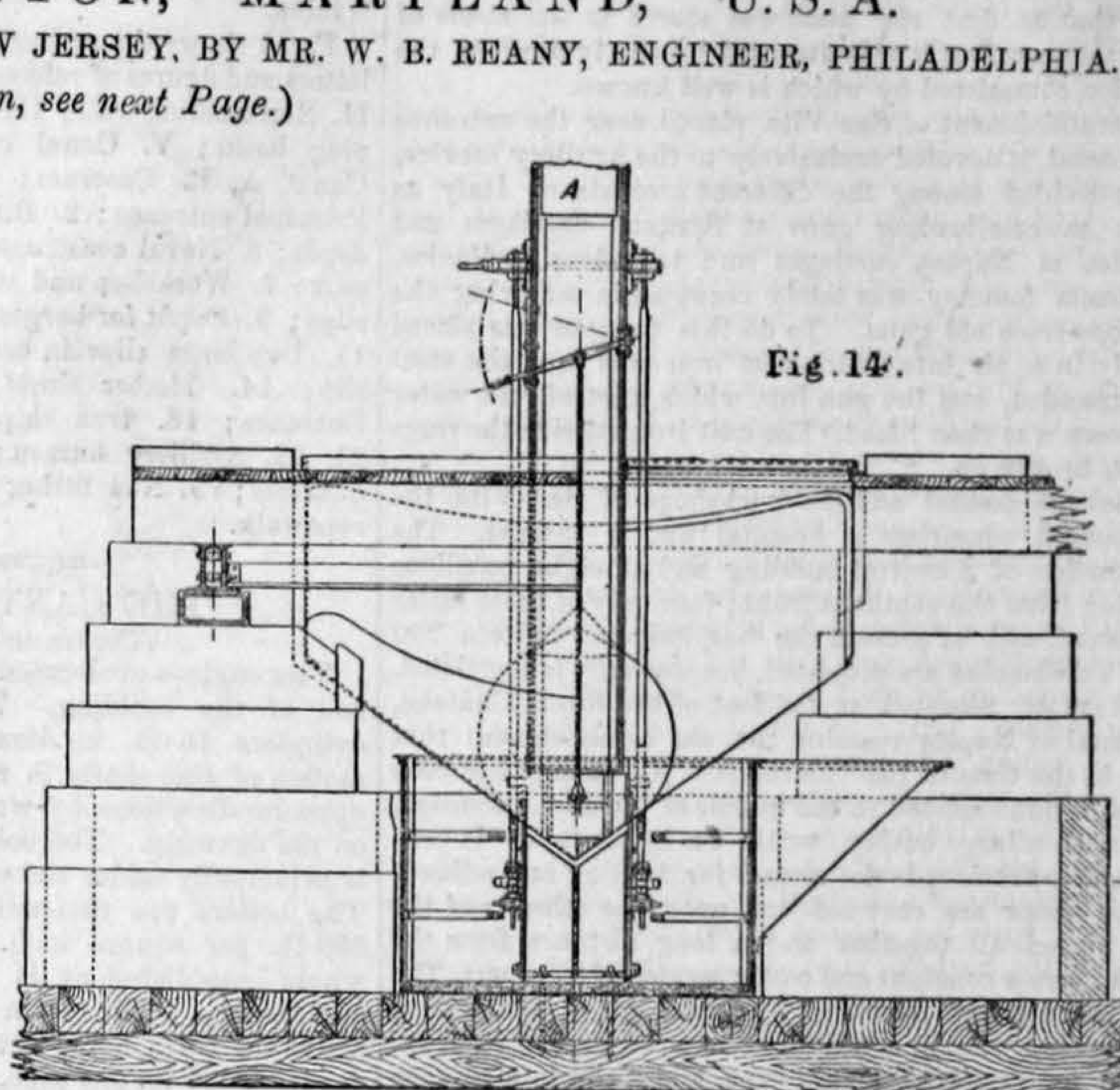


Fig. 13.

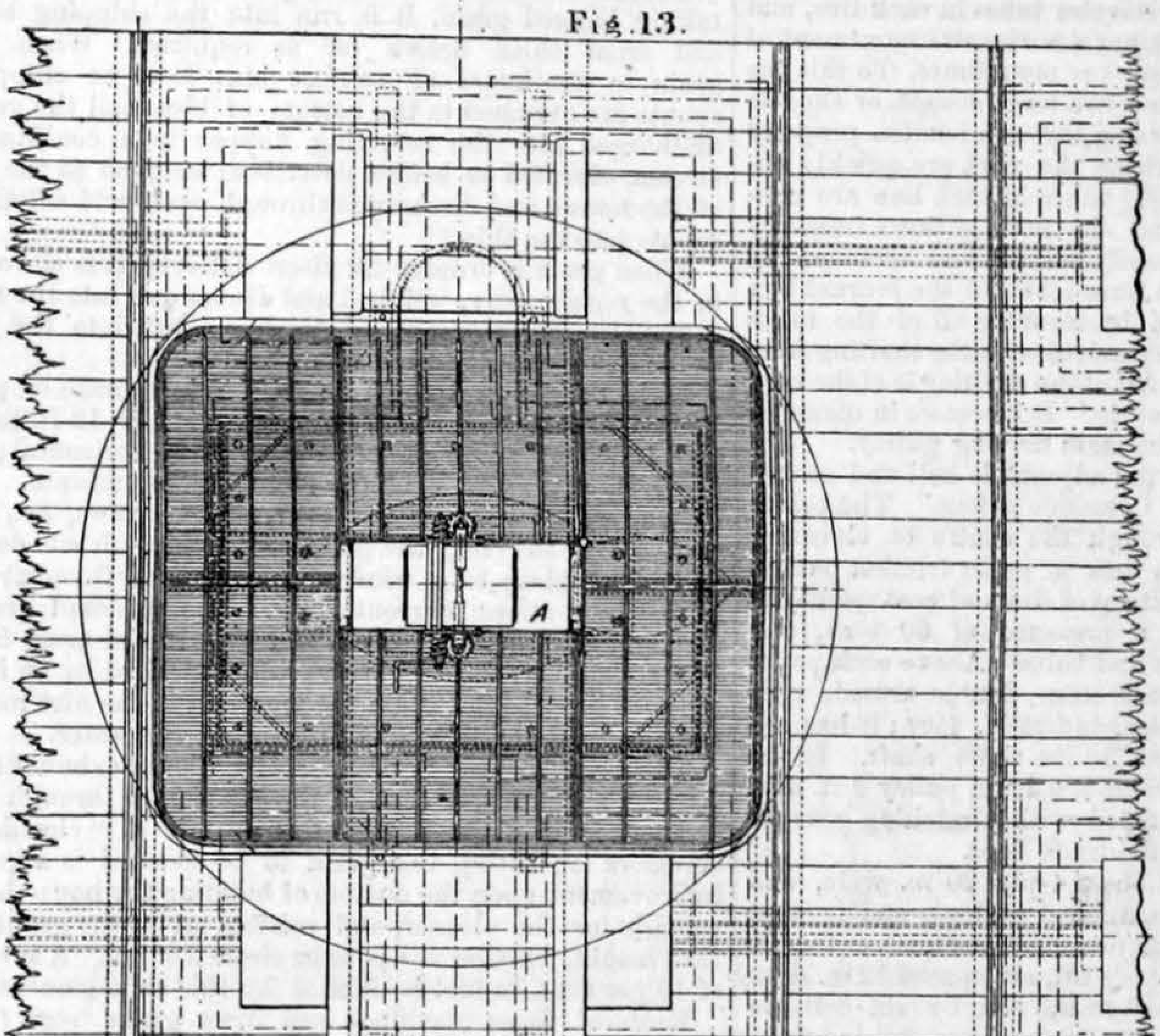


Fig. 15.

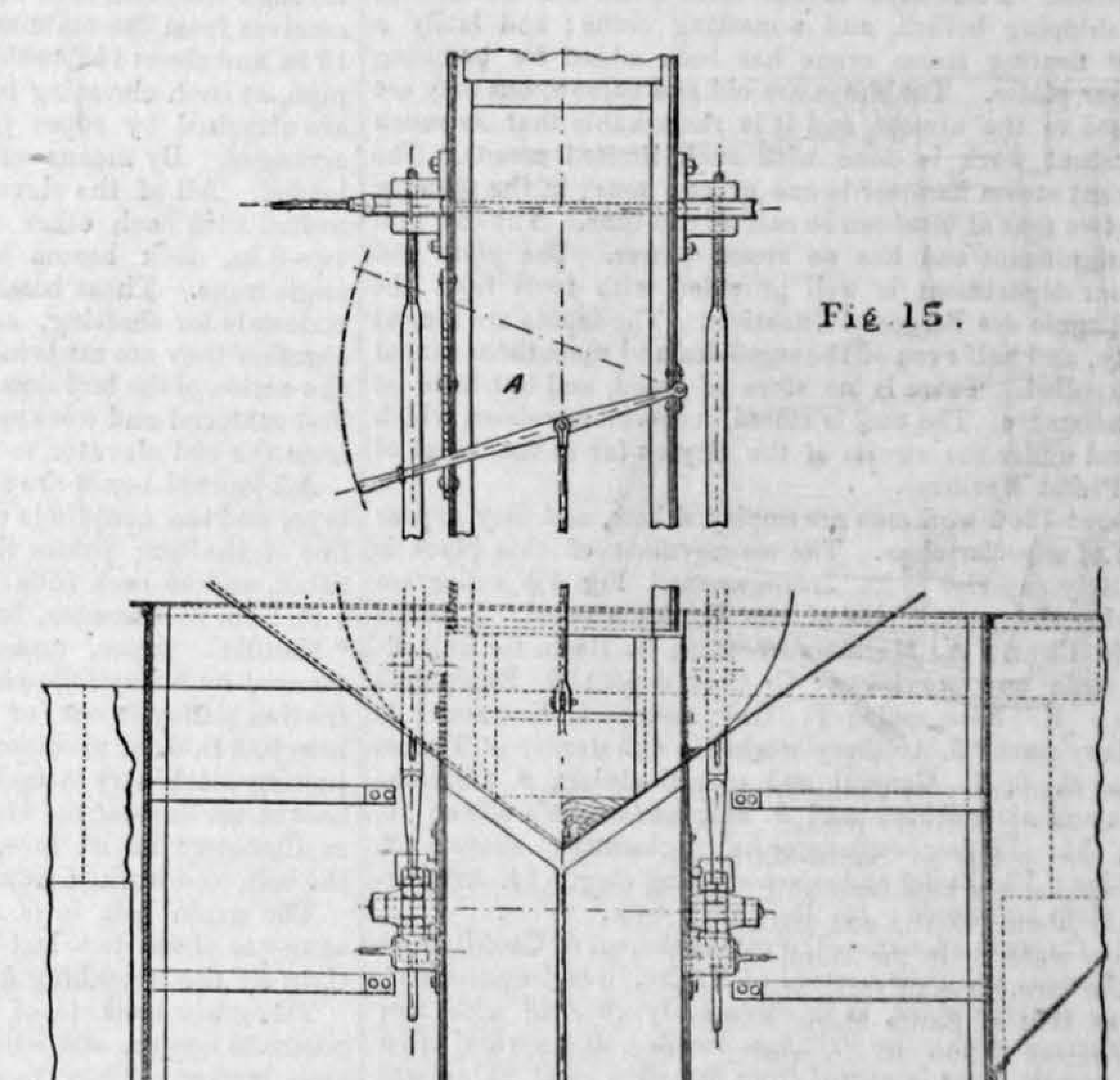
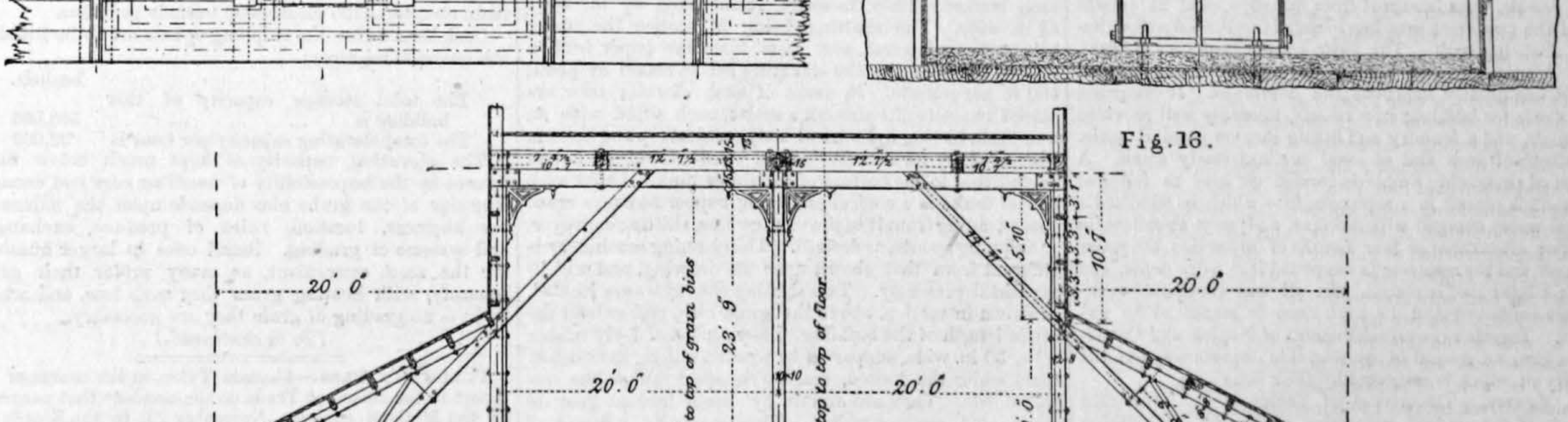


Fig. 16.



structed near the building slip for the construction of iron ships are worth mentioning for their extreme simplicity and cheapness. It was necessary to place the steam hammers in separate buildings, on account of the nature of the ground; the vibration would have endangered the walls, and special care must have been taken in making the foundation had the hammers not been isolated. These hammers are very small, the largest being only 3 tons.

The depôts are very badly supplied. There exist as in France a general and special depôt, but these are not divided into sections and placed near the different shops. The unwrought material department and the ships' stores depôts are situated a long distance from the points where they are required. The timber stores scarcely exist. The ponds at San-Vito first prepared for them have been connected with the sea, and are used for artillery purposes. It appears that at first the wood was stored in the sheds of San-Bartolomeo, but it was attacked by the lymexilon, the destruction committed by which is well known.

The establishment of San-Vito, placed near the entrance to the arsenal, is devoted exclusively to the artillery service, which is divided among the different arsenals of Italy as follows: muzzle-loading guns at Spezzia, carriages and projectiles at Naples, carriages and torpedoes at Venice. The Spezzia foundry was lately occupied in removing the steel hoops from old guns. To do this the gun was placed vertically in a pit into which cast iron was run, the steel rings expanded, and the gun into which a jet of cold water was thrown was then lifted. The cast iron outside the rings was then broken up.

Besides the arsenal and the workshops of San-Vito, the establishment comprises a hospital and a caserne. The latter consists of a central building and of eight pavilions projecting from the southern front; four only of these latter are finished, and at present the hospital can contain 250 beds. Two casernes are projected, but one only is completed.

II. Naples. Situated at the foot of the Royal Château, the arsenal of Naples remains the old establishment that existed in the time of the Bourbons. No change has been made in it, and enclosed in the middle of the city, extension, except with a large outlay, would be impossible. It contains neither tramroads nor cranes for loading and unloading; the shops are crowded one upon the other, and the stores, placed all together and a long distance from the shops, involve a constant and costly service of transport. The basins, too, are very narrow. The resources of the arsenal as a repairing station are limited to a basin 230 ft. long, arranged for vessels of an old type, and a slip in a ruinous condition. There is a 40-ton fixed crane for unshipping and shipping boilers, and a masting crane; and lately a small floating steam crane has been added for handling armour plates. The shops are old and narrow, but they are utilised to the utmost, and it is remarkable that so much important work is done with such limited means. The heaviest steam hammer is one of two tons; in the foundry only two tons at most can be cast at one time. The saw mill is insignificant and has no steam power. The plate and armour department is well provided with tools from the Compagnie des Forges et Chantiers. The depôts are almost empty, and half even of the small demand upon them cannot be supplied. There is no store of wood, and but little at Castellamare. The coal is stored in enormous cellars, which extend under the streets of the city as far as the hotel of the Préfet Maritime.

About 1200 workmen are employed here, and they appear to be of superior class. The management of this place is infinitely superior to its arrangement. Fig. 3 is a diagram showing the general plan of the Naples arsenal. I. is the Palais Royal; A. Mariners' caserne; B. Basin for unloading coals and provisions; C. Coal depôt; D. Equipment basin; E. New mole; F. Old mole; 1. Entrance; 2. Artillery park; 3. Artillery workshop and stores; 4. Timber stores; 5, 6, 7. General and special stores; 8. Commissariat and arsenal bureaux; 9. Harbourmaster's office; 10. Slip; 11. Fitting, coppersmiths', locksmiths' shops; 12. Foundry; 13. Boiler and wood-working shop; 14. Armour-plate shop and depôt; 15. Repairing dock.

III. Castellamare.—The establishment of Castellamare is dependent upon the arsenal of Naples. Besides possessing a large cordage plant, it is exclusively charged with new construction work; the Principe-Amedeo, and several other large vessels, were launched from its slips, and at present one of the two great mastless ironclads and two wooden gunboats are being built. This little arsenal is of very old date, but under the direction of Sané during the French occupation, it was greatly improved and developed. It comprises large sheds for building iron vessels, tolerably well provided with tools, and a foundry and fitting shop on a small scale. The stocks of iron and of wood are extremely small. A process of preserving timber is carried on here as follows: The wood is placed in a reservoir, into which is admitted a mineral water charged with sulphur, and very abundant in the city; after three or four months of immersion, the water is run off, and the reservoir is converted into a dry depôt, and over it a light roof is placed. In all one thousand workmen are employed, and the work done is stated to be excellent. Together the establishments of Naples and Castellamare form an arsenal of considerable importance, but the capacity of which is restricted by their situation.

IV. Venice.—The arsenal of Venice is an interesting example of the gradual conversion of an old shipbuilding establishment into one adapted to present requirements. Workshops, slips, and basins are all fitted for modern vessels, but great enlargements will be necessary to enable vessels to go in and out; new canals will have to be made, and the entrances of the ports and lagunes must be enlarged, the depth of the latter being less than 20 ft.

It is proposed to spend eight to ten millions of francs on the arsenal of Venice, and the principal works projected or in course of construction are two large slips, one 360 ft. and the other 260 ft. long; and the forming of two basins similar to those at Spezzia. The small islets in the middle of the basins will also be removed in order to facilitate the movements of vessels, and to give greater room. Pending these extensive alterations, one of the slips has been extended for a high-speed wooden corvette. Work is not very active at this place, although about 1000 men are employed, and the number of ships which enter is of course limited owing to the want of depth of water at the entrances.

Fig. 4 shows the arrangement of the Venice arsenal. The letters and figures of reference are as follows: I. I. Lagunes; II. Surrounding wall; III. Construction basin; IV. Equipping basin; V. Canal communicating with the Grand Canal. A, B. Casernes; C. New basins; D. Mole. 1. Principal entrance; 2. Bureaux; 3. Museum; 4. General depôt; 5. Naval constructor's office; 6. Office of director of port; 7. Workshop and stores; 8, 12, 17, 19. Old building slips; 9. Depôt for barges and lighters; 10. Masting slip; 11. Two large slips in course of construction; 13. Small slip; 14. Timber sheds; 15. Masting machines; 16. Entrance; 18. Iron shipbuilding shed; 20, 27. Stores; 21, 22. Artillery bureau; 23. Torpedo stores; 24. Salles d'Armes; 25. New fitting shop; 26. New forges; 28. Old ropewalk.

THE CANTON ELEVATOR.

(Continued from page 486.)

The engines are located above the grain bins at the land end of the building. They are horizontal, with two cylinders 16 in. in diameter and 24 in. stroke. The motion of line shafts is reversed by being made to go in opposite directions by wood and iron gearing, as shown on the drawing. The boiler-house, of iron and masonry, is principally under the pier, about 60 ft. from elevator. The boilers are unusually heavy and are worked up to 100 lb. per square inch. The water for supplying the whole establishment is furnished by an artesian well 190 ft. deep. The steam shovels are located about 12 ft. above the track floor, but are not shown on the drawings. A piece of 4 in. gas pipe, supported by bearings, extends through the centres of all elevator tubes in each line, and receives from the main engines a horizontal movement of 12 ft. and about 14 double strokes per minute. To this gas pipe, at each elevating tube, two large scoops or shovels are attached by ropes passing through leaders properly arranged. By means of these the cars are quickly unloaded. All of the elevating tubes in each line are connected with each other and the main gallows frame by two 8 in. deck beams heavily braced and stiffened by angle irons. These beams form seats for the journal box pedestals for shafting, and by securing all of the tubes together they are made independent with the shafting from the action of the building. All of the shafting is of the very best material and workmanship. It increases in diameter from the end elevator to the main driving pulley.

All journal boxes are of the adjustable ball and socket type, and the couplings of Cresson's patent. The centre line of shafting passes through the centre of elevating tubes, and at each tube it has a paper friction pulley, 1 ft. 6 in. in diameter, built up of discs of best quality of "Manilla" paper, under a pressure of 60 tons, and secured by heavy followers and bolts. Above each paper friction pulley is one of cast iron, double armed, very heavy, 3 ft. 9 in. in diameter, and 22 in. face; it has adjusting machinery attached to its short shaft. In the boot at the base of the elevator is a drum pulley 2 ft. 6 in. in diameter, 22 in. face, fitted with stretching gear for the belt, and worked from the track floor.

The grain belt is of rubber, 4-ply 20 in. wide, and connects these two last-mentioned pulleys, and is kept tight by the stretching gear just mentioned.

The grain buckets, of heavy tin, are spaced 12 in. from centre to centre, and secured to the belt by six bolts in each bucket. They measure 18 in. long, 5½ in. deep, 6½ in. wide. The shafting being in motion the upper belt pulley is lowered, and rests upon the paper friction pulley, thus causing the elevating belt to travel at about 450 ft. per minute. In front of each elevator tube are placed two sets of Fairbank's scales, each fitted with an iron tank, having cylindrical body, conical top and bottom, with capacity for 540 bushels of wheat, shoot spout and valve fitted to the bottom of weighing tank. Under each pair of tanks is a conical collecting hopper having a crane spout leading from it to the storage bins, shifting conveyor, or shipping spouts, as desired. The cleaning machinery is different from that shown upon the drawing, and will be explained presently. Two shifting conveyors are located, as shown in section, above the grain bins, and extend the whole length of the building. They consist of 4-ply rubber belts, 30 in. wide, supported by wooden rollers, spaced 5 ft. apart under the loaded, and 10 ft. apart under the unloaded belt. They are driven by bevel friction gear of paper, and are reversible. They move at a speed of 550 ft. per minute, and are arranged to throw off the grain wherever desired. The belt is perfectly flat, has no raised edges, and does not spill any grain when working under a capacity of 9000 bushels per hour. The arrangement of crane spouts is fully explained by the drawings.

The working of each line of elevators is as follows: Four cars of grain having been passed by the inspector are pushed in upon one track, until stopped by the bumper at the end, which will leave the doors nearly opposite the elevators. The car doors having been opened, two attendants enter each car with the wooden shovels (before mentioned in describing the steam shovels) with which they quickly discharge the grain into the receiving hopper. The ropes which work the scoops are attached so as to work alternately, this causing a continuous flow of grain through the door of the car, so long as any remains or the gas-pipe plunger is kept in motion. At the beginning of this operation the grain valve in the boot should be opened, so as to allow the grain to flow from the receiving hopper into the ascending belt buckets (all of the machinery being in operation) just fast enough to fill them.

The grain is discharged from the head of the elevator into one of the weighing tanks where the whole car load is collected, weighed, and distributed. While this operation is in progress four cars are pushed in on the other side of the same elevators, and discharged in the same manner, as soon as the valve at elevator head is shifted to the other weighing tank, which is done after all of the first lot is raised. The first line of empty cars is now drawn out and full ones take their places, and this operation is repeated as rapidly as circumstances will allow.

The weighing tank having been filled the grain is weighed and discharged through the valve into the collecting hopper and crane spout, to where it may be required. The crane spout is made of sufficient size to deliver the grain much faster than the elevator can lift, so that one weighing tank may always be ready to receive grain. The crane spout can deliver the grain into each of many storage bins, shipping bins, shipping spouts, or shifting conveyors as may be desired or found necessary. Should all the elevators be working one kind or lot of grain to be stored in one part of the house, the crane spouts which can reach those bins may be used, and the balance of the grain be discharged upon the shifting conveyors, and by them placed in the bins. Similar use is often made of shipping conveyors when working the whole house upon one vessel, or a single elevator upon a large vessel which cannot be moved, the elevator being a long distance from the spout leading to vessel.

Should a vessel be nearly ready for grain or be taking bagged grain, it is run into the shipping bins, and from them drawn off as required. When the grain in the house or storage bins is to be shipped, spouts are attached to the bottom of bins, and the grain discharged into the receiving hopper in a continuous stream, elevated as before described, weighed at the top of the house, and discharged through crane and shipping spouts into the ship.

When grain is ordered for clean delivery it is elevated in the regular way, weighed and discharged into the foot of the cleaning elevator, by which it is lifted to the top of the house and delivered into a feeder.

From the feeder it flows on to a screen made of perforated Russia iron, measuring 8 ft. wide by 12 ft. long, and is set at an angle of 25 deg. from horizontal; it is driven at a speed of 1100 vibrations per minute. As the grain falls upon it the cobs, sticks, straws, &c., are carried over the end; the grain passes through and down an inclined plane to a wind spout 8 ft. by 1 ft., where it is met by a strong current of air. The unsound grain, dirt, and chaff are carried off, and the cleaned grain falls into a chamber, and is carried where desired by an iron pipe. The unsound grain is deposited in the dirt room, and the chaff and light dirt thrown into the water.

The current of air is produced by a large exhaust fan. As only about 10 per cent. of the grain goes through the cleaner, it is claimed that this system of "cleaning" elevators for lifting the grain to be cleaned is a great improvement upon the custom of building the house high enough for the cleaner, and raising all of the grain to that height, whether it has to be cleaned or not. A saving of 10 per cent. in fuel is claimed by this arrangement.

Each of these machines will draw grain from four main elevators, and clean 8000 bushels per hour.

Corn screens for the shipping spouts are to be fitted as the business requires:

	bushels.
The total storage capacity of this building is	500,000
The total elevating capacity per hour is	32,000

The elevating capacity is kept much below these figures by the impossibility of handling cars fast enough. The size of the grain bins depends upon the nature of the business, location, rules of produce, exchanges, and systems of grading. Small ones in larger numbers are the most convenient, as many prefer their grain separate, with heating grain they save loss, and where there is no grading of grain they are necessary.

(To be continued.)

Pullman's Cars.—Captain Tyler, in the course of his report to the Board of Trade on the accident that occurred on the Midland Railway, November 22, to the Scotch express from London, near the Sheffield station, alluding to the Pullman car, remarks: "The engine driver and fireman plainly felt the rails and chairs giving way under the engine; and it was the damage thus occasioned to the permanent way during the passage of the engine, tender, and leading vehicles, which caused the gauge between the rails to be widened out or spread sufficiently to admit of the near wheels of the leading truck of the Pullman car 'Australia' dropping inside the near rails. The weight on the six wheels of the engine having been 38 tons 8 cwt. 3 qrs., spread over a wheel base of 16 ft. 6 in., and the weight on the eight wheels of the Pullman car having been 21 tons 9 cwt. 1 qr., spread over a much longer wheel base, it is obvious that the strains produced on the permanent way by the engine greatly exceeded those produced by the Pullman car. On the other hand, the employment of vehicles of this description tends materially, in proportion to their strength, to diminish the danger, when accidents occur, to passengers riding in them."

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ENGINEERING.

FRIDAY, DECEMBER 22, 1876.

TESTING STEAM ENGINES.

We have frequently had occasion to refer in this journal to a system of testing steam engines devised by Mr. B. W. Farey and Mr. B. Donkin, Jun., and to commend it as one which, from the trustworthy nature of the information it affords, is worthy of general adoption. The system, as our readers well know, consists in ascertaining the quantity of water discharged from the condenser, by allowing this water to flow over a tumbling bay, noting at the same time the rise of temperature which the water has undergone in the condenser, and calculating from these data the quantity of heat thrown away per minute by the engine under trial. This quantity divided by the indicated power developed gives a certain figure of merit or "constant" by which the performance of the engine may be judged; the lower this constant the smaller the quantity of heat thrown away, and the more economical, therefore, the engine. We may say here that we did not commend this mode of testing engines to our readers until we had carefully examined into its merits. Through the courtesy of Messrs. B. Donkin and Co. we had the opportunity afforded us of doing this very fully, and at their works we were enabled not only to see the system in operation, but to examine into the arrangements which Mr. Farey and Mr. B. Donkin, Jun., have employed to ascertain and verify the coefficient used by them to calculate the discharge over the tumbling bays. Moreover, we have since been present at experiments made to test this coefficient (a description of one of these experiments appeared on page 204 of our last volume), while we have ourselves had practical experience in the carrying out of engine trials on Messrs. Farey and Donkin's system, the results of our investigations and experience being to fully convince us of the trustworthiness of that system and its general convenience. It is under these circumstances that we have urged the advisability of its employment, and this being so it is impossible for us to pass without notice two leading articles which have lately appeared in our contemporary *The Engineer*, and in which the system is condemned as practically worthless.

The two articles in question, which appeared in the numbers of our contemporary for the 24th ult. and 8th inst. respectively, are both entitled "Testing Steam Engines," and in the first of them, the writer, after admitting that the Farey and Donkin system of testing can be readily employed if the proper appliances are once fitted up, goes on to say: "Its defects are that it debits the engine with much "of the heat carried over in the priming water; that "it takes no account of the quality of the steam "used; that it requires highly trained experimenters "to estimate the quantity of water passing over the "measuring notch; and that when every precaution "has been used, an error amounting to as much as "one-seventh of the whole weight of the condensing "water may creep in—which means that an engine "may be said to be using 26 lb. of steam per horse "power, when it is really using but 22.3 lb." Now these are grave charges, and some of them, even if they could be but partially substantiated, would render the system of testing we have advocated quite unworthy of adoption. We think, however, that we can clearly show that these charges arise from an ignorance of the real facts of the case, and that they are quite untenable. We propose to deal with them in the order in which they are stated by our contemporary.

First, then, as to the allegation that the system "debits the engine with much of the heat carried "over in the priming water." In proof of this assertion the writer in our contemporary gives a calculation referring to an engine expanding steam to a final pressure of 10 lb. absolute, and using 570 lb. of condensing water per horse power per hour, this water being raised in temperature from 60 deg. to 100 deg. The quantity of condensing water here stated appears from the context to be that injected into—and not that discharged from—the condenser, this latter quantity being of course augmented by the quantity of steam condensed. First assuming that the steam used is dry, the writer in our contemporary makes his calculations as follows: "Then each pound of this "steam exhausted into the condenser will carry with "it 1320 thermal units, all which it would resign on "being converted into ice. If we assume the tempe"rature of the water in the hot well to be 100 deg., "then the steam cannot give up the 180 deg. which "are required to keep it, after condensation, in the "condition of water, and we have available 1140 "units only. If the water entered the condenser "at 60 deg. and left it at 100 deg., then each pound "would absorb forty thermal units in the act of "condensing the steam, and, dividing 1140 deg. by "40 deg., we have 28.5 lb. as the weight of con"densing water raised from 60 deg. to 100 deg. by "each pound of steam passed through the engine. "If, now, we find by measurement that 570 lb. of "condensing water are required per horse per hour, "we then know that the engine is using 20 lb. of "steam in the same period."

Here we have a nice collection of blunders to commence with. We fancy that the assertion that each pound of steam at 10 lb. pressure (absolute) will carry into the condenser 1320 thermal units, "all of which it would resign on being converted into ice," will puzzle many of our readers, as it certainly puzzled us when we first read it. The total heat of steam at 10 lb pressure, measured from the Fahrenheit zero is 1172.89 deg., and a pound of it, if reduced to water at a temperature of 32 deg., would thus give up $1172.85-32=1140.89$ thermal units. But the generally accepted value for the latent heat of fusion of ice is 142 deg., and thus to convert the pound of steam at 10 lb. pressure into ice, there would have to be abstracted $1140.89+142=1282.89$ thermal units, and not 1320 as our contemporary asserts. But as a matter of fact the quantity of heat which the steam would give up if converted into ice has nothing whatever to do with the question at issue. The only fact with which we have to deal is that each pound of the steam at 10 lb. pressure would in being condensed into water at a temperature of 100 deg. give up $1172.89-100=1072.89$, or, say, 1073 thermal units, and not 1140 units as *The Engineer* has mysteriously calculated. We here find that this stickler after minute accuracy has made an error of about 6 per cent. to commence with. Of course this affects his subsequent figures, and the 570 lb. of condensing water instead of condensing 20 lb. of steam as he calculates will, under the conditions named, really condense $\frac{570\times 40}{1073}=21.25$ lb. The quantity of steam condensed to supply the heat converted into work is assumed by the writer in our contemporary to be from 2 lb. to $2\frac{1}{2}$ lb. and he thus makes the total steam used to be from 22 lb. to $22\frac{1}{2}$ lb. per indicated horse power per hour. Calculating from his own data we have shown this to be $1\frac{1}{4}$ lb. too low, the quantity being $23\frac{1}{4}$ lb. or $23\frac{3}{4}$ lb. according to whether 2 lb. or $2\frac{1}{2}$ lb. be allowed for the conversion of heat into work.

The writer in *The Engineer* next takes the case in which steam used by the engine is mixed with a certain quantity of priming water, and he makes his calculations as follows: "Let us suppose as before "that the terminal pressure is 10 lb. absolute. The "temperature corresponding to this is 194 deg.; "consequently, each pound of priming water can "abandon 94 deg., or, in other words, it will raise "2.35 lb. of condensing water from 60 deg. to 100 "deg. Referring to the case previously stated, let "us assume that 2 lb. of priming water per horse "per hour pass through the cylinder. The quanity "of condensing water required will then be, not "570 lb. per horse per hour, but 574.7 lb.; and the "apparent consumption of steam by the engine will "be, not 20 lb., but $20\frac{1}{6}$ lb. nearly. It may be said "that such an error as this is inappreciable; but "small errors acquire great importance when they "appear under a system of experimenting which "professedly gives results perfectly accurate." Here we have more blunders, and very stupid ones. Passing over the minor error of giving the temperature of 10 lb. steam as 194 deg. instead of 193.3 deg. we have the fact that the use of 574.7 lb. of condensing water under the conditions assumed might lead to the consumption of steam being calculated as $\frac{574.7\times 40}{1073}=21.424$, and not $20\frac{1}{6}$ lb. as stated. Now the error here introduced by the large amount of priming assumed amounts, even on *The Engineer's* showing, to but about four-fifths of 1 per cent., but in reality it is even much less than this. We see from *The Engineer's* calculations that 2 lb. of priming water are debited to the engine as the equivalent of $\frac{1}{6}$ lb. of steam, each pound of priming water having thus a value given to it equal to one-twelfth of its weight of steam. But if we suppose the initial pressure in the cylinder to be 75 lb. absolute, the temperature of this priming water on being received from the boiler would be 307.5 deg., and in being reduced to 193.3 deg., each pound must, therefore, have given up 114.2 thermal units. This heat would probably be in a great part devoted to the evaporation of a portion of the priming water, and its action would be such that by the time the final pressure was reached 0.117 lb. of water would be so evaporated. We have thus placed at the disposal of the engine rather more than $\frac{1}{9}$ lb. of water evaporated during the period of expansion instead of $\frac{1}{12}$ lb. at the initial pressure which was debited to the engine according to *The Engineer's* calculations, the error here introduced being but a very small fraction of 1 per cent. We are quite ready to admit that in an engine working with a less degree of expansion the effect of priming would be less closely compensated for, but in any case, so long as the amount of priming did not exceed that ordinarily met with in practice, the error introduced by it would be exceedingly minute, far smaller indeed than that which is introduced by the action of the indicator.

The next charge is that the system "takes no "account of the quality of the steam used." This has already been disproved by what we have already said concerning priming, the fact being that when priming occurs this is allowed for very approximately so long as the engine is working with a fair degree of expansion, while if the expansion is small the error introduced is still unimportant. We may add that in the case of a trial carried out to prove whether an engine was fulfilling a guarantee, no one who knew his business would allow steam which contained 10 per cent. of priming water to pass into the engine. Where so large a proportion of priming exists it is easily discovered and can to a great extent be got rid of by suitable arrangements.

But while speaking on this point let us see what our contemporary sets forth as the proper way of proceeding to secure accurate information regard ing the quality of the steam. On this point, in *The Engineer* of the 24th ult., the writer says:

"It is expedient, therefore, in all cases to determine precisely how much water is contained in the steam by tapping the main steam pipe close to the engine and providing a hose, through which given weights of steam can be delivered into a tub of cold water supported on a platform weighing machine. As we have already supplied full details of the method of working on this system in our impression for May 12th, 1876, we need not enter here into further explanations. Suffice it to say that in this way it is possible to determine in the most satisfactory manner, and with the greatest precision, the weights of steam and water used by any engine in developing one indicated horse-power. All the arrangements are exceedingly simple and easily carried out; they involve no complex calculations, and appear to meet every requirement."

Further, in the number of the 8th inst., he adds that the mode of estimating priming above referred to "has been known and used in the United States for some time; but we believe that it was never tried in this country until last May, when we used it in testing at Birmingham the performance of a Roots boiler." Now we cannot but regard it as singular that a writer who presumes to so confidentally condemn Messrs. Farey and Donkin's system of testing on the score that it is "too complex and difficult of application to be universally serviceable" and because "it requires highly-trained experimenters" to carry it out, should almost at the same time so strongly recommend the mode of estimating priming water above referred to. The only explanation we can imagine is that he is utterly ignorant of the delicacy of the mode of operating he so commends. Judging from the last quotation we have given he appears to believe that this mode of estimating priming water is of American origin and that the merit of introducing it here is due to himself, whereas it was well known in this country very many years ago, and it is in fact upwards of eight years since we published the result of a boiler trial carried out here in which this mode of estimating the priming was adopted. That it has not been extensively used is due to the fact that without extreme care and the provision of special apparatus it is impossible to obtain anything like accurate results. We do not know with whom this mode of testing the quality of steam originated, but the credit of having developed its practical application undoubtedly belongs to M. Hirn, who has devised special apparatus which enables it to be applied with tolerable ease.

We have had the curiosity to refer to *The Engineer* of May 12th last, to see the way in which the writer in our contemporary himself carries out the estimation of priming water, and we have been greatly amused with the result. We there find that this precise individual who objects to a system which *may* give an error of a fraction of one per cent. in the results of an engine trial, proceeded as follows: A bucket containing 30 lb. of water was placed on the platform of a weighing machine and steam was discharged into the water through an india-rubber hose until, by the condensation of this steam, the weight of the contents of the bucket had been increased 2 lb. The flow of steam was then stopped, and from the rise in temperature which the water had undergone the quantity of priming water in the steam was calculated.* An example is given in which, by blowing in 2 lb. of steam at 71 lb. pressure (absolute), the temperature of the water in the bucket was raised from 58 deg. to 128 deg., and from this it is calculated that of the 2 lb. of steam blown in 1.93 lb. were dry steam and 0.07 lb. water, or, in other words, that there was priming to the extent of 3½ per cent. Now very little investigation is required to show that an error of but 1 deg. in the determination of the final temperature of the heated water would have modified this deduction fully 60 per cent., and yet we find that no allowance was made for the heating of the bucket as well as the water, nor for the loss of heat by radiation, &c., during the time the steam was blown in! Under the circumstances it would be folly to suppose that the estimation of the priming water was within 50 per cent. of being correct. We may also point out that an error of half an ounce in the determination of the weight of the steam blown in —or less than one-thousandth of the weight of the bucket and its contents—would modify the results by more than 60 per cent., and yet the weighing was performed on a platform weighing machine! How in the face of these facts the writer in *The Engineer* can inform his readers "that in this way it is possible to determine in the most satisfactory manner, and with the greatest precision, the weights of steam and water," we utterly fail to understand.

To return, however, to our contemporary's objections to Messrs. Farey and Donkin's system of testing. The next charge which he makes against it is "that it requires highly-trained experimenters to estimate the quantity of water passing over the measuring notch." Now we do not know the precise value which the writer in our contemporary attaches to the word "highly," but if he means that for gauging the discharge of water over a tumbling bay there is required a higher degree of skill and intelligence than is required for carrying out the other details of an engine trial, he is simply utterly wrong. We may repeat here what we have frequently stated, namely, that it is not every engineer who is qualified to carry out an engine trial properly. To conduct such a trial with accuracy and success requires certain habits of exactitude and careful observation combined with experience in similar work. Without such experience hitches are almost sure to arise, while points of importance are apt to escape notice. We have no faith in trials made under inexperienced guidance, and we know of many instances where the publication of the results of such trials has done much harm by leading to the formation of erroneous theories. As regards the view taken by our contemporary, we have no wish to deny that in the hands of a man who would attempt to determine the quality of steam by blowing it into a bucket of water placed on the platform of a weighing machine, Messrs. Farey and Donkin's system of testing might prove an utter failure, but given the skill and experience which we hold necessary to the proper carrying out of *all* experiments on steam machinery, the system presents no difficulties, while it affords results of the most trustworthy character.

We now come to the final—and in some respects most sweeping—objection, namely, "that when every precaution has been used, an error amounting to as much as one-seventh of the condensing water may creep in—which means that an engine may be said to be using 26 lb. of steam per hour, when it was really using but 22.3 lb." Now this statement and the deduction from it are both, to say the least of it, singular; for the writer not only assumes that the coefficient proper to a certain set of conditions may vary by one-seventh, but also that if this was the case the highest value would at once be assumed in making any calculation about an engine trial. Most engineers we apprehend, if supplied with coefficients varying by one-seventh for a particular discharge, and without information to guide them as to which was the most trustworthy, would take the mean value, and the possible error would thus be reduced to one-fourteenth instead of *The Engineer's* one-seventh. In reality, however, there is no such range of coefficients as the writer in our contemporary supposes, the laws which govern the discharge of water from a notch being, of course, as rigidly fixed as any other natural laws, and it only being necessary to determine by accurate experiment what these laws are. The remarks of the writer in our contemporary on this subject are of a very singular kind, and after reading them we are irresistibly led to the conclusion that notwithstanding he presumes to condemn Messrs. Farey and Donkin's system so strongly, he is either very ignorant of the subject of which he writes, or else that in dealing with it he is grossly careless as to the nature of the facts before him. Regarding coefficients he says: "We have the broad fact that no two authorities agree as to the coefficient of discharge. For example, if we turn to Neville's tables, we find that for notches 1 ft. in length, and for depths of 0.25 in. to 10 in., the coefficients vary between 0.606 and 0.518; that is to say, a notch 12 in. wide with a head of 1 in., may deliver the following quantities of water in cubic feet per minute: 4.68, 4.595, 4.510, 4.340, 4.170, or 4.00. It is thus possible that on even so small a scale as this an estimate of the quantity of condensing water used per hour may be wrong, by as much as 40 cubic feet, or, say, 2500 lb. per hour out of a possible 17,500 lb. That is to say, an error of nearly one-seventh may creep in. The coefficients given above are, however, by no means the only ones in use. Thus, Brindley and Smeaton give .657, Du Buat .627, and Simpson and Blackwell, .756, for notches having a length ten times the depth."

Now if the writer in *The Engineer* had taken the trouble to make himself acquainted with the character of the experiments from which the coefficients above quoted were derived, he would have found that many of them were totally inapplicable to the tumbling bays used by Messrs. Farey and Donkin. Some were made with overflows the full width of the channels of supply, some with heads of water forming but a very small fraction of the width of overflow, and some under circumstances which would justify us in accepting the results with much hesitation; but the writer in our contemporary takes no cognisance of these facts, but bundles the whole of the coefficients together as if they were all applicable to each and every case, and then exclaims that because of the divergence he points out, this system of measuring water must be untrustworthy. These, however, are not his only misconceptions or perversions of the facts of the case, as we shall see presently.

Luckily for those interested in trustworthy information concerning steam engine performance, Messrs. Farey and Donkin approached the subject in a different spirit. When they first desired to use tumbling bays for measuring the discharge from a condenser, they found that comparatively few experiments were on record bearing directly on the proportions of notches which they desired to employ, and that these experiments were not in all cases so consistent amongst themselves as to warrant reliance being placed upon them. Under these circumstances they wisely resolved to investigate the subject thoroughly for themselves, and they fitted up measuring tanks and other appliances which enabled them to carry out the necessary experiments with great accuracy. Their researches, carried on at intervals during a number of years, are probably the most extensive and trustworthy of the kind ever carried out, and they embraced investigations not only of the discharge through rectangular notches, but also through rectangular and circular orifices, &c. As a result of their investigations they came finally to the conclusion that for the purpose they had in view the measurement of the discharge by means of a tumbling bay with a rectangular notch was that which possessed the greatest advantages. More than this they found that with the measuring boxes made as they now use them—that is with the notch about one-fourth the width of the box or less—the coefficient of discharge was 0.62, and remained constant at that value for all variations of depth which it was necessary to use in practice. Our space will not permit us to enter here into an account of the leading experiments which have from time to time been made on the discharge from rectangular notches, or we could show that the coefficient just given is one which is verified by the researches of D'Aubuisson, Castel, Francis, and others.

The labours of Messrs. Farey and Donkin, however, did not end with the determination of the proper coefficient to be employed; they were desirous of so simplifying the measurement of the head of water over the notch, that this measurement could be made by any one exercising proper care. In their earlier experiments they employed for this purpose the well-known hook gauge, an appliance which gives very accurate results, but which requires some practice to use it properly. Then they devised various arrangements of point gauges, but ultimately they found that on the whole nothing was more satisfactory than a properly arranged float, having an index point moving against a proper scale. Of the construction and arrangement of this float, of the mode of adjusting the scale, and of the precautions to be observed in using it, we gave full particulars on page 98 of our nineteenth volume.

To return, however, to *The Engineer's* statements. In his article of the 8th inst. we find the writer in our contemporary saying: "The notch is usually made in a thin copper plate, and is precisely 12 in. long, the head over the notch being measured with a delicate float. Now, any one who has experience in measuring the delivery of water knows that not one man in fifty can make observations with the requisite accuracy; and when we add that the precise position of the float with regard to the notch-board must be fixed to a hair's breadth, we have said enough, we think, to justify our assertion that it is only in the hands of a highly-trained experimenter that anything like accurate results can be obtained. . . . It remains with

* Our readers will find some particulars of this mode of testing, with the formula to be employed, on page 21 of our last volume.

"Mr. Farey to explain how he has succeeded "in obtaining minute accuracy in his gauging "operations, how he fixes the position of the float "so that it shall measure the head of water "precisely over the notch-board, and not a minute "fraction of an inch too much to the front or too "far to the back, errors which would materially "alter the apparent depth of the overflow; and, "lastly, what and whose coefficient of discharge he "uses." Here we have some extraordinary misconceptions or perversions of facts. In the first place Messrs. Farey and Donkin have never, so far as we are aware, used a notch 12 in. wide at all. No doubt they would use such a notch if the circumstances of the case required it; but as a fact the widest notch used in any of their experiments which have been made public is 6 in. Again, the statement that the notch used is always one width is also incorrect, as the writer in our contemporary would certainly have known had he taken the trouble to acquaint himself with the working of the system he criticises. Generally Messrs. Farey and Donkin use such a width of notch that the depth of the discharge over it is not less than half the width, and by preference they work with a discharge deeper rather than shallower than this, as with the deep discharge any error in the measurement of the head is proportionately of less importance. Again, the statement made by the writer in our contemporary that: "the precise position of the float with regard to "the notch-board must be fixed to a hair's-breadth," is simple nonsense. As a matter of fact the position of the float may be varied within wide limits, all that is necessary being that it is sufficiently far back from the notch to be unaffected by the fall in the surface of the water as it approaches the overflow. In a measuring box with a 6 in. notch there would be an area of fully three square feet in any part of which the float could be placed. What, too, are we to think of the statement in our contemporary, that the position of the float has to be fixed "so that it shall measure the "head of water precisely over the notch board, and "not a fraction of an inch too much to the front or "too far to the back, errors which would materially "alter the apparent depth of the overflow"? Are we to suppose that the writer is so thoroughly ignorant of the subject that he imagines the float is placed over the notch instead of in the still water behind it? We find it difficult to believe this, yet what other construction can be placed upon his words? We should have thought that the most elementary knowledge of hydraulics would have made him aquainted with the fact, that in gauging the discharge of water over weirs or notches the depth at the point of overflow is not measured at all, the "head" causing the discharge being that due to the height of the still water above the edge over which the overflow takes place.

Lastly, the writer in our contemporary appears to imagine that a very minute mistake in the measurement of the head over the notch involves an important error in the results. Here he is again wrong. In the case of a 6 in. notch working with a 4 in. head an error of even $\frac{1}{16}$ in. in the measurement of that head—and it must be a very careless observer who would make such an error as this—would cause a difference in the final result of less than $2\frac{1}{2}$ per cent., whereas a similar mistake in the measurement of the mean height of an indicator card would on the average induce an error of fully 5 per cent., and in many cases very much more. Inasmuch, therefore, as the head of water flowing over a notch is much more easy to measure than the mean height of an indicator card, our contemporary's objection on this score falls to the ground.

We have now, we think, disposed of our contemporary's objections to Messrs. Farey and Donkin's system of testing, and have shown that those objections have their origin in an insufficient knowledge of the subject. There is the less excuse for this as Messrs. Farey and Donkin have made no secret of their modes of operating, but have in the freest manner given full information to those interested in such investigations, and have placed the results of their labours at the free disposal of all. Before dismissing the subject, however, we desire to say a few words on a branch of the question which our contemporary has thought fit to notice, and this is the calculation of the weight of steam used by an engine from the data afforded by Messrs. Farey and Donkin's mode of testing. We have ourselves on several occasions explained how this may be done, but the writer in our contemporary has chosen to investigate the subject for himself, and in so doing has arrived at some very amusing results, and discovered a mare's nest of very satisfactory proportions. It would, however, be impossible to do full justice to a discovery like this at the end of a long article like the present, and we therefore merely advert to it, leaving it to be dealt with fully on an early occasion.

PATENT SPECIFICATIONS.

As a judge in a patent case, we could wish for no better than the Master of the Rolls. But as a Commissioner of Patents he is not, to our mind, equally successful.

Not only did he, as now appears from his own words, fully sanction the recent change for the worse in the printing of specifications, but despite the incontestible evidence to the contrary, he maintains that it was a change for the better. This is certainly startling. Can it be possible that his lordship was really in earnest when he made the assertion, with actual facts staring him in the face? It was in the course of a trial last week that his lordship alluded to the subject. He complained about some imperfection in a printed specification of the old type, whereupon an eminent Q.C. remarking that, as at present issued, the printed specifications were much worse, appealed to his lordship to use his influence in favour of improvement.

This appeal, so far from being successful, elicited from the Master of the Rolls observations in the sense already mentioned, coupled with a statement to the effect that nothing was done in the Patent Office without his approval, and that the change in the printing of specifications had not been made without careful consideration and the unanimous approval of the leading patent agents, with one exception. The dissentient referred to, it seems, sent in a report against the alteration, but the grounds adduced in support of the objection were not considered sufficient to justify abandonment of the plan then contemplated and since adopted.

It would have been more correct had his lordship said that he received only one adverse report. He was clearly mistaken if he assumed that all the leading patent agents, with one exception, approved of the scheme. The fact appears to be that matters were hurried forward in such a way that the subject was not in reality maturely considered by the whole of the committee of patent agents to whom it was referred.

We do not know whether the favourable report went to his lordship in the name of the committee as a body, or whether it simply professed to emanate from those members who, having attended the hurriedly called meeting and briefly discussed the matter, approved of the plan. If the former course was adopted we can account for his lordship's mistake, but if the approving members submitted their report on their own responsibility, his lordship might readily have ascertained how the matter stood by comparing the signatures to the report with the list of members of the committee. This would at least have saved those who took a sound practical view of the question from the imputation of having committed themselves to a great blunder. That any experienced patent agent was ever found willing to sanction such an objectionable innovation is to us wholly unaccountable.

The Master of the Rolls pointed out that full-size copies of drawings could still be obtained when required. Of course we know tracings may be had. In other words, one can now obtain, after days of delay, for pounds of delay, a poor equivalent for what was previously available at a moment's notice, and at the cost of only shillings or even pence.

And it seems we have not even yet done. Any one who may want a copy of the specification of an expired patent that is out of print, will himself have to pay the entire cost of setting up and printing the new edition.

This opens up a cheerful prospect to the thousands of inventors who may wish to carefully investigate the novelty of their inventions prior to applying for patents. If the Commissioners of Patents desired to encourage to the utmost the repatenting of old inventions, they could not adopt a course more surely calculated to attain their end. What may we expect next?

CONVERSAZIONE OF THE SOCIETY OF TELEGRAPH ENGINEERS.

ALTHOUGH the Society of Telegraph Engineers is but five years old, having been founded in the year 1871 by Major Frank Bolton and Major Webber, R.E., it has taken a position for high scientific character and vigorous work second to no other body in London, and its conversaziones are perhaps the pleasantest and the most interesting to which men of science are invited.

The Society is a connecting link between the Institution of Civil Engineers on the one hand and the Physical Society on the other. Its papers embrace large operations which constructively belong to the domain of the civil engineer, such as the laying of cables, the working of railways, the blasting of rocks, and the improvement of manufactures, while technically they embrace principles of pure physical science depending upon the laws of magnetism and electricity, light, heat, sound, and chemical action. With three societies so intimately connected by the overlapping of their domains it is pleasant to record the cordial co-operation which exists between them, the Institution of Civil Engineers having from the first given to the new Society a home, and so much sympathy exists between the Society of Telegraph Engineers and the Physical Society that the fusion of the two into one has been several times proposed, and has been received with favour.

On Monday evening the President and Council of the Society of Telegraph Engineers entertained the members of the Society and a great number of distinguished visitors at a conversazione which was held in the ball-room at Willis's Rooms, and it is not too much to say that owing to the energy and organisation of the acting secretary, Mr. Sivewright, and to the co-operation of men distinguished in every branch of electrical research, the collection of objects of scientific interest was as good, if not better, than those which have gone be fore, and which have made the soirées of the Society of Telegraph Engineers so proverbially attractive.

The President, Mr. Charles V. Walker, F.R.S., exhibited a most interesting series of specimens and original instruments, illustrative of the rise of the electric telegraph in connexion with the South-Eastern Railway from the year 1844 to the present time. The first of this series was a set of thirty-six insulators for telegraph posts. The first telegraphs had no insulation, but were merely strung through metal eyes screwed into the posts; the next step was to wrap felt round the wire at the point of passing through the ring. This was followed by a ring of wood, through which the wire was threaded, having a groove round its circumference for binding it to the post. The next step was the employment of porcelain, which was the same shape as the last, and consequently had to be threaded from the end of the wire. This was next modified by a portion being cut away from the circumference to the centre, and this may be looked upon as the earliest type of modern insulators which have developed into many hundred forms.

Mr. Walker also exhibited the first piece of wire (No. 8 B.W.G.) covered with gutta-percha, this was in the year 1848, also the first lightning protector for telegraphs, which consists of two small brackets carrying brass balls and fixed upon a stand, so that the balls very nearly touch; each bracket is armed with a set of spikes, the points of which are directed towards, and are in close proximity to, a corresponding set of points upon the other bracket. By this arrangement, which may be taken as the type of many of the modern lightning protectors, the voltaic current has not sufficient tension to leap across the air space between the balls or the points, but has to traverse the coils of the instrument, while a spark of statical electricity leaps the air space and leaves the coils uninjured

In the same series was shown a curious recording instrument known as McCullum's globotype, which records signals passing through it by dropping pellets coloured black, white, or blue, corresponding to its three magnets respectively, into a zigzag groove closed in front by a sheet of glass, so that as the space enclosed between the glass and the groove becomes filled by the pellets running down, a sort of pattern is produced which records the number of signals that have passed through each magnet, and the order in which the magnets have been working. The release of the pellets from their hoppers is effected by a valve similar to that adopted in shot flasks, and which is actuated by the armature of its corresponding magnet.

Mr. Walker also exhibited the first time-signal commutator of 1852, and as a matter of popular historical interest the original time tables of the royal specials, as well as the signalling instruments employed on the occasion of the journey of the

Princess Alexandra from Gravesend to London, on the 7th of March, 1863.

Passing to instruments in use at the present time upon the South-Eastern system, Mr. Walker showed in action a complete set of block-system instruments, including his beautiful "train describers" and double action repeaters, as well as the complete apparatus for electrical communication between passenger and guard and guard and engine-driver.

The Astronomer Royal contributed some interesting specimens of the photographic registers of the movements of the declination and horizontal force magnetometers,* and of the earth-current galvanometers at the Royal Observatory, showing a remarkable correspondence existing between the magnetic and galvanic disturbances. The specimens were chosen so as to represent days upon which "magnetic storms" occurred as well as days of "magnetic calms."

Messrs. Siemens Brothers exhibited a splendid collection of self-recording instruments, including their registering sounders which are in use in the General Post Office.

The Western and Brazilian Telegraph Company exhibited Jamieson and King's self-relieving grapnel for recovering and fishing up submarine cables. The special characteristic of this most ingenious invention lies in the fact that it slips a rock but holds a cable. Its form is that of an anchor of five flukes, which are hinged at their bases to its shaft, so as to be capable of doubling back when their points encounter an obstacle, such as a sunken rock; they are however kept in their normal position by a flat spiral spring acting against a plunger within the shaft, and which in its turn presses against the prolongations of the fluke arms, and keeps them in their places. If, however, a cable be hooked, it passes down to the base of the arms, as into an ordinary grapnel, and a set of supplementary spring catches make it doubly secure from slipping out again. This grapnel was illustrated on Monday evening by a working model, which could be dragged along the ground upon which were fixed obstructions of wood to represent rocks, and cords representing cables; its action was invariably satisfactory, and attracted much attention. A full size grapnel was shown, as well as large working drawings showing its construction.

Mr. Latimer Clark, who presided over the Society last year, showed his beautiful Thomson's reflecting galvanometer, which by being fitted with very perfect optical apparatus and a perfectly plane reflecting mirror silvered on its front surface, is capable of projecting upon a screen 50 ft. off a sharply defined image of the aperture of the illuminating apparatus, whether that aperture be in the form of an elaborately cut arrow, a slit, a lenticular form, or a wire stretched across a hole. For lecture purposes this fine instrument is unrivalled; the range of its scale is only limited by the size of the room, and at a distance of 50 ft. a displacement of its needle through 1 deg. of azimuth is represented by a movement of the spot of light through 10½ in. from its zero point. The coils of this galvanometer are wound with about 1150 turns of No. 22 copper wire in two parallel circuits, and has a resistance of four ohms.

Sir William Thomson exhibited his new form of mariner's compass, with his method and appliances for adjustment. This instrument was described in these columns a short time ago.† Also the very beautiful irrepressible liquid gyrostat, which he described at the meeting of the British Association, and which created much amusement by its persistence in fighting against difficulties and appearing as if animated by a living intelligence.

Mr. Robert Sabine showed his beautifully worked-out apparatus for measuring very minute intervals of time. It depends for its principle upon the law that when a charged body accumulator or condenser is discharged steadily, the rate at which its electricity is neutralised is a definite one, depending upon the resistance of the circuit through which the discharge takes place, that is to say, that if a certain percentage of discharge or leakage take place through the circuit during one second, the same percentage of the residual charge will be neutralised during the next second, and so on, until equilibrium be established. Mr. Sabine's apparatus, by measuring the fall of charge in a condenser after a momentary contact, renders it possible to determine intervals of time of one-thousandth part of a second. As an illustration a small anvil was connected with one side of a charged condenser, while a light hammer was connected with the other side of it through a known resistance. When the hammer was struck sharply on the anvil it necessarily rested on the anvil for a minute fraction of a second before rebounding, during which time a certain percentage of the charge in the condenser leaked away through the resistance, and the residual charge of the condenser was discharged through the galvanometer. The falling off in the charge due to the leakage during the contact of hammer and anvil enabled the duration of that contact to be determined with extraordinary precision.

Mr. Sabine also showed his apparatus and method for determining the contour and speed of waves in telegraph lines; and he exhibited a very beautiful series of experiments, due, we believe, to the late Sir Charles Wheatstone, for showing the circulation set up in mercury partly by deoxidation and partly by variations in the surface tension of the mercury when influenced by voltaic currents varying in direction. Upon this principle is based Professor Dewar's electrometer, which was exhibited by Messrs. Tisley and Spiller, by whom it is constructed. It consists of two glass vessels containing mercury, upon which floats sulphuric acid diluted in the proportion of 1 to 15. These vessels are connected by a horizontal siphon-tube dipping into them, and which is filled with mercury with the exception of a small globule of the same acid solution, which serves as an index, and traverses from one end of the horizontal tube to the other. Upon connecting the mercury in one vessel with one terminal of an electro-motor, and the other vessel with the other terminal, a difference of surface tension is established at the two ends of the electrolytic globule, oxygen being disengaged at one end and hydrogen at the other, and these differences each tend to move the globule in the same direction, so that it moves along the tube, which is graduated to record its displacement. If the current be reversed, the index moves in the opposite direction. This instrument is of considerable sensitiveness, and for the lecture table is especially convenient.

Messrs. Cecil and Leonard Wray exhibited their new form of thermo-pile and an improved form of Reis's telephone. The thermo-pile is an improvement upon Clamond's, which was described in this journal some months ago.* The elements are the same as those of Clamond, but the connexions are made in such a way that the fracture of a bar does not stop the current. The principal improvement, however, consists in supporting the sets of bars upon a fixed framework of porcelain fireclay, instead of upon rings as in Clamond's, where one layer of elements has to support all above it, rendering the pile liable to tumble to pieces through either the lower bars becoming broken, or the rings, which are composed of asbestos and silicate of potash, crumbling away.

Messrs. Wray's improvement upon Reis's telephone, a description of which will be found on another page,† consists in giving to the transmitting instrument a second vibrating membrane, so as to protect the transmitting membrane from the action of the breath and other disturbing influences. The receiving instrument is also somewhat different; the soft iron bar is in two parts, each of which is surrounded by a magnetic helix and placed end to end with reversed poles, so that not only do they produce a tick or sound of doubled intensity, but by tending to pull against one another the sound is increased by a strain produced on the sounding box to which they are fixed. Any note sung into the transmitter, however feebly, was instantly repeated by the bar, and so sensitive is this apparatus that it reproduced the beats of the contact breaker of an induction coil at the further end of the great hall whenever the latter was working.

The Electric Writing Company exhibited Mr. Edison's electric pen and specimens of the work done by it. Our readers may remember that a description of this instrument recently appeared in these columns.‡ Near the entrance was a fine collection of instruments for the measurement of electrical resistances constructed by Messrs. Elliott Brothers, exhibiting all the scientific accuracy and beauty of workmanship for which that firm has so great a name, and to which the late Mr. Becker so largely contributed.

Mr. Apps had a brilliant display, including a fine induction coil giving 20 in. sparks in air and illuminating some fine specimens of vacuum and fluorescent tubes. Mr. Apps also showed a large block of optical glass pierced and split by spark from the great induction coil which he has recently completed for Mr. William Spottiswoode, F.R.S., and which is capable of giving a lightning flash 42 in. in length!

Faraday's magnificent classical experiment of the rotation of the plane of a polarised beam of light under the influence of magnetism was well shown by Mr. Ladd with a fine diamagnetic apparatus.

As an example of what may be done by delicate manipulation and beautiful machinery we may cite samples of silk-covered wires exhibited by Mr. Walter Hall, some of which being not more than two-thousandths of an inch in diameter.

Mr. Spagnoletti exhibited a very interesting collection of railway signalling apparatus, including an electric semaphore signal which has been in use upon the Metropolitan Railway for upwards of twelve months, and which, although of the full size adopted on that railway, was worked with but six cells of battery.

Messrs. Montefiore showed in action their auto-kinetic telegraph, which may be described as a system for the laying on of electricity "from the main"—like the water or the gas in domestic houses and public institutions. By this system any private dwelling can be in instant communication with the nearest fire engine station, the police, a cab-stand, or a hospital. The transmitting instrument consists of a small plate carrying four buttons. By touching the first a signal is sent to the central station, which indicates the position of the house; a second gives an alarm of fire; by touching a third a medical man is telegraphed for, and the fourth is set apart for giving notice to the police that burglars are in the house. By combining these four signals other messages may be transmitted.

This year's conversazione of the Society of Telegraph Engineers will long be remembered as an exceptionally brilliant one, and we must congratulate the President and Council and Mr. Sivewright upon its success.

We may add that a selection of excellent music was performed by the band of the Royal Engineers, and contributed not a little to the enjoyment of the visitors.

THE INSTITUTION OF CIVIL ENGINEERS.

The fifty-ninth annual meeting of the Institution took place on Tuesday, the 19th of December, Mr. George Robert Stephenson, President, in the chair.

The proceedings commenced by the appointment of scrutineers of the ballot for Council, when, the ballot having first been declared open, the report of the Council was read. The constitution of the Society, which was alluded to in the two previous reports, had again received careful consideration. According to the present classification, no distinct provision was made for the large number of engineers who were past the age when they could remain students, but had not yet occupied such positions, nor been so employed, as to render them eligible for members. This omission it was proposed to supply by the creation of a class of "associate members"—the least objectionable title out of many that had been suggested. Simple as the matter might appear, the selection of a suitable expression for the new class had been difficult, as, for weighty reasons, it was deemed undesirable to disturb the existing title of member and that of associate. The proposed class was intended to embrace persons actually engaged in some of the branches of civil engineering, while in the future, associates were to be restricted, as they originally were, to those "who are not engineers by profession." The changes in the roll of the Institution during the past twelve months had led to an effective addition of 41 members and of 137 associates, bringing up the total number (exclusive of the students) to 2462, or an increase at the rate of nearly 8 per cent. per annum. Eleven years ago the gross total was 1203, and in December, 1862, it was exactly 1000. Into the class of students attached to the Institution, 696 candidates had been admitted since it was established nine years ago. Of that number 385 were still on the books, 158 had been elected associates, while the remaining 153 had ceased, from various causes, to be connected with the Society. As the scale of contributions to the funds had been unchanged for forty years, notwithstanding that in the interval all the circumstances had been so materially altered, it was open for serious consideration, whether the scale should not now be revised, and whether the time had not also arrived when the area for "residents" should be made to include the whole of the United Kingdom, instead of being limited, as at present, to those living within ten miles of the General Post Office.

There were twenty-six ordinary meetings during the past session, when nineteen papers were read and discussed. The character of the original communications, and of the remarks to which they gave rise, might be gathered from the printed records in the four volumes of "Minutes of Proceedings" already issued. Nine other papers had also been selected for publication in the second section of the Proceedings. To the authors of fifteen out of these twenty-eight essays, Telford Medals and Premiums had been awarded. Of the recipients six were members and six

* See Engineering, vol. xxi., p. 478.
† See Engineering, vol. xxi., p. 478.

* See Engineering, vol. xviii., p. 477.
† Page 518 of the present number.
‡ See Engineering, p. 511 *ante*.

associates of the Institution, while three did not belong to the Society, and one of these was a foreigner. A comparison of the earliest volumes of the "Minutes of Proceedings," first published in 1837, with the latest, showed that some progress had been made in the application of the exact sciences in designing works, so as to insure the greatest economy both of labour and of material; and it was in this direction, the combination of theory with practice, that the younger members of the profession must look to maintain their relative positions in the world. With a view of informing the members as to the state of engineering on the Continent, in the United States, and in the colonies, the Council had, during the last two years, caused an epitome of some of the most important papers in foreign transactions and periodicals to be embodied in the Proceedings. These abstracts had included descriptions or works, studies of a purely theoretical nature, and memoirs and results of costly and elaborate experiments, the details of which were not to be found in any other English publication. In addition to the ordinary meetings there were fifteen supplemental meetings for the reading and discussion of papers exclusively by students, nine of whom had been considered deserving of Miller prizes. The Council had recently determined to print in the Proceedings any papers by students that contained such original information as to warrant their appearing in the publications.

The property of the Institution comprised securities of the nominal value of 14,322*l*. 3s. 1d. held in trust for various purposes, of 22,494*l*. 1s. 8d. invested on the general account, and of a cash balance of 326*l*. 11s. 7d., together 37,142*l*. 16s. 4d., as against 35,297*l*. 15s. 8d. last year. Also, the stock in hand of the forty-six volumes of the "Minutes of Proceedings," numbering together about 7000 volumes; the collections of original drawings and of portraits of past-presidents and other eminent engineers, to which a portrait of the late Mr. Joseph Miller had lately been added; and the library, unrivalled and unique of its kind, now containing 13,431 volumes, being an increase of 3000 volumes during the past three years. These effects were insured for 10,000*l*. The statement of accounts showed receipts in the twelve months amounting to 11,181*l*. 17s. 7d., made up of three items, viz: To the credit of income, 8844*l*. 10s. 4d., to that of trust funds, 459*l*. 19s. 3d., and to capital, 1877*l*. 8s. The payments might be summarised under five heads, thus: By house and establishment charges, 1864*l*. 12s.; salaries and wages, 2419*l*. 3s.; library, 605*l*. 4s. 3d.; publications, "Minutes of Proceedings," 4055*l*. 15s. 4d.; and by premiums under trust, 313*l*. 7s. 8d.; while 1847*l*. 17s. 3d. had been invested, and the cash balance was, as before stated, 326*l*. 11s. 7d. Favourable as these results appeared to be, they were not entirely so, as the liabilities to the printers and engravers, as well as to the several trust funds for unexpended dividends and to capital, were greater than at the same date last year. In fact, the expenditure now exceeded the income, though not the receipts, which comprised admissions and building fund fees hitherto regarded as capital.

The report having been, after considerable discussion, adopted, the premiums and prizes (awarded at the close of last session, according to a list already circulated), were presented by the President, who congratulated the various recipients, in complimentary terms, upon the value of their contributions, especially the Hon. R. Clere Parsons, B.A., student, who had gained a Miller Scholarship, the first that had been given, of 40*l*. per annum, tenable for three years.

A vote of thanks was then passed to the Council, for their unremitting attention to the affairs of the Corporation; and a similar vote to the President, for his zealous efforts to promote at all times the welfare of the Institution and of its members, was carried by acclamation.

The ballot having been declared closed, the scrutineers reported that the following gentlemen had been elected: George Robert Stephenson, President; James Abernethy, Sir William George Armstrong, C.B., William Henry Barlow, and John Frederic Bateman, Vice-Presidents; Sir Joseph William Bazalgette, C.B., I. Lowthian Bell, M.P., George Berkley, Frederick Joseph Bramwell, George Barclay Bruce, James Brunlees, Sir John Coode, Harrison Hayter, William Pole, C. William Siemens, Sir Joseph Whitworth, Bart., and Edward Woods, Members; and Col. George Chancellor Collyer, R.E., Henry Oakley and Col. John Thomas Smith, R.E., Associates.

The meeting was then adjourned to Tuesday, the 16th of January, 1877, at 8 p.m., when the monthly ballot for members will take place.

HARTNELL'S GOVERNOR.

To the Editor of Engineering.

Sir,—In these days of active thought and increasing knowledge, it becomes more and more difficult to develop an invention which shall be entirely novel and almost impossible to bring forward a wholly new idea.

Probably every engineer with an inventive mind from time to time has noticed schemes brought forward in good faith as new, but which he himself had more or less worked out previously. This is especially the case in regard to governors and expansion gears where many minds have been for years earnestly engaged. Priority of idea can scarcely be claimed by any one.

Because two arrangements look much alike, it by no means follows they are identical, the differences may be vital. Small additions, omissions, or variations often completely change the resultant action. Indeed, it is a common experience that apparently slight alterations of detail, discovered after prolonged trial and expense, convert the unsuccessful into the successful machine.

If any one can succeed by careful research or experiment in so rearranging any known form of governing gear as to add but one small link to the chain of improvement, where so many must be supposed to have failed, has he not removed another obstacle to progress, added to our resources, and may he not justly be credited with a new invention?

My "patent automatic regulator" (so called to distinguish it from my former patent worked by Messrs. E. R. and F. Turner, of Ipswich) is founded on a somewhat curious theorem, which is, to the best of my knowledge, entirely new, viz., if at any given speed the turning moment of the arms produced by the centrifugal force for any two positions (in the plane passing through the governor axis) be balanced by a spring acting in a fixed direction, and the angles made by the levers with the respective forces be equal, then will the forces balance for all other possible positions, or any part of an entire revolution of the arms around their pivots. This governor is a particular application, the forces being at right angles, so are the arms, but from the condition of the machine the angular movement is limited to, say, under 45 deg., instead of 360 deg.

My governor is therefore, so far as I can discover, the first spring governor of this class in which this principle (which may be briefly termed that of "similar cosines") has been fully recognised, made the leading principle of construction, and attempted to be carried out to its full logical consequences. All the usual proportions are widely departed from, weights are abolished, the arms made rectangular, the centres spaced far apart, the ball arm shortened, the other arm (by comparison with the usual forms) very long, and that the correct relations of the cosines may be maintained for all positions and conditions of wear a friction wheel is placed there; not with the first intention, as might be supposed, of reducing the friction, although fortunately it serves that important purpose. As large a spring box is provided as the design will readily admit. In consequence of these arrangements, not only can very powerful springs be applied if desired, but a maximum of their power can be utilised. At the same time the sensitiveness can be adjusted to the maximum that the condition of the engine will allow.

It is the magnitude of the available power that can be obtained without sacrificing sensitiveness, compared with dimensions and weight of the governor, that constitute a novel and much-needed feature for controlling, the expansion gear without complications, more especially that of portable engines.

As an invention seems by many to be little more than a "happy thought," made with slight effort (as indeed it sometimes may be), and but few are aware of the thought, time, and expense required to mature an invention, or the gulf that divides a first idea from its ultimate realisation as an article of utility and commerce, it may interest some of your readers to know by what slow degrees my governor has been developed, although of course they are to be ascribed not so much to the individual as to the waves of thought that exist in the present age. Two of my expansion gears were patented, and manufactured by Mr. James Ferrabee previous to 1860—one was in the Exhibition of 1862 at work. It took four years before the governor on the crankshaft, patented in 1868, reached the form shown at Cardiff, and seven before it reached its later development. In like manner the automatic regulator is the result of a slow and tedious process of induction, deduction, experiment, and investigation.

In regard to Mr. Brown's governor (which I now see for the first time); since your engraving is made from a tracing recently supplied by him for the express purpose of illustration, it must be taken to represent his arrangement in what he considers its most perfect form (to the exclusion of any alteration that might now be made to make it more resemble my arrangement). It resembles mine in having inverted balls and no links, but there the resemblance ceases. He does not seem to have been at all aware of the theorem underlying my design. The illustration shows a combined weight and spring, and by duly proportioning each it may be that a sufficiently sensitive and rather powerful governor may be obtained. As a combined governor it differs from mine as well as in the proportions and arrangements of its parts. With a powerful spring, unless the angular movement were more limited or the difference of extreme speeds considerable, its action would be deranged by a liability to a kind of tottering equilibrium during some portion of its travel.

The shape of its arms is very similar to one of my earlier designs, the balls being suspended from above. I rejected it after calculating the extreme and several intermediate speeds due to several different tensions of the spring. If Mr. Brown (or Mr. Bernays) will kindly give us the extreme and several (at least three) intermediate equidistant positions and the corresponding speeds carefully calculated, allowing for all the disturbing forces and also the net work done in foot-pounds by the full rise of the weight, we can form a clear idea of its action. If disposed to make similar calculation with the same and also with a stronger spring with different tensions, he will discover the instability alluded to, and beginning to realise how tedious was the process which led to the new principle embodied in my design, he may perceive that it is no small step in advance, at least for the purpose for which it was especially intended.

Automatic expansion gears may be roughly divided into three classes, according to the means taken to enable the governor to act.

1. By diminishing the resistance by means of equilibrium valves, pistons, and gridiron valves, tappet arrangements, &c. A good example of the latter is the Corliss gear.

2. By utilising some source of power which the governor directs. The best examples of this class are perhaps auxiliary pistons actuated by differential gear.

3. By so increasing the power of the governor that of itself it shall be able to control the action of the valves. In this class belong my two last governor arrangements.

By either of the systems good results can be obtained, and it is to be hoped that their more general introduction is at last approaching.

Yours truly,
W. Hartnell.

December 19, 1876.

To the Editor of Engineering.

Sir,—Will you allow me space for a second letter especially referring to that which appeared in your columns and in which the writer endeavours to make quantitative investigations in regard to governors, especially alluding to your recent description of mine. He remarks that little trustworthy information is obtainable on this subject.

The idea, he thinks, implied in the second paragraph of your description is not found there, the words used being "cannot exceed" equivalent to the well known phrase "is not greater than" not "is equal to." They are used with the indefinite expression "when the speed varies." The sentence appears mathematically correct.

If the throttle valve worked without friction no power would be given out by the sliding piece under any variation of speed. The other extreme would be if the throttle valve stuck until the engine gradually stopped, and at the last opened the valve.

Thus "the amount of power really given out by governor" (through the sliding piece) is variable between zero and a maximum, viz., that required to open the balls.

The writer calculates one possible case. By screwing up or unscrewing the throttle valve gland it might be more or less than he calculates.

"The higher the balls rise the greater the power," if not self-evident can be easily demonstrated.

"But the less the sensitiveness." There is an ambiguity in the use of the word sensitiveness, it being commonly applied indifferently to the two different conditions, the governor free and acting against a resistance. Used in the latter sense, the ordinary governor is less sensitive the higher the balls rise. However, as the resistance increases the contrary may be the case. Many engine drivers have found out that a certain rise of the governor gives the best results, and adjust both the rise of the governor and the length of the throttle valve lever.

The reference to a parabolic governor in regard to sensitiveness is beside the mark where pendulum governors are expressly alluded.

To apply power to overcome the stability of the governor, and for the governor to apply power to overcome a passive resistance, are two entirely different conditions requiring different treatment. Your correspondent uses the word power presumably in the former sense in the paragraph with the words *no power*, else the first two lines are nonsense.

To act on a cut-off gear a governor must have stability. The relative stability of governors must be ascertained by those who have to apply them. For this purpose the calculation he has made on the Porter governor is of real service though meant for something else. Using the word *power* in the first sense, as the description alluded to assumes "that the arms are crossed so that the balls may rise higher with the *same* variation of speed and the actual speed is greater, the stability will be greater.

Using the word power in its second sense, the more usual case, even the hyperbolic governor would exert power directly the speed varied, more than any other of equal capable energy. The crossed arm could of course do more work than with the arms uncrossed in proportion to the increased rise of the balls.

A governor with $3\frac{1}{2}$ in. balls is said to be equal to an ordinary governor with 9 in. balls rising 2 in. But a ball of half the weight rising 4 in., or double the weight rising 1 in., might as well have been given by way of illustration. It seems the balls by chance named bear the ratio of 1 to 17. Hence the misconception of the next paragraph.

In comparing two governors of about the same size, he assumes mine to run at the same speed. The speed of the one is regulated by the heaviest weight it can conveniently carry. The special advantage of the other is that it has a much higher limit, to suit which it might run faster.

The gravity governor is said to lift 70 lb. $2\frac{1}{2}$ in., or equal to 14.6 foot-pounds. It is slightly larger across the extended balls than the governor exhibited by Messrs. Marshall at the Smithfield Show. But the governor described is only that of an eight-horse portable engine, where it would be rather inconvenient to have more than 150 lb. weight rising $2\frac{1}{2}$ in. on the spindle.

The remark that for every $\frac{1}{4}$ in. rise of the central weight equal work is done, apparently refers to the governor when it ceases to revolve. In paragraph nine he recognises the fact that the lifting force due to a variation of speed is dependent on the radius. Hence all the final calculations fall to the ground; $\frac{36 \text{ ft.-lbs.}}{14.6}$ or under two and one-half times, expressing with sufficient exactness the relative power of the two examples given.

Yours truly,
W. Hartnell.

December 20, 1876.

REVERSIBLE ROLLING MILL ENGINES.

To the Editor of Engineering.

Sir,—I was much gratified to find by your illustrated description of the great reversible rolling mill, so admirably carried out by Mr. Gillott at the Farnley Iron Works, has proved so entirely successful.

It may interest some of your readers to know that this system of working rolling mills was originated by me in 1855, and was first carried into practice by my friend Mr. J. Ramsbottom, at the Crewe Works, in 1865. A letter from Mr. Ramsbottom on the subject I take the liberty to enclose.

I am yours very truly,
James Nasmyth.

Hammerfield, Penshurst, Kent, December 14, 1876.

"James Nasmyth, Esq.

(Copy.)

"Dear Sir,—I must crave your forgiveness for the great delay in acknowledging the receipt of your kind letter of the 29th August, in which you refer to the successful carrying out at these works of your idea, of a reversible rolling mill without flywheel.' I have been from home the greater part of the last two months owing to ill health, and this is the principal cause of the delay. It has long been to me a matter of astonishment that your idea has not been reduced to practice years ago, particularly when it is considered how well the arrangement is adapted to the rolling of armour plates or other work requiring sustained effort, whilst it is at the same time more effective than the ordinary mill arrangement for even very light work; so much is this latter true that our men who are left to their own choice in the matter will reverse the mill rather than pass a light sheet of 8 lb. or 10 lb. weight over the upper roll.

"This country is much indebted to you for so valuable a suggestion, and now that it has been brought to a successful issue I have no doubt but it will be widely acted upon. I must add that it will afford me much pleasure to show you the mill at work, and also what we are doing generally, if you should at any time visit Crewe.

"Believe me I am very faithfully yours,
(Signed) "J. RAMSBOTTOM.

"London and North-Western Railway Locomotive Department, Crewe Station, Dec. 4, 1866."

PATENT SPECIFICATIONS.

TO THE EDITOR OF ENGINEERING.

SIR,—Owing to remarks made by the Master of the Rolls during the trial of Hinks *v.* Safety Light Company this week, an impression has got abroad that with only one exception all the members of the Committee of Patent Agents approved of the present mode of printing the specifications and drawings before the change was made.

It seems advisable to correct this erroneous impression. The fact, as you will be aware, is, that a meeting was held to consider the subject. If I remember rightly, some notice of that meeting appeared in your journal at the time.

Now, the notices of that meeting were, I find, sent out on the 7th of February last, and the meeting was held *on the following day* to enable an early report to be sent to the Master of the Rolls.

Happening to be out of town, I did not receive notice until after the meeting, or should most certainly have raised my voice against the scheme.

That I (in addition to the member who sent the adverse report to the Master of the Rolls) strongly objected to the change proposed, and foresaw the inconveniences now found to attend it, is well known to many.

I am, Sir, your obedient servant,
W. LLOYD WISE.

Buckingham-street, Adelphi, December 16, 1876.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Midland Institute of Engineers.—At a general meeting of the members of this Institute, held on Wednesday last at Wakefield, a paper was read on "A Heavy Outburst of Firedamp from the Floor of the New Oaks Colliery, near Barnsley," by Mr. James Wilson (manager of the Oaks Collieries), and Mr. R. Miller (manager of the Strafford Collieries). The effect of the outburst was stated to have been to upheave the floor in places as much as 5 ft., its sudden force being as great as if it had been caused by the firing of a blasting shot. Several of those present expressed great surprise that such an outburst could have occurred on the floor of a mine, but Mr. Miller said another such instance had once taken place at his collieries. Discussion on Mr. Miller's paper, "Pressure of Gas from a Bore Hole in the Floor of the Strafford Collieries," was adjourned.

An Architects' and Civil Engineers' Association at Leeds.—On Thursday last a meeting of gentlemen in these professions at Leeds was held in the Philosophical Hall, under the presidency of Mr. George Corson, for the purpose of forming an association of the two bodies. The objects of the association were stated to be to afford facilities for study, and to serve as a medium of friendly intercommunication. It was resolved to form the association, and to have papers read, with discussions thereon, on subjects of professional interest, with prizes as an encouragement to the pursuit of close studies.

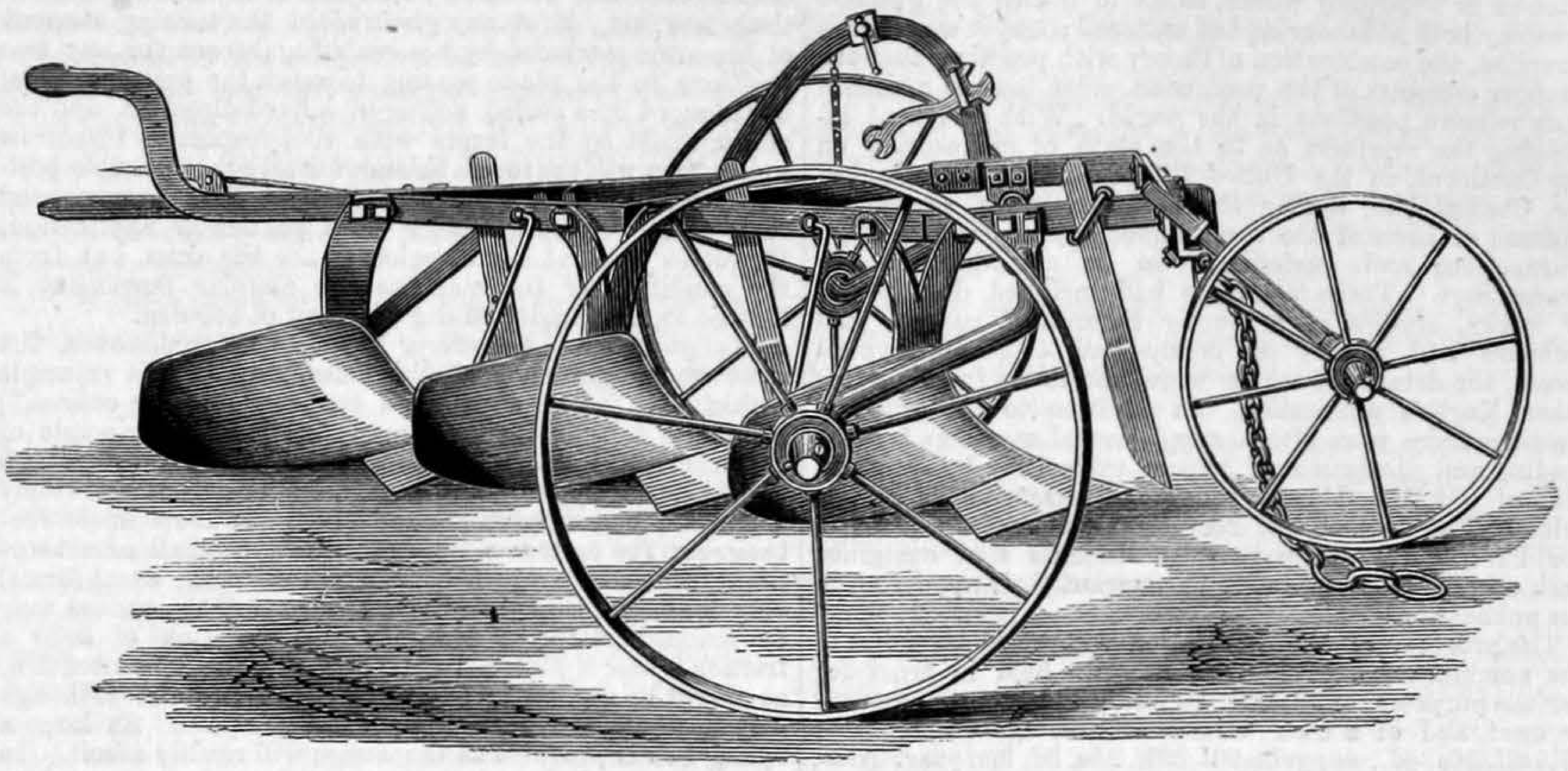
Colliery Progress near Normanton.—On Friday last the well-known and favourite Silkstone seam of coal was reached at the new pit of Messrs. H. Briggs and Co., at Whitwood, at a total depth of 400 yards from the surface. The sinking was commenced about twelve months ago, the shaft being 15 ft. in diameter. The seam at this point is 5 ft. 2 in. thick. The upcast shaft is 15 ft. in diameter, and has now reached a depth of about 150 yards.

Water Supply of Altofts, Normanton.—Last week a Local Government Board inspector visited this place to hold an inquiry as to the proposed new water works for the supply of this populous township. Evidence was adduced proving the bad quality of the water now used, and the scheme proposed by the engineer (Mr. Lumley, of Bradford) was gone into. The inspector pointed out that the Board was bound to get a supply, and suggested that trial sinkings should be made at various places.

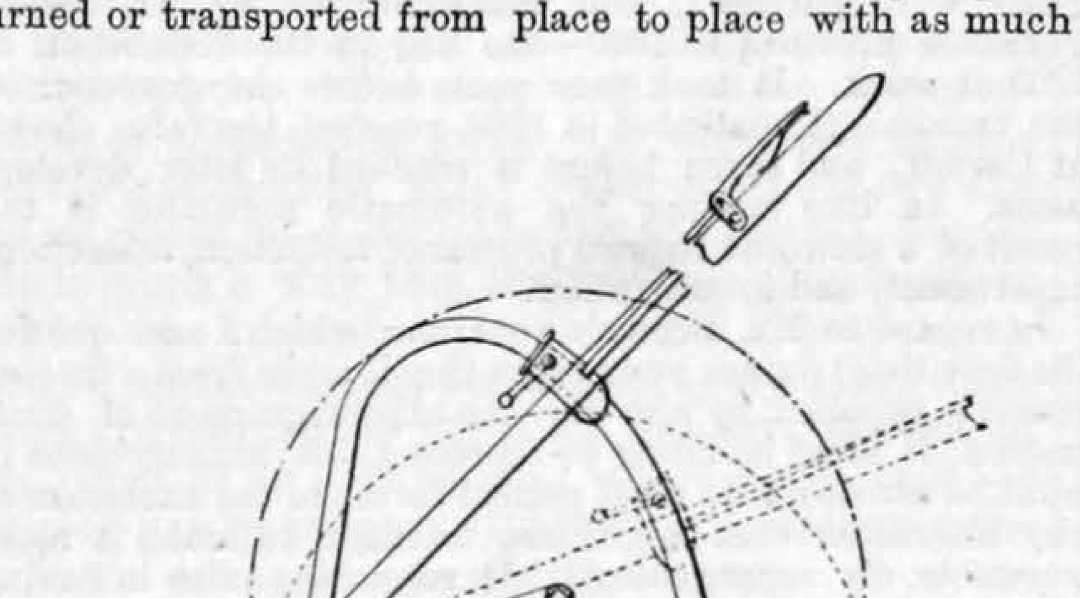
INDIAN RAILWAYS.—Surveys for a further extension of the Dakor branch of the Bombay, Baroda, and Central India Railway from Palee to Godra, about 17 miles in length, have been sanctioned by the Indian Government. The construction, as a State line, of the West Rajpootana Railway from Ahmedabad to Ajmere has been authorised by the Secretary of State for India in Council; but the line will only be proceeded with as funds for new lines become available. The Bombay Government has again submitted to the Government of India the expediency of adopting a 5 ft. 6 in. gauge in preference to a 3 ft. 3 in. gauge for at least the southern portion of this important railway.

THREE-FURROW PLOUGH.

CONSTRUCTED BY MESSRS. RANSOMES, SIMS, AND HEAD, ENGINEERS, IPSWICH.



THE multiple plough, which was exhibited at Smithfield by Messrs. Ransomes, Sims and Head, of Ipswich, and of which we annex illustrations, contains some new features. This implement was originally designed for use in the neighbourhood of Galatz, and was adapted for quick work. It is of a very strong design, so as to reduce the chance of breakage, and of a construction permitting its easy turning at the headlands. It is mounted on a triangular braced frame of a light but rigid section. On this frame the three skifes carrying the breasts are fixed, and in such a manner as to provide for the adjustment of the pitch of the share. The plough has one slade only, which is fitted to the hind skife, and, with the furrow-wheel in front, is found sufficient to keep the plough perfectly steady in work. The plough is carried on two large wheels, which, by means of a lever, are depressed so as to lift it some 7 in. clear of the ground, and these wheels are so placed that, when raised on them in this way, an almost exact balance is obtained, and the plough is turned or transported from place to place with as much



facility as may be expected from the implement. By a simple arrangement of an adjustable screw clip, which can be set in any position on an arc fixed on the beam, the lever, before mentioned, is used also to regulate the depth of ploughing, and a spring catch on this lever controlled by the hand of the ploughman, enables him to lift the plough out of work, and set it again to the required depth without moving from the handle. When in work the left-hand of the two large wheels serves as a handwheel, while the other, being set some 2 in. or 3 in. higher, just skims over the surface of the ploughed land. The breasts and shares of this plough are of steel, and all the other parts of wrought iron. Each body ploughs a furrow 10 in. wide, and from 2 in. to 7 in. deep, and in the corn-growing districts of the east of Europe they are usually worked with a eight oxen and two men.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Market.—On Tuesday business was quiet, and showed no improvement upon last week, but nevertheless the tone was cheerful, and consumers are evidently desirous of placing orders as soon as the new year commences, seeing that the inquiries they are making are very numerous. Trade has recently been better than at any time during the past twelvemonth, and it is the general opinion that 1877 will give better results than 1876 has done. There are certainly reasonable grounds for believing that such will be the case, and this makes speculators more eager to buy iron where they can, for the value of Cleveland pigs is likely to be higher than at present instead of lower. Prices all round are firmly maintained, and yesterday on 'Change they were as under for Cleveland G.M.B., delivery immediate and terms net cash: No. 1, 49s.; No. 3, 46s. No. 4 forge, 44s. per ton. Producers have no lack of orders at present, and though they can obtain 1s. per ton extra for forward orders they are not taking them in any quantity. Forge iron is very scarce, and this may in the spring lead to the re-lighting of some of the furnaces which have been put out. Deliveries of pig iron next week will be *nil*, owing to the stoppage of the mills and forges, foundries, and other manufactories consuming pig iron.

The Finished Iron Trade.—This is, with the exception of the rail department, briskly employed, but on Saturday nearly all of the works will be closed for a week or more, on account of the Christmas holidays, and the annual stock takings. Prices have an upward tendency, and prospects are very encouraging. Ship plates are in good request, and large orders may be placed for 7*l*. 5s., but small orders will not be accepted under 7*l*. 7s. 6d. per ton. Sheets are in better demand than any other kind of iron, and realise fully 8*l*. 10s. Merchant iron finds a ready sale. Rails still without a shade of improvement.

Ironfounding and Engineering.—All the foundries are well off, and in the engineering shops work is on hand which will keep them going for several months to come. During the last two months a large number—over one hundred—of marine engines has been ordered in this district, the cost of these engines being at the lowest estimate, some 200,000*l*. The holidays will affect these businesses as they do the iron trade.

The West Hartlepool Iron Works.—It has been rumoured on Tees-side that the West Hartlepool Iron Works, which have been stopped for eighteen months, owing to the failure of their owners, were to be purchased by Mr. I. Lowthian Bell, M.P., but this rumour had no foundation in fact. Mr. Bell's process for making iron is still in an experimental stage, and Mr. Adam Spencer, who was formerly at West Hartlepool, and is himself the inventor of a revolving puddling furnace, is assisting him in his experiments.

The Skerne Iron Works Company.—Some time ago this firm wished to dispose of their bridge-building business, and to carry on exclusively the manufacture of plates. A company was formed to take over the bridge works, but they failed to secure the necessary capital, and the works are still held by the old company.

The Britannia Iron Works Company.—Mr. H. Chatteris has been appointed official liquidator of this unfortunate company. The manufacture of iron rails has not in their case, as in that of several others, proved a remunerative undertaking.

The Coal and Coke Trades.—The demand for coal is dull, and prices are weaker. Many of the collieries have been on short time recently, but next week all will be closed for the holidays. Mr. Joseph Dodds, M.P., on Monday evening gave his award relative to the wages of the Durham Colliery enginemen. He decides that they be reduced 6¼ per cent. instead of 13 per cent. as claimed by the employers. These men were reduced considerably in March last under the award of the same gentleman. The Durham colliers and their employers are discussing the advisability of establishing a sliding scale for regulating wages by the rise and fall of the marketable value of coal. This will do away to a large extent with the expensive arbitrations which they have had during the last two years.

WASHERS FOR STEAM PIPE JOINTS.—We notice that Messrs. Turner Brothers, of Spotland, Rochdale, have lately introduced a useful form of india-rubber washer especially adapted for making tight joints in steam, water, or other pipes that are subjected to high pressure. It consists simply of the addition of a ⊔-shaped ring around the inner edge of the washer, so that the rubber is protected, and at the same time prevented from being squeezed inwards in making the joint or from being burst when under pressure. We believe that these washers have already been largely used, and with great success.

THE TAY BRIDGE.*

By G. Gilkes, Middlesbrough.

In a paper descriptive of the Tay Bridge, it would be out of place to enter upon the consideration of the merits of different iron structures, the relative values of different spans, or the comparative strengths of plate and lattice girders, and yet it would be perhaps less than sufficient, if some mention were not made of the great changes which have taken place in wrought and cast-iron bridges, and similar structures, since the days of the Britannia and the High Level Bridges. These were, at their date, two of the most remarkable structures of their kind, and, to this day, the High Level Bridge remains one of the finest specimens, as a whole, of a cast-iron structure required to perform a two-fold duty—to be rigid as a roadway, and strong, with elasticity, as a railway bridge. The design is instinct with the beauty of fitness, and the whole bridge, as a work of engineering skill and mechanical construction, will long remain, to every one who studies it with engineering eyes, a testimony of the ability and skill of the engineer and the constructors. The Menai Bridge was one of the marvels of its day, but probably the eminent man who created it, would not, in the light of engineering science of the present day, adopt the same means to span the turbulent torrent over which it takes "the Flying Irishman" so safely. He would use less material. He would trust more to the muscle without the flesh, or, in other words, he would put the material in the lines of the forces called out by the load, and eliminate the surplus plate. Thus the whole load would be less, the bridge cheaper, the strains more direct and simple, and the structure more durable. These remarks only faintly indicate the change which time, experience, and the progress of science have brought about in the structure of railway bridges. The Tay Bridge, the subject of our present consideration, is an eminent example of lightness and strength. Mr. Thomas Bouch, the engineer, has already signalised himself as one of the chief innovators on the old *regime* of dead weight and strength got out of it miscellaneously. In his bridges over the Deepdale and Beulah gorges in Westmoreland, he gave most notable examples of material in the right place, and muscular strength *versus* adipose bulk, and they remain unchanged, unshaken, and as perfect in their integrity as when they were built by the writer of this paper years ago. Brunel, that genius who did so much that was brilliant and bold and clever, and yet left so little that was purely successful, produced one of the most scientifically beautiful and commercially useful bridges, that has ever been built, in the great Saltash Bridge, spanning the distance with less material than had ever been done before. Time will not admit of our going further into this subject, the end of which, for our present purpose, is simply that railway bridges have undergone a most important change in scientific detail, and a reduction in bulk, and that the Tay Bridge is one of the latest examples of this fact.

Fig. 1

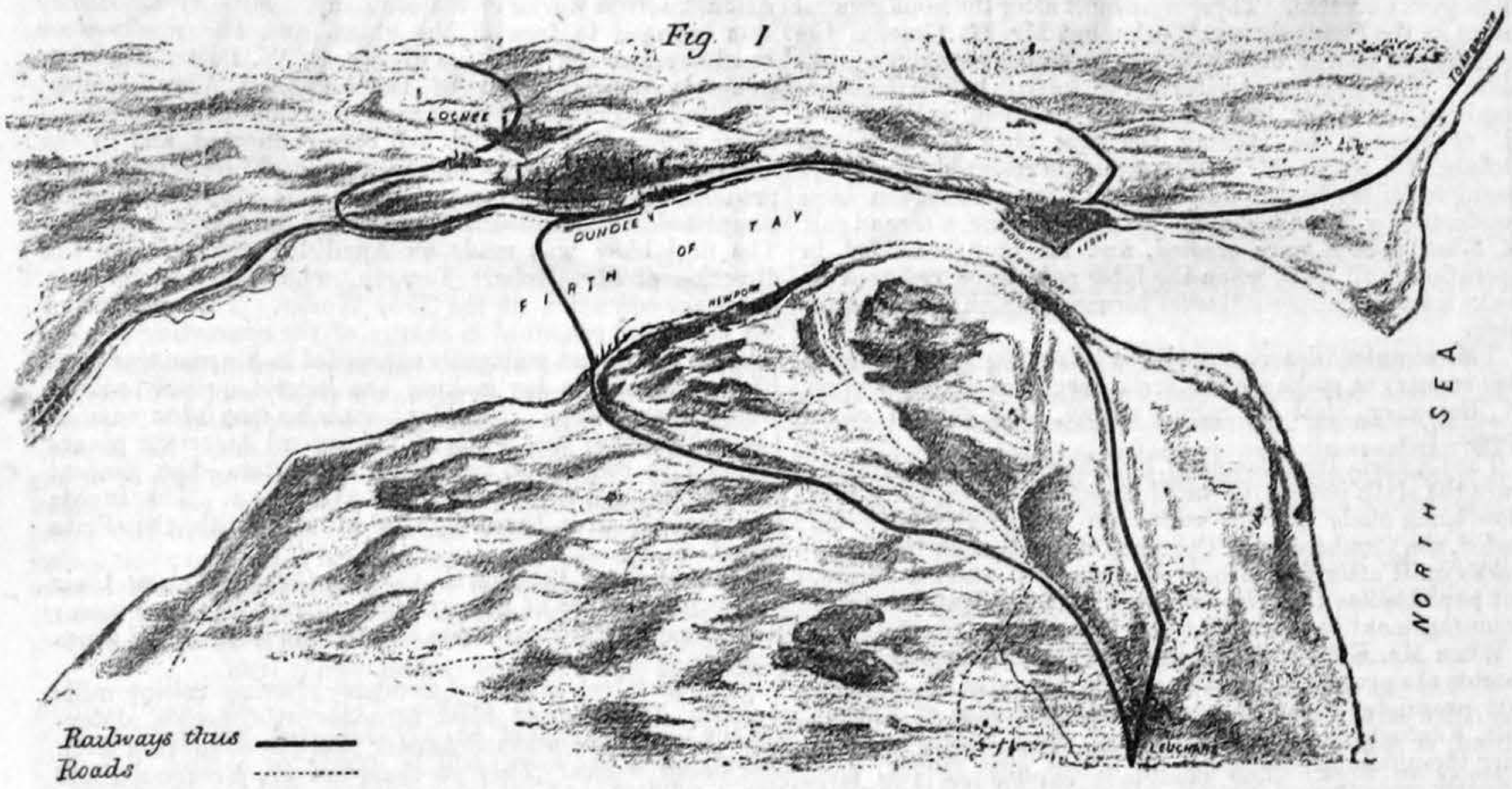


Fig. 2

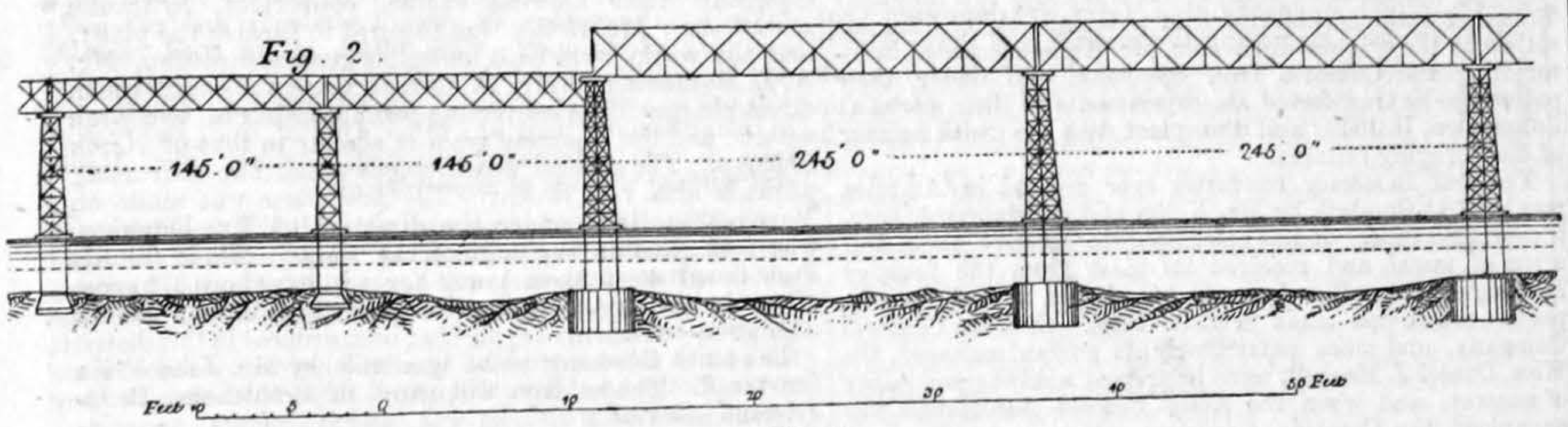
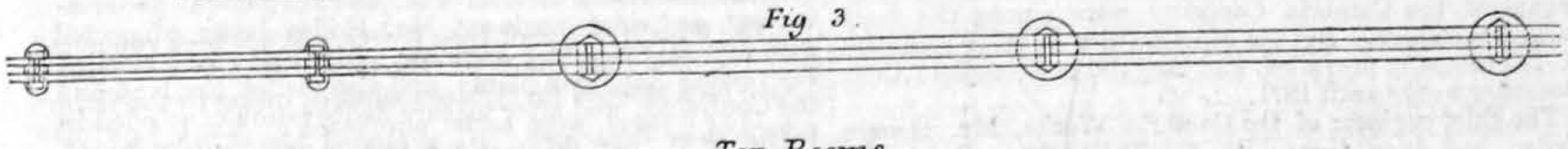
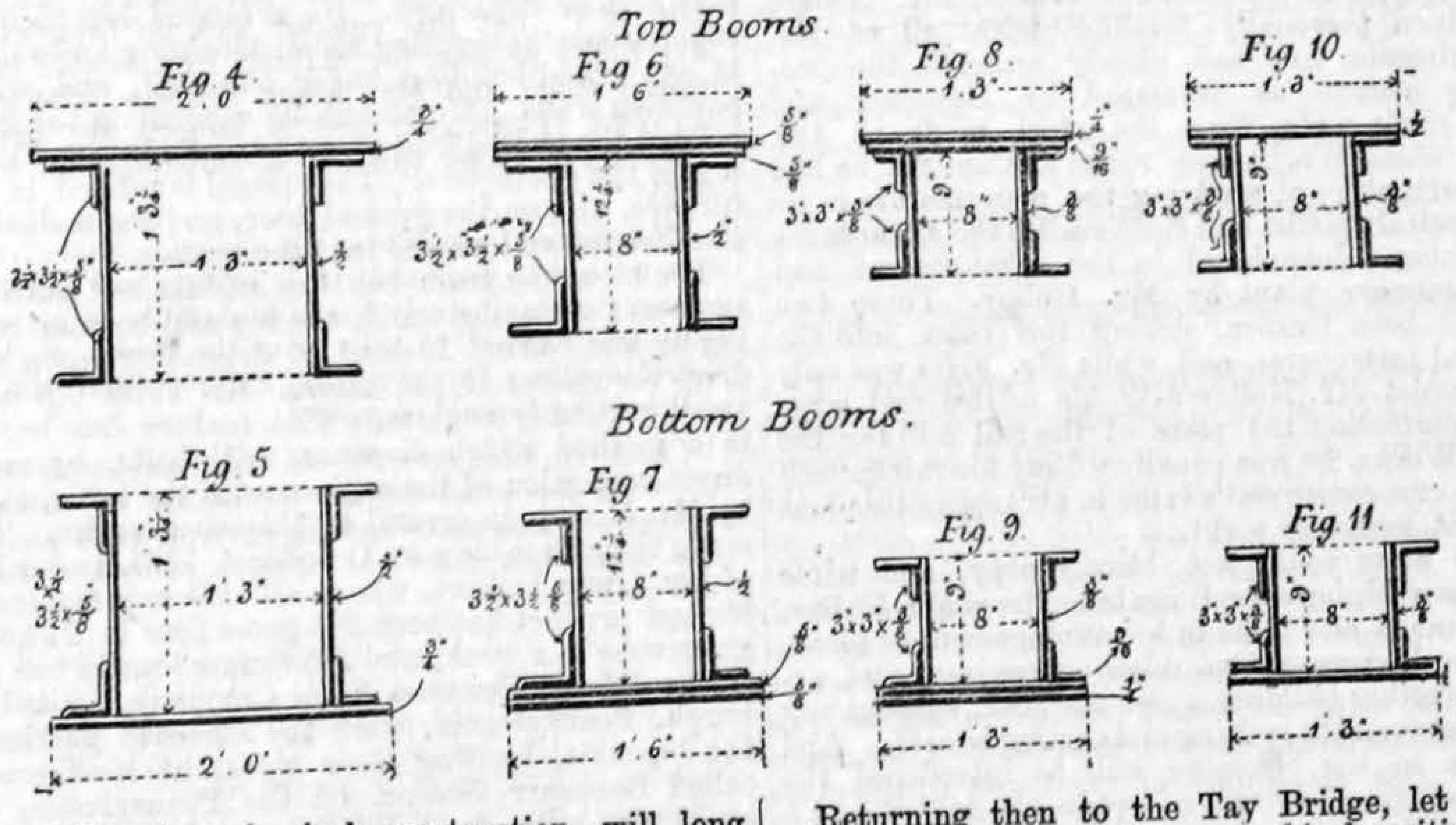


Fig. 3



Top Booms. Bottom Booms.



Returning then to the Tay Bridge, let us for a few moments look first at its geographical position and then at its history. (See plan, Fig. 1.)

Early in the year 1871, the necessities of the traffic on the North British Railway made it evident that the ferries over the Friths of Forth and Tay were not only unequal to the conveyance of the traffic on that great main railway artery of Scotland, but that, in what they did towards this conveyance, they were a heavy loss. Traffic had to be diverted and sent round by Perth, the cost of maintenance was very severe, the time occupied, even under the wonderfully good arrangements of the company, far too much, and in short the ferries must be changed for some continuous unbroken mode of communication. In 1859 and 1860 the great Frith of Forth Bridge was projected, designed, carried through Parliament, begun, and given up, the climax being the result of a want of unity in the parties interested, and perhaps a scarcity of the one metal, which is the base and the crown of all bridges. The scheme was given up, not on its merits, for they certainly would have carried it to success, but let us say, by the law of "Natural Selection."

The year 1871 saw the commencement of the Tay Bridge, as the first link in the continuous chain between London and Aberdeen, and since that date a scheme for another Frith of Forth Bridge has been successfully carried through Parliament by the North British Railway Company, which for boldness and beauty, for novelty and real scientific excellence, has not its equal in the history of railway structures.

The Tay Bridge, which forms a portion of the new branch railway from Leuchars, on the Fife Line, to Dundee, was placed in the hands of Messrs. Chas. De Bergue and Co., of Strangeways, Manchester, in May, 1871. The problem was to bridge over a distance of almost two miles, with a rapid tidal river, and a bottom chiefly formed by alluvial deposit to contend with.

Mr. Bouch met these difficult elements with much skill and ingenuity, and was well seconded by Messrs. De Bergue and Co., who were ably represented by Messrs. Austin and and Grothe. The original design of the bridge comprised 89 spans, of varying lengths, 6 of 28 ft., 25 of 66 ft., 16 of 120 ft., and 1 of 160 ft. on the Dundee side of the centre; and 3 of 60 ft., 2 of 80 ft., 22 of 120 ft., and 14 of 200 ft. on the Fife side. The experiences gained in the course of the construction of the work rendered many alterations in this arrangement needful. The original plans were altered as experience indicated, and the modes of erection—of sinking the sub-piers, and of many other details—were changed to meet the new circumstances, the one fact remaining ever, that a space of 10,321 ft., or nearly two miles, had to be crossed, and that however spans might vary or foundations fail, this must be accomplished. On July 24, 1871, the foundation stone of the land abutment on the Fife side was laid by Master W. A. Paterson, the son of Mr. William Paterson, the resident engineer, Sheriff Monro remarking, in his complimentary address, "that the scheme was singularly gigantic, and he hoped those who invested their money in it might secure that profit to which their enterprise entitled them. He only hoped that the spanning of the Tay was but the prelude to even a more extraordinary achievement, the bridging of the Forth. Then, and not till then, the east coast of Scotland would enjoy what was really a necessity—an unbroken railway communication." This was the dream of 1871, and this is now the avowed purpose of the North British Railway Company in 1876.

In the original design the piers were to be built of brick, set in cement, the foundations being produced by sunk cylinders filled with concrete. This plan was carried out on the Fife side of the river with considerable success. The cylinders being sunk by the ordinary pneumatic process known as the "air-bell" process, the water being driven out of the cylinders by compressed air, and the cylinders sunk by the ordinary modes of excavation. Of course the pressure on the men who were excavating, and also on the cylinder itself, depended on the depth to which the latter was sunk.

This plan was successfully carried out until 15 of the piers on the Fifeshire coast were erected, not, however, without accident, for in August, 1873, in sinking one of the cylinders, 8 ft. 6 in. in diameter, it suddenly burst, letting in the water on the men, causing the death of six of those then engaged in the work. So this momentous undertaking proceeded with varying success, through many difficulties, such as can only be appreciated by those who have had to contend with them. Foundations failed, in some cases from a total and unexpected variation of the strata, in others from want of bearing surface and the scouring action of the tidal flow, &c., until the 10th of March, 1873, when the death of Mr. Charles De Bergue checked the progress, and rendered new arrangements necessary. By this time a considerable amount of work had been erected at the Dundee end of the bridge. Here the piers were formed of hollow cast-iron tubes braced together with tie bars, and sunk in the sand by means of a constant current of water forced through them.

In July, 1874, the completion of the work thus commenced was undertaken by Messrs. Hopkins, Gilkes, and Co., and the work, which had never actually stopped, was resumed with vigour. During the winter of this year small progress was made — the frequent storms impeding the work very seriously, and it was not until the middle of 1875, that, with the aid of new and more powerful plant, the general design having also undergone some important alterations, the bridge began to exhibit rapid growth. The engineer found that, on the original construction, the various operations when put into time, would clearly occupy a much longer period in execution than his first calculations contemplated, or than would suit the exigencies of the company; and after very careful consideration it was decided to widen the centre spans, to adopt single large caissons, instead of two to each pier—and to make other important changes which both added to the strength of the work and shortened the time required for its execution. The design, as then decided on, is the one now being carried out.

The bridge when finished will consist of 84 spans:

	ft.	in.	
6 of	27	0	
14 ,,	67	6	
14 ,,	70	6	
2 ,,	88	0	
21 ,,	129	6	
13 ,,	146	0	
1 ,,	162	0	
1 ,,	170	0	Bowstring girder.
13 ,,	245	0	

Fourteen only of the piers, those on the Fife coast, are of brick, all the rest being of combined cast and wrought iron of various strengths, and composed of varying numbers of columns, according to the plan they take in the structure, and the work they have to do.

The height of the largest girders above high water line is 88 ft., the line of rails being on a rising gradient from the Dundee end of about 1 in 73.

The girders (see Figs. 2 to 11) are of the lattice construc-

* Paper read before the Cleveland Institution of Engineers.

tion with double triangulation, and trough booms at top and bottom, from 15 in. to 24 in. in width according to the span, a vertical tie being fixed from the top boom to the crossing of the struts and tees, at every alternate crossing.

This is a construction that has been much questioned. It has the advantage of producing stiffness, and renders the adopting of a lighter top boom safe by dividing the bearing more intimately. The depth of these girders is one-eighth of the span, a proportion adopted by Mr. Bouch and Mr. A. D. Stewart, C.E. (whose exhaustive paper on wrought-iron girders was read before the Edinburgh and Leith Engineers Society in 1872) as the result of many experiments, and as giving the greatest strength with the least material. The cross girders are of pitch pine 12 in. by 9 in., the rails being carried on longitudinal beams 17 in. by 7 in., and the whole planked with 3-in. Memel, covered with asphalte as a protection from weather, and the falling ashes from the locomotives. A light hand-rail of 2¼ in. (inside) gas tube runs the whole length of the bridge, carried by metal stanchions. These tubes it is intended to utilise—the one to convey water and the other gas from one side of the Tay to the other.

A noteworthy feature of the bridge is that with the large spans of 245 ft., the engines and trains will run between the girders, the rail platform resting on the bottom booms, but in all the other spans the trains will run on platforms fixed on the upper booms. A saving of cost and a more equal gradient are secured by this plan. The girders are continuous in sets of four with sliding beds on those at each end of each set.

(*To be continued.*)

A HISTORY OF THE BESSEMER MANUFACTURE IN AMERICA.*

By R. W. Hunt, Troy, New York.

(*Concluded from page* 509.)

The Pennsylvania Steel Works were the third Bessemer works started in the United States. The company was organised under the presidency of S. M. Felton, Esq., and under the auspices of such prominent railroad men and engineers as the late Edgar J. Thomson, Nathaniel Thayer, M. W. Baldwin and Co., William Sellers and Co., Bement and Dougherty, R. P. Parrott, H. R. Worthington, Merrick and Sons, Morris, Tasker, and Co., and others. Upon the first organisation of the company Mr. William Butcher, of Sheffield, England, was elected as the engineer, and ground was broken, but, later, other arrangements were made, and the works were built upon plans furnished by Mr. A. L. Holley, and on January 1, 1867, that gentleman severed his connexion with the Troy Works, and removing to Harrisburg, assumed entire charge of the construction, being assisted by Mr. H. S. Nourse. In June, 1867, the Bessemer works were first started and have been ever since in operation. The rail mill of the company not then being completed, most of the ingots were rolled into rails at the Cambria Iron Works, Johnstown, Pennsylvania, this arrangement lasting until May, 1868. I find it stated in an official publication of July 27, 1868, that the "annual capacity of the present Bessemer plant (two 5-ton converters) is about 10,000 tons, and of the rail mill 30,000 tons. Additional converters will be erected from time to time." The time for such additions has not yet arrived, but the product has been increased fully 500 per cent., the heaviest day up to date, having been 281; week, 1291; and month, 5455 gross tons.

The writer had charge of the rolling at Cambria of the Pennsylvania Steel Company's steel, and well remembers with what proud satisfaction Mr. Holley visited Johnstown and proclaimed to us all that at last his dream was realised; that the Pennsylvania Works were making four conversions on each turn, or eight per day; producing 40 tons of ingots. I presume that "official document" was inspired just about this time. In May, 1868, the rail mill was completed, and since then the company have taken care of their product at their own works. At first they pursued the same plan (rolling 8¼ in. ingots with a reheat) under which their steel had been rolled at Cambria, but subsequently introduced hammering; two hammers have up to the present time drawn the ingots into rail blooms, but the company are now erecting a blooming mill constructed by Mr. James Moore at Bush Hill Iron Works, Philadelphia.

Upon Mr. Holley's relinquishing the management of these works in 1868, he was succeeded by the joint management of Mr. Nourse and Mr. John B. Pearse. This arrangement was in turn succeeded by another by which, in 1870, Mr. Pearse took charge of the company's business as general manager, Mr. Nourse remaining as superintendent. Mr. L. S. Bent is now in charge of the works.

The first ingots made at Harrisburg and sent to Johnstown to be put into rails were drawn into blooms under a 5-ton hammer. A limited number were also hammered at the works of Seyfert, McManus, and Co., Reading, and the blooms sent to Cambria. While watching the behaviour of the steel under the hammer, Mr. George Fritz, chief engineer of the Cambria Works, became convinced that it was not the proper manner of treating the material, and he and Mr. Holley had many consultations on the subject. Mr. Fritz at once turned up a set of blooming rolls which he placed in a 21-rail train, and Mr. Holley caused 8¼-in. ingots to be cast and sent him. These were drawn to 6¼ in. square, then recharged and wash heated, and then rolled into rails. So well did this work, that Mr. Holley adopted it in the Pennsylvania Steel Company's rail mill, which he was then building. After many discussions and consultations he decided on his return to Troy to build the heavier blooming mill to which I have before referred.

The Freedom Iron and Steel Works, near Lewistown, Mifflin County, Pennsylvania, were the fourth Bessemer works started in this country. They were organised under the presidency of Mr. John A. Wright, and absorbed the interests of the Logan Iron Company, which company had been successfully working for many years. Mr. Wright visited England, and made purchases of the most complete machinery there known, and with the exception of the blowing engine, which Messrs. I. P. Morriss and Towne, of Philadelphia, built, the works may be said to have been of English construction and arrangement. The company intended to manufacture principally boiler plates and tyres, but the plate mill, which was driven by a Ramsbottom reversing engine, was soon changed to a rail mill. The works were under the direction of Mr. R. H. Lee, and ran for about one year, when, owing principally to the unsuitableness of the company's irons for Bessemer steel, the works were stopped, and much of the machinery subsequently sold. Their first blow was made May 1, 1868.

The Cleveland Rolling Mill Company's Bessemer Works, situated at Newburg, six miles from Cleveland, were the fifth works erected. These were built after the same general plans as the Pennsylvania Works, but Mr. H. Gmelin, the engineer in charge of construction, made many modifications. This gentleman returned to Austria before the blowing in of the works, which task was assumed by Mr. John C. Thompson, he making the first blow on or about October 15, 1868. Mr. Thompson soon resigned the charge owing to failing health, and the works have since then been conducted by Mr. Chisholm. In a short time, a second pair of 5-ton vessels were erected, and all four remained in operation until 1875, when the later pair were removed to make way for Siemens-Martin furnaces, which are now running.

This company deserves credit as being the first parties in this country to make a commercial success of the application of Bessemer steel to wire, screws, and several other specialities.

The Cambria Iron Company, of Johnstown, Pennsylvania, were the sixth parties to build Bessemer works, their first blow being made by the writer on July 10th, 1871. As stated, the Cambria Iron Company did not erect Bessemer works until after five other concerns had started theirs, but nevertheless they were the very first corporation to give encouragement to attempts to perfect the new process.

When Mr. Kelly turned his attention to endeavours to shorten the process of refining iron by blasts of air, he was part proprietor and manager of a blast furnace at Eddysville, Kentucky. As in the case of many another seeker after the unknown, he spent all of his own money, and seriously embarrassed himself. It was about this time that Bessemer obtained his American patents. After filing his claims as the original discoverer, Mr. Kelly succeeded in interesting the Cambria Iron Company, and under their patronage he transferred his experiments to their works at Johnstown, in 1859, and there met with the usual number of discouraging failures.

The first Bessemer converter ever erected in America was built at Cambria by Mr. Kelly, and still remains there, a cherished relic. It was calculated to convert about half a ton of metal, and received its blast from the foundry blowing engine. But I never heard even a tradition of a perfect conversion made in this vessel. Still the Cambria Company, and more particularly its general manager, the Hon. Daniel J. Morrell, were impressed with the possibility of success, and when the Kelly Process Association was organised the Cambria Company were among the most earnest members. But the conservatism of other members of the company prevailed, and they did not complete their Bessemer works until 1871.

The chief engineer of the Cambria Works, Mr. George Fritz, had been personally familiar with all of Mr. Kelly's experiments, and had closely watched the progress of the process as developed by Bessemer and others, and during the time the steel made at the Pennsylvania Steel Works was rolled at Cambria he had abundant opportunities of studying the manufacture in its various mechanical details, and fully realise the advantages of the innovations introduced in the arrangement and details of Bessemer plant by Mr. Holley. These two gentlemen had been thrown, during this time, into the closest personal intercourse, and while Mr. Fritz was only too happy to assist Mr. Holley with his advice and large experience in perfecting the plans of the rail mill for the Pennsylvania Works, he was equally willing to avail himself of the latter's experience and advice in arranging his plans for the Cambria Bessemer plant.

But George Fritz could not blindly copy, and while cheerfully acknowledging everything taken from Mr. Holley, he introduced many new ideas in his arrangement of plant. He built vertical disconnected blowing engines, and arranged his converting building under one roof, without any dividing wall between the melting and casting houses. And when he came to the blooming mill he introduced the entirely new features of driven rollers in the tables, and a hydraulic pusher for turning over and moving the ingots on the tables. These two features constitute the Fritz blooming mill patent, now used by most of the Bessemer works of this country. The merits of rolling as compared with hammering had been fully discussed between Mr. Fritz and Mr. Holley, and they had, at various times, gone over the numerous details of a blooming mill, and Mr. Holley, as already stated, had built one at the Troy Works. Mr. Fritz had availed himself of the benefit of the extensive knowledge and sound judgment of his brother, Mr. John Fritz, of Bethlehem, Pa., and the result of all was the Johnstown Blooming Mill, which marked a new era in the Bessemer manufacture. While living to see many difficulties overcome, and great progress made, George Fritz died too soon, his country losing one of her noblest and ablest sons. He died August 5th, 1873.

The writer remained in charge of the works until September, 1873, when he went to Troy and was succeeded by Mr. John E. Fry, who is still in charge. The greatest yield at these works has been as follows: March 21, 1876, 297 gross tons in 24 hours; week ending May 20, 1876, 1475 gross tons; month ending March, 1876, 6051 gross tons.

The seventh works to go into operation, the Union Iron Company, are owned by the same parties who controlled the Cleveland Works, and are located at Bridgeport, or South Chicago, Illinois. Their first blow was made on July 26, 1871, and the works have been in almost constant operation ever since. They contain two 5-ton vessels, and the general arrangement is similar to the Newburg plant.

The North Chicago Rolling Mill Company, of Chicago, Illinois, built and started the eighth Bessemer works. Captain E. B. Ward, of Detroit, was one of the heaviest owners in this company, and he, as before stated, had owned the Wyandotte Works, and was fully convinced of the merits of the process, and while abandoning the last-named establishment, took steps to have a larger and more complete plant erected in Chicago in connexion with the extensive iron works of the company. Mr. A. L. Holley was engaged to furnish the plans, and the works were erected under the direction of Mr. O. W. Potter, then the general superintendent of the company. Mr. Holley, profiting by the experience acquired in building the several other works with which he had been connected, and by the already advanced state of the art, introduced many improvements in the arrangement of this plant, and when completed it was undoubtedly the most perfect in existence. The first blow was made on April 10, 1872, under the direction of Mr. Robert Forsyth, who had received his Bessemer education at the Troy Works. This gentleman has ever since remained in charge of the converting works, and has been most eminently successful in his management. His works are to-day making the largest output product of any in the world. The plant contains two 5-ton vessels. I might here say that while all the present American plants are said to consist of two 5-ton converters—the general practice is to convert nearer 6 tons in them. The ingots are bloomed in a three-high 30-in. mill with the Fritz tables.

The records of the North Chicago Company show their largest product for 24 hours to have been 330¼ gross tons; for one week 1583 gross tons; and for one month 6457 gross tons.

The Joliet Iron and Steel Company, having rolling mills at Joliet, Illinois, and blast furnaces at Chicago, determined to erect the ninth Bessemer plant in connexion with their Joliet works. They purchased of the Freedom Steel Company their blowing engine, converters, hydraulic cranes, &c. Mr. Holley was engaged to furnish the plans, and the works were built under his general direction, Mr. A. L. Rothman and Mr. P. Barnes being the engineers in direct charge. The converting plant consists of two 5-ton vessels, and the blooming train is similar to that of North Chicago. The general arrangement of the two converting works is also very similar. The first blow was made on March 13th, 1873, under the direction of Mr. Dunning, who still remains in charge of the works. Their records show the greatest product in 24 hours to have been 350 gross tons; in one week 1528 gross tons; and in one month 5367 gross tons.

The tenth Bessemer plant was built by Mr. John Fritz for the Bethlehem Iron Company, of Bethlehem, Pennsylvania, and of which he was, and is, general superintendent and chief engineer, Mr. Holley being connected with him as consulting engineer. Mr. Fritz had studied the various American plants, and also visited England and the Continent, and after mature deliberation concluded to take a new departure. He arranged his melting house, engine-room, converting room, blooming and rail mills, all in one grand building, under one roof, and without any partition walls. He placed his cupolas on the ground and hoisted the melted iron on a hydraulic lift, and then poured it into the converters. The spiegel is melted in a Siemens furnace, also on the ground floor, and the melted spiegel is also hoisted and poured into the vessels.

The blooming train has the middle roll stationary, the same as the Cambria mill, the top and bottom rolls screwing up and down. Instead of depending upon friction to drive the rollers of the tables, Mr. Fritz put in a pair of small reversing engines. This feature has been adopted in a method which dispenses with belts, by means of a direct connexion of the engines with the table, as arranged by Mr. Holley, in several of the other works. The works made their first blow on October 4, 1873, under the charge of Mr. Owen Leibert, who is still the superintendent. The highest product has been 264 gross tons in 24 hours; 1340 gross tons in a week, and 5282 gross tons in one month.

The Edgar Thomson Steel Company, limited, of Pittsburgh, Pennsylvania, were the eleventh parties to enter the business, locating their works at McKenney's, now called Bessemer Station, on the Pennsylvania Railroad, about nine miles from Pittsburgh; Mr. Holley furnishing the plans and Mr. P. Barnes being the resident engineer, he having severed his connexion with the Joliet Works. In the fall of 1873, Mr. Wm. R. Jones, who had been George Fritz's assistant at Cambria, became connected with the Edgar Thomson Company, and upon the starting of the works in August, 1875, assumed charge of them. He is now the general superintendent of the company. Their largest product for 24 hours has been 265 gross tons; largest for a month's work, 5403 gross tons.

In arranging these works, Mr. Holley made many improvements over any of his previous efforts, and assisted as he was, the works stand to-day as a fit monument of the progress of the Bessemer process in this country.

The twelfth and last works to start were those of the Lackawanna Iron and Coal Company, of Scranton, Pennsylvania, being added to their already large iron plant. The converting works were built by Mr. A. L. Rothman, Mr. Holley acting as consulting engineer. The former gentleman started the works on October 23, 1875, and remained in charge until May, 1876, when he was succeeded

* A paper read before the American Institute of Mining Engineers. From the *Engineering and Mining Journal*, New York.

by Mr. George F. Wilhour, who obtained his Bessemer experience at Johnstown, Pennsylvania. The blooming mill was built from Mr. Holley's plans, under the supervision of Mr. W. W. Scranton, the general superintendent of the company, and has all the late improvements.

The Vulcan Iron Company, of St. Louis, Mobile, have their converting works and blooming mill nearly ready to start, they being an addition to their already large iron rail mill and extensive blast furnaces. Mr. Holley has furnished the plans and Mr. D. E. Garrison, the general manager of the company, has had immediate charge of the erection, Mr. John Hogan being his assistant. When these works start there will be in operation eleven 5-ton plants with 22 vessels, capable of turning out, in the aggregate, 550,000 gross tons of ingots per year.

Having enumerated the various Bessemer works according to the order in which they started, and in so doing having referred to the wonderful increase in product, it seems a fitting conclusion to briefly review the causes of such wonderful strides in capacity. As stated, after building the original experimental plant at Troy, Mr. A. L. Holley seems to have appreciated that the manufacture was capable of a development far beyond any which had been attained in those countries in which it was already considered a success.

Even if his mind did not fully realise this conclusion, his mechanical intuition was alive to the possibilities of improvement, and the result of his thought gave us the present accepted type of American Bessemer plant. He did away with the English deep pit, and raised the vessels so as to get working space under them on the ground floor; he substituted top-supported hydraulic cranes for the more expensive counter - weighted English ones, and put three ingot cranes around the pit instead of two, and thereby obtained greater area of power. He changed the location of the vessels as related to the pit and melting house. He modified the ladle crane, and worked all the cranes and the vessels from a single point; he substituted cupolas for reverberatory furnaces, and last, but by no means least, introduced the intermediate or accumulative ladle, which is placed on scales, and thus insures accuracy of operation by rendering possible the weighing of each charge of melted iron, before pouring it into the converter. These points cover the radical features of his innovation. After building such a plant, he began to meet the difficulties of details in manufacture, among the most serious of which was the short duration of the vessel bottoms, and the time required to cool off the vessels to a point at which it was possible for workmen to enter and make new bottoms. After many experiments the result was the Holley vessel bottom, which, either in its form as patented, or in a modification of it, as now used in all American works, has rendered possible as much as any other one thing, the present immense production.

Then he tried many forms of cupolas at Troy, adopting in the original plant a changeable bottom, or section below the tuyeres, and developing this idea still further in the first 5-ton works; then later, at Harrisburg, assisting Mr. J. B. Pearse in developing the furnace to a point which rendered these many bottoms unnecessary, chiefly by deepening the bottom and enlarging the tuyere area. Upon his rebuilding the Troy Works after their destruction by fire, Mr. Holley put in the perfected cupolas. At this time the practice was to run a cupola for a turn's melting, which had reached eight heats or 40 tons of steel, and then dropping its bottom. This was already an increase of 100 per cent. over his boast about the same amount in 24 hours.

The Cambria Works were now running, and Mr. Holley had become officially connected with them as consulting Bessemer engineer. Many discussions and consultations took place between George Fritz, Mr. Holley, and the writer, as to the possibility of increasing the product of the works. Among other things, tapping cinder from the cupolas was thought of, and decided upon. These works had already placed their turn's work at nine instead of eight heats. The Pennsylvania Works, under Mr. J. B. Pearse's management, followed with an increased production. The Cambria Works applied the cinder tap, and the production went up to the unanticipated amount of 30 heats, or 150 tons in 24 hours. Grand as we thought this, it is only about one-half of the present yield of each of several works. During all this time many details were modified, and as the new ways proved successful they were adopted into the regular practice. I think one thing which had a strong bearing on the increased production was the labour organisation of the Cambria Works. In compliance with the policy decided upon, I started the converting works without a single man who had ever seen the outside of a Bessemer works, and, with a very few exceptions, they were not even skilled rolling-mill men, but on the contrary were selected from intelligent labourers. The result was that we had willing pupils with no prejudices and without any reminiscences of what they had done in the old country or at any other works. Of course when one works went ahead, the others had to follow. Mr. George Fritz was the embodiment of push, and with such men to call on as William R. Jones, J. E. Fry, Charles Kennedy, Alexander Hamilton, and D. N. Jones, his efforts were ably seconded, and Cambria for a long time maintained the lead.

Mr. Z. S. Durfee tried at Wyandotte to fill an ingot mould from the bottom, the steel being poured into the top of an adjoining mould. Upon taking charge of the works, I still further carried out this idea, and later Mr. John E. Fry and myself took out a patent on the process. At about the same time Mr. Holley, at Troy, was elaborating the same idea, and later, at Harrisburg, carried it much further and patented it. After the starting of the Cambria Works the process of bottom casting was fully gone into, and Mr. William R. Jones' improvements, since patented by him, rendered it a complete success. I know that some makers do not fully acknowledge its merits, but it certainly has a right to rank among the prominent features of the American Bessemer practice.

While I am not able to mention all the very many good things accomplished by the gentlemen at each and all the various works, I am, at the same time, well aware they have all done their share towards achieving the great end; and, fortunately, their respective relations have been so pleasant, that each one's experiences have been freely imparted to the others. This has done wonders to advance the science. But without one element, all skill and all mechanical talent would have been wasted, and with it nearly all things have been possible. That element has been, and is—"American push."

THE GUN TRIALS AT SPEZZIA.

The Engineer of November 17 announced that the Admiralty had despatched Mr. Barnaby, Chief Naval Constructor, to Spezzia, in order to examine into results, and to obtain official details of the comparative trials recently made with the 100-ton gun against the steel and armour plated shield. It also expressed its opinion as follows:

"The enormous and startling improvements both in artillery and armour plating, which are daily being made, most conclusively, we think, show the wisdom of the policy which has been adopted in our navy, and which we have consistently upheld, viz., that we should advance by slow degrees, and when we think we have got the type of the fighting line-of-battle-ship to build only one or two experimental vessels, instead of a large fleet, as we may be certain that before the year is out some fresh improvement is sure to be made which will necessitate a new design. The Inflexible has been built to carry four 81-ton guns, and already the construction of a 160-ton gun, the size of which would prevent its being carried in the turrets of the Inflexible, is talked of. We are pleased that Mr. Barnaby is going to Spezia, but we doubt that steel is better than iron."

The *Diritto*, which is the official organ of the Italian Government, after having, in its issue of the 25th of November, reproduced verbatim the article of *The Engineer* just referred to, considers itself called upon to reply to the final remarks of *The Engineer*, and publishes some remarks on the use of steel, based evidently upon official data, on the results obtained at Spezzia, and which bring into remarkable relief the great superiority of the steel as compared with the iron plates. This article is of value and importance on account of the evident reliability of the data on which it is based, and we therefore take the opportunity of reproducing it.

The results obtained with the trial of the 100-ton gun at Spezzia have attracted great interest throughout the naval bureaus of Europe, and we consider that the final opinions advanced by the writer in *The Engineer* are comparatively baseless. The problem for which a solution is sought today in the cuirassing of ships of war, is how best to protect them against the effects of the shock of the enormous projectiles which, projected with an extraordinary energy, from heavy guns of large calibre, will have to be resisted in future naval engagements, and against the convergent and simultaneous fire of other heavy guns but of smaller calibres. The difficulties connected with the manufacture of iron plates of thicknesses greater than about 14 in., and the consequent deterioration of the manufactured product, have hitherto led to a preference being given to armour built up of two plates, the thicker of which placed outside has sufficient strength to arrest, or nearly so, the heaviest projectiles at present forming the armaments of European navies (that is to say calibres of from 10 in. to 14 in.). The inner skin of the ship is thus protected by the second and thinner armour plate, unless the shell should burst in the packing between the two plates, which would necessarily produce disastrous effects. The penetration of iron plates 14 in. in thickness requires an energy in the projectile of 230 foot-tons per inch of circumference, and only the heaviest calibres have hitherto been able to effect this, imparting as they do a striking energy of about this amount. So that in the presence of 12 in. or 14 in. calibres the adoption of this form of armour has been entirely justified.

In the experiments against the targets recently conducted at Spezzia, the projectiles from the 100-ton gun developed a mean striking energy of 550 foot-tons, and those of the 18-ton and 25-ton guns an energy of 170 foot-tons per inch of circumference. The outer iron plate of the compound target at Spezzia was 12 in. thick, to perforate which, according to Noble's formula, would require a somewhat less force, and the recent trials with the 18-ton gun entirely confirmed this theory, the projectiles possessing only the force actually required to pierce the outer plate; this force being thus absorbed, the shots were of course stopped without producing any further destructive effects upon the target. The projectiles fired with an energy of 230 foot-tons per inch of circumference, fired separately as well as simultaneously and converging, produced naturally effects very similar to those fired against the heavy 22-in. iron and the steel plates.

Invariably, however, totally different effects were produced by the projectiles from the 100-ton gun, which were fired, as has been already stated, with a velocity representing an average of 550 foot-tons per inch of circumference. The thickest iron plates forming the target should have been, according to Noble, easily pierced by the projectile endowed with such a striking force, and they were pierced completely. No reference need be made here to the compound target, which required only 275 foot-tons per inch to penetrate it; while the shot from the 100-ton gun possessing twofold this force had, as the experiments showed, a very large excess of power. On the other hand, the untouched steel plate, and the second one that had been injured by previous rounds, both completely stopped the projectiles from the 100-ton gun, and thus preserved the inner wall of the ship. The results of these rounds, and especially of that one fired against a fragment of the target, much smaller than the original plate, and which moreover was only hanging to the backing, proves undoubtedly the superior resisting power of steel as compared with iron. Thus the same plate resisted one round from a 9.8 in. calibre gun, with a striking force of projectile of 162 foot-tons per inch of circumference: two simultaneous rounds from the 9.8in. and 11-in. gun, with a striking force of about 170 foot-tons for each projectile, and one round from the 100-ton gun. After sustaining these three rounds, the backing was quite preserved without the skin of the ship sustaining serious injury. The pointed end of the projectile striking the iron plate acted like a wedge, rolled the fibres of the iron back laterally, and in destroying by the vibration produced the welding between the layers of iron forming the plate—an effect very visible at the Spezzia trials—and the projectile thus opens a way for itself through what can only be considered as a series of plates in close juxtaposition, but with only imperfect adherence.

Steel plates, which are constructed of a compact metal, are homogeneous, of an equal and constant resistance in all directions, and present quite a different nature of resistance to the pointed head of the projectile, which striking a compact mass cannot penetrate with the same facility, and finding no fibre it can throw back it is broken up, and tends to act like a wedge; in consequence of the rupture of the point, the shot is stopped, producing an effect which, it is true, damages the plate, but thanks to the uniform compactness of the metal of the plate, the penetrating effects of the projectile are destroyed. Progress in the science of artillery has been constant and rapid. The 100-ton gun has already thrown a projectile with a striking force of 550 foot-tons per inch of circumference, and this be will shortly increased to 730 foot-tons. In England the facilities for building heavy guns weighing 160 tons, and even 200 tons, are being discussed, which will be able to impart a far higher striking force to the projectile.

Iron plates, even of enormous thickness, must remain powerless to resist such formidable assaults. Steel alone is capable of opposing itself to shocks of these tremendous magnitudes, and the manufacture of the heaviest armour of whatever kind, is possible and attended with certainty, with the powerful means at the disposal of the metallurgist, and with the certainty of obtaining always a perfectly uniform metal. The struggle between guns and armour has possibly reached its limits, since the experiments at Spezzia have shown the possibility of opposing to the ever increasing power of artillery a shield which can destroy its heaviest projectiles.

FOREIGN AND COLONIAL NOTES.

Locomotives on the Madras.—The expenses in the locomotive department of the Madras Railway were very heavy during the first half of 1876, the time having arrived when many of the engines are beginning from age to require frequent repairs. The cost of these repairs is augmented, in regard to the engines, owing to the difficulty experienced in sparing them for a thorough examination and renewal. Out of 107 engines available for general traffic 93 are in daily use, and the locomotive superintendent states in his report that 36 were repaired during the first half of this year, while 33 were awaiting repair June 30. The present supply of engines is inadequate to the work to be performed, and the old type of construction is not of sufficient power to draw the heavier loads now required; designs are accordingly being prepared for 20 new engines of a more powerful type. There has been a considerable decrease in the cost of the fuel consumed, and a farther improvement is anticipated in future half-years in this respect.

Long Rails.—The South Italian Railway Company has ordered experimentally 1000 tons of rails 40 ft. in length. These rails are expected to present greater stability; a saving is also looked for in the matter of fishplates. Rails 30 ft. in length are now in use between Liége and Namur, and the result has been satisfactory.

English Steam Shipping and the Southern States.—An English Company is stated to have proposed to Governor Smith, of Georgia, to put on a first-class line of steamships between Savannah or Brunswick and Liverpool, and to keep them running steadily, provided the State will give a bonus of 50,000 dols. for three years.

French Rolling Stock.—More rolling stock is being ordered for the great French railways. Thus the Orleans has given out an order for 2000 trucks; the Paris, Lyons, and Mediterranean has also ordered 6000.

New South Wales.—An official calculation shows that at the close of June, 1876, New South Wales had a population of 617,166. The colony will complete 90 years of existence in January, 1877.

The Suez Canal.—The Suez Canal route is now taken by 24 regular lines of steamers employing 234 vessels, of an aggregate burthen of 509,447 tons. The company which employs the greatest number of vessels on this route is the Peninsular and Oriental with 46; the Messageries Nationales (French) and the Austrian Lloyd's have each 18. Small lines of German, Spanish, Italian, and Russian steamers also pass through the canal. With regard to the itineraries of the different steamers, 17 run to the Red Sea and the Persian Gulf; 62 to Bombay; 60 to Colombo, Madras, and Calcutta; 5 to the Mauritius and Réanion; 62 to Cochin-China, China, and Japan; 5 to Rangoon and Burmah; 5 to the Philippines and, 18 to the Dutch Indies.

The Australasian Mails.—The Legislative Assembly of New Zealand has agreed to the following resolution proposed by the Postmaster-General: "That the mail service be direct from San Francisco to Sydney, calling at Honolulu and Auckland or Bay of Islands; that the coast service be performed by 10-knot boats, and that the annual contribution of New Zealand be reduced by 7500*l.* if calling at Auckland, and 10,000*l.* if at the Bay of Islands."

PRICE LIST OF MATERIALS.

THURSDAY, DEC. 21, 1876.

METALS.

	£	s.	£	s
ANTIMONY ORE (per ton)—	14	0	15	0
Regulus (star)	55	0	56	0
BRASS (per lb.)—	s.	d.	s.	d.
Sheets, 48 × 24	0	10	0	10½
Yellow metal	0	7	0	7½
CASTINGS, TYNE AND CLEVELAND, (per ton)—	£	s.	£	s
Girders	5	10	6	15
Chairs	3	5	4	0
Pipes	5	10	6	15
COPPER (per ton)—				
Chili bars	75	10	75	15
Australian	85	0	85	10
English tough, best	80	0	83	0
„ ingot	84	10	85	10
Sheets, &c.	88	0	90	0
Bottoms	89	0	91	0
IRON ORES (per ton)—	s	d.	s.	d.
Red hematite, British	12	0	13	6
„ „ puddling	19	0	21	0
IRON PIG (per ton)—				
Barrow No. 1	67	6	70	0
„ No. 2	62	6	64	0
„ No. 3	64	0	65	0
Cleveland No. 1	49	6	00	0
„ „ 2	47	6	48	0
„ „ 3	46	0	46	6
„ „ 4 (Forge)	44	6	45	0
Other qualities	44	6	45	0
Welsh (South Wales)	75	0	80	0
„ (North Wales)	62	0	78	0
	No. 1.		No. 3.	
Scotch Pig—	s.	d.	s.	d.
G.m.b., at Glasgow	59	6	57	0
Gartsherrie	66	0	58	0
Coltness	71	0	59	0
Summerlee	64	6	58	6
Langloan	66	6	58	6
Carnbroe	60	6	58	0
Monkland	60	0	57	6
Clyde	60	6	58	0
Govan, at Broomielaw	61	0	58	6
Calder, at Port Dundas	66	0	60	0
Glengarnock, at Ardrossan	64	0	58	6
Eglinton, ditto	60	6	56	0
Dalmellington, ditto	60	6	57	6
Carron, at Grangemouth	67	6	—	
Ditto, specially selected	72	6	—	
Shotts, at Leith	65	6	59	6
Kinneil, at Bo'ness	60	0	55	6
(The above all deliverable alongside)				
	s.	d.	s.	d.
Shropshire	80	0	92	6
North Staffordshire	62	0	70	0
South „	62	0	87	0
Yorkshire Thornaby pig.	60	0	70	0
Ridsdale Nos. 1 and 2	105	0	110	0
IRON, WROUGHT—	£	s.	£	s.
Cleveland angles	6	15	6	17
„ bars	6	7	6	10
„ boiler plates	8	0	8	10
„ rails	6	0	6	5
„ ship plates	7	5	7	7
„ sheets	8	0	8	10
Scotch bars	7	0	7	10
„ nail rods	8	0	8	10
Staffordshire bars	6	15	8	10
„ plates	8	15	10	10
„ boiler	10	0	12	10
„ hoops	8	15	10	10
Welsh rails, S.W.	6	5	6	15
„ bars „	6	10	7	10
„ boiler plates, S.W.	10	0	12	0
„ hoops, S.W.	8	0	9	10
LEAD (per ton)—				
Soft English pig	22	0	22	15
„ „ W.B.	22	10	22	15
Other brands	21	10	00	0
Sheet	22	0	23	10
PHOSPHOR BRONZE— (per ton)	112	0	140	0
QUICKSILVER (per bottle)	8	5	8	10
SCRAP (per ton)—				
Old rails for re-manufacture	4	10	5	0
Old steel scrap	5	0	6	0
SPELTER (per ton)—				
Silesian, ordinary	21	15	00	0
SPIEGELEISEN (per ton)—				
Best	6	0	6	10
Common	5	0	5	10
STEEL (per ton)—				
Best cast	34	0	50	0
„ double shear	45	0	65	0
„ single „	32	0	50	0
English spring	14	0	22	0
Blister	00	0	00	0
Milan	28	10	30	0
Bessemer rails	7	10	8	0
„ tyres	11	0	13	0
„ axles	11	10	13	0
„ billets	7	10	8	10
„ ingots	7	0	8	0
SWEDISH IRON (F.o.b.) at Gottenburg—				
Pig	5	0	5	15
Bar rolled	12	0	13	0
„ hammered	15	0	16	0
TIN (per ton)—				
Straits	76	0	00	0
Billiton	76	0	78	0
Banca	75	0	77	0
English ingots	80	0	00	0
TIN—*Continued.*	s.	d.	s.	d.
English bars	78	0	79	0
English refined	80	0	81	0
Australian	75	0	00	0
TIN PLATES (per box)—				
I. C. charcoal	24	0	28	0
IX. „	30	0	31	0
I.C. coke	19	6	23	0
I.X. „	24	0	26	6
ZINC (per ton)—	£	s.	£	s.
Sheets, English	25	15	26	0
WIRE, Fencing	11	10	15	10
„ Telegraph (galvan'sd)	17	5	21	10

COALS AND COKE.

COALS (per ton)—	s.	d.	s.	d.
Barrow	10	0	12	6
Bristol	9	0	10	6
Derbyshire	8	0	10	6
Lancashire	8	0	11	0
Newcastle and Durham	8	0	12	6
Scotch	7	0	11	6
Staffordshire	8	0	11	0
Welsh	9	0	11	0
Yorkshire	8	0	11	0
COKE—				
Cleveland	9	6	12	0
Durham	22	0	24	0

OILS, GREASE, & LUBRICATORS.

OILS (per tun)	£	s.	£	s.
Seal, brown	29	10	32	10
„ pale	33	0	33	10
Sperm head	85	0	86	0
Whale, pale	34	10	35	0
„ yellow	31	0	32	0
„ brown	28	10	30	0
GLUE	35	0	80	0
PETROLEUM—	s.	d.	s.	d.
Fine (per gallon)	2	2	2	3
„ spirit	1	6	0	0
PITCH (per cwt.)—				
British	8	0	8	6
Archangel	12	0	12	6
PLUMBAGO (per cwt.)—				
Ceylon lump	12	9	15	6
„ chips	10	0	11	0
„ dust	8	0	9	0
Italian	0	0	0	0
RAILWAY GREASE (per cwt.)—Rose's	28	0	00	0
RESIN (per cwt.)—				
American	6	9	7	0
TALLOW (per cwt.)				
S. American beef	43	0	43	3
„ sheep	42	6	43	6
Australian beef	42	0	42	6
„ sheep	42	6	43	6
St. Petersburg, Y.C.	45	0	45	6
English, town	41	0	41	6
Rough, English	13	6	14	0
TAR—Stockholm (per barl.)	19	0	20	6
Archangel	16	6	17	6
TURPENTINE—Spirit—				
American (casks)	35	0	00	0
WIPINGS, engine	20	0	35	0

CHEMICALS, &c.

ACIDS—	s.	d.	s.	d.
Aquafortis (per lb.)	0	4¾	0	5
Sulphuric acid (per lb.)	0	0¾	0	1
Sulphuric acid, brown	0	0½	0	0¾
AMMONIA — Muriate (per ton)	£ 28	s. 0	£ 35	s. 0
ARSENIC—	s.	d.	s.	d.
White, lump (per cwt.)	26	0	27	0
Powdered (per cwt.)	9	6	10	0
BLEACHING powder per cwt.	7	0	7	9
BORAX—refined (per cwt.)	42	0	43	0
BRIMSTONE (per ton)—	£	s.	£	s.
Rough	6	10	7	10
Flour	12	0	12	6
Roll	10	0	10	6
COPPERAS — green (per ton)—	54	0	56	0
COPPER — Sulphate (per cwt.)	22	0	24	0
LEAD, SALTS, &C., (per cwt.)—				
Acetate, best	37	0	38	0
Brown „	23	0	26	0
Red	23	3	26	0
White	28	0	28	6
LITHARGE (per cwt.)	25	0	37	0
POTASH—Bichromate (per lb.)	0	4½	0	5
SALTPETRE (per ton.)				
English refined, kegs	22	0	22	0
Bombay	18	6	19	0
Bengal	20	3	20	6
SODA Caustic	13	6	13	9
TINCAL (Bengal)	25	0	26	0

TIMBER, DEALS, &c.

LONDON.

(Per Petersburg standard)	£	s.	d.	£	s.	d.
Archangel 1st yellow	16	10	0	18	0	0
„ 2nd „	12	10	0	14	10	0
Petersburg	15	5	0	17	10	0
Wyburg	11	10	0	12	10	0
Petersburg & Riga white	9	0	0	11	10	0
Christiana deals, best sorts, yell. and white	13	5	0	14	10	0
Norway deals, other sorts	8	0	0	11	10	0
Norway battens, all sorts	6	0	0	9	0	0
Swedish deals mixed	12	10	0	16	10	0
Swedish deals 3rd	12	0	0	13	10	0
Swedish deals, inferior and 4th	9	5	0	11	0	0
(Battens 30s. less than deals)						
Finland deals 1st	11	10	0	13	10	0
„ battens	9	10	0	12	0	0
„ H. S. deals	7	10	0	8	10	0
„ H. S. battens	7	0	0	8	0	0
AMERICAN DEALS—						
Quebec 1st bright pine	21	0	0	25	10	0
„ 2nd „	12	10	0	15	15	0
„ 3rd „	9	0	0	11	0	0
Floated pine 40s., 20s., and 10s., less for 1st, 2nd, and 3rd, respectively.						
Canadian spruce, 1st	10	0	0	12	0	0
„ „ 2nd	8	10	0	9	5	0
„ „ 3rd	7	5	0	8	0	0
New Brunswick spruce	8	0	0	8	10	0
Ditto battens	7	10	0	8	0	0
N. S. & P. E. Isle spruce	7	10	0	8	10	0
U. S. pitch pine	12	10	0	13	10	0
AMERICAN TIMBER—(per load)						
Red pine (mixed and building)	3	12	0	4	0	0
Do. for yards and spars	4	10	0	5	0	0
Yellow pine, large	5	0	0	5	10	0
Ditto waney board	4	0	0	5	0	0
Ditto small	3	15	0	4	0	0
Pitch pine	3	0	0	3	15	0
Oak, Quebec	6	0	0	7	0	0
Do. United States	5	0	0	5	10	0
Elm, Rock	4	10	0	0	0	0
Ash	4	0	0	5	0	0
Birch, Quebec large	4	15	0	5	10	0
Masts, red pine	4	10	0	5	3	0
„ Oregon	7	10	0	8	10	0
„ Kawrie	8	0	0	10	0	0
Indian teak	11	0	0	13	0	0
British Guiana greenheart	8	5	0	4	0	0
Australian ironbark	6	0	0	7	10	0
BALTIC TIMBER (per load)						
Riga fir	3	10	0	4	5	0
Dantzic and Memel crown	4	0	0	5	10	0
„ 1st middling	3	5	0	4	10	0
„ good, middling, and 2nd	3	3	0	4	0	0
„ common middling	2	15	0	3	0	0
„ undersized	2	12	0	2	15	0
„ small, short, and irregular	2	6	0	2	10	0
Stettin	3	0	0	3	10	0
Swedish	2	10	0	2	15	0
„ small	2	5	0	2	15	0
„ and Norway balks	1	16	0	2	5	0
FLOORING BOARDS (per sq. of 1 in.)—						
First yellow	0	14	6	0	15	6
„ white	0	12	0	0	13	0
Second qualities	0	10	0	0	12	0

The above prices "at the Docks."

LIVERPOOL.

WHOLESALE PRICES OF TIMBER, DEALS, &C. FROM BRITISH NORTH AMERICA.

PINE TIMBER (per cubic foot string measure)	£	s.	d.	£	s.	d.
Quebec yellow square	0	1	6	0	2	2
„ Waney board	0	2	0	0	2	6
St. John's, N. B., 18 in.	0	2	2	0	2	4
Miramichi and British Chaleur	0	1	2	0	1	9
Richibucto	0	1	4	0	1	8
Nova Scotia and Prince Edward Island	0	1	4	0	1	8
Quebec red	0	1	4	0	1	7
Oak, Quebec	0	2	3	0	2	11
Elm „	0	1	9	0	2	4
Ash „	0	1	6	0	2	0
Whitewood	0	1	9	0	2	8
Walnut, Canadian and United States	0	3	0	0	4	6
Birch, St. John's, &c. N.B.	0	1	4	0	1	9
„ Quebec	0	1	0	0	1	10
„ Nova Scotia and Prince Edward Island	0	1	2	0	1	5
Masts, Quebec 1st. yellow (calliper)	0	2	6	0	3	0
DEALS AND BATTENS (per Petersburg standard)						
Quebec yellow pine, 1st	19	10	0	22	0	0
„ „ „ 2nd	12	15	0	15	0	0
„ „ „ 3rd	9	10	0	10	10	0
St. John, Bangor, &c., spruce	7	10	0	7	12	6
Ditto, other ports	7	0	0	7	10	0
St. John mixed pine	7	2	6	7	5	0
Boards, pine	7	10	0	8	10	0
„ spruce	6	15	0	7	5	0

FROM THE UNITED STATES, EAST AND WEST INDIES, AND AFRICA.

(Per cubic foot, string measure)	£	s.	d.	£	s.	d.
Pitch pine, hewn	0	1	4	0	1	6
„ sawn	0	1	3½	0	1	6
United States oak logs	0	2	5	0	2	11
(Per load calliper measure)						
East Indian teak (per ld.)	11	0	0	11	5	0
African teak	7	5	0	7	10	0
Greenheart	7	5	0	7	10	0
Demerara Morra	6	5	0	6	10	0
Bullet tree (per foot)	0	2	3	0	2	6

FROM THE BALTIC, &C.

(Per cb. ft. string measure)	£	s.	d.	£	s.	d.
Fir timber, Riga red	0	1	2	0	1	8
Fir timber, Dantzic and Memel crown	0	1	6	0	1	9½
Ditto, ditto, other kinds	0	1	2	0	1	7
Stettin	0	1	2	0	1	7
Swedish	0	1	1	0	1	3½
Norway	0	1	0	0	1	1
WAINSCOT (Logs calliper measure)						
Riga, &c., crown	0	6	6	0	7	6
Ditto brack	0	4	6	0	5	6
Oak timber, Dantzic (string measure)	0	2	2	0	2	5
Pit props per lineal yard	0	0	2¼	0	0	4
Mining timber per foot	0	0	10	0	1	0
DEALS, &c.—						
(Per Petersburg standard)						
Redwood, Archangel, and Onega, 1st	17	10	0	19	0	0
Ditto, ditto, 2nd	13	0	0	16	0	0
Ditto, ditto, 3rd	11	10	0	13	0	0
Redwood, Petersburg 1st	17	0	0	18	0	0
„ „ 2nd	13	0	0	14	5	0
„ Wyburg	11	5	0	13	10	0
„ Uleaborg	10	10	0	12	10	0
„ Gothenburg	11	10	0	15	0	0
„ Memel	10	10	0	12	0	0
„ Gefle and Stockholm	13	0	0	16	0	0
MAHOGANY, &c. (per foot 1 in.)						
City St. Domingo	0	0	7½	0	1	6
Cuba	0	0	6	0	0	10
Sabicu	0	0	5	0	0	7
Cedar, Havana, &c.	0	0	3½	0	0	6¼
Sleepers, Hackmatack, each 9 × 10 × 5	0	3	6	0	4	0
„ Pine „	0	3	0	0	3	6
„ Hemlock „	0	2	3	0	2	6
„ Fir	0	2	9	0	3	3

HULL.

(Per load).						
Memel crown fir timber	4	7	6	4	10	0
„ „ 2nd	3	10	0	3	15	0
Riga and Dantzic 1st	4	5	0	4	10	0
„ „ 2nd	3	0	0	0	0	0
Swedish	2	17	6	3	0	0
„ small	2	5	0	2	10	0
Mining timber	2	2	6	2	5	0
(Per cubic foot).						
Quebec elm	0	2	8	0	2	9
„ birch	0	1	10	0	2	0
„ ash	0	2	3	0	2	6
St. John's birch	0	1	10	0	2	0
Pitch pine, hewn	0	1	5	0	1	8
„ „ sawn	0	1	5	0	1	9
(Per Petersburg standard).						
Best Arch. and Onega red	19	5	0	20	10	0
„ Petersburg red	18	10	0	19	10	0
Wyburg red	14	10	0	15	0	0
Quebec 1st pine	24	0	0	26	10	0
„ 2nd „	16	15	0	18	10	0
„ 3rd „	12	10	0	13	10	0
„ 4th „	8	5	0	11	10	0
Quebec spruce	8	10	0	9	10	0
Baltic 1st red flooring bds.	14	0	0	14	15	0
Ditto white	12	0	0	12	5	0

Charge for labour 2s. per standard for deals, &c., and 1s. 6d. per load for timber.

WEST HARTLEPOOL.

(Per cubic foot)						
DANTZIC crown fir 13 in., average 12 ft. to 19½ ft.	0	1	5	0	1	
Ditto good middling ditto 13 in., average 12 to 16½ ft.	0	1	3	0	0	0
Ditto ditto, 17 ft. to 21½ ft.	0	1	4	0	1	4½
Ditto common middling fir 13 in. average 22 ft. & up.	0	1	1½	0	0	0
(Per load.)						
Rectangular red fir sleepers, 9 ft., 10 × 5	2	6	3	2	7	6
(Per Petersburg standard.)						
Riga crown white deals	10	2	6	10	5	0
Ditto half crown	9	10	0	9	12	6
Gefle 1st red deals	17	15	0	18	10	0
„ 2nd „	14	2	6	14	10	0
„ 3rd „	12	2	6	12	10	0
„ 4th „	10	5	0	10	7	6
Tunadal 2nd red deals	13	10	0	17	12	6
„ battens	12	10	0	13	10	0
„ 3rd red deals	12	0	0	12	2	6
„ battens	10	5	0	11	5	0
Gottenburg 2nd red battens	12	10	0	12	15	0
„ 3rd „	11	0	0	0	0	0
Petersburg 1st red deals	18	5	0	19	0	0
Quebec 1st pine 3in. × 7 in. and upwards	24	0	0	24	5	0
Ditto, ditto, 2nd	16	0	0	0	0	0
Ditto, ditto, 3rd	11	0	0	0	0	0
Wyburg 1st red battens	11	10	0	12	5	0
„ 2nd „ deals and battens	10	5	0	11	12	6

Charge for labour 2s. per standard for deals, &c. and 1s. 6d. per load for timber.

WISBEACH.

(Per Petersburg standard.)						
Memel 2nd red deals	12	5	0	12	10	0
„ 3rd „	11	5	0	0	0	0
Gefle 3rd red deals	12	10	0	13	0	0
Gothenbrg. 2nd red deals	13	5	0	13	7	6
„ 3rd „	12	0	0	12	2	6
Petersburg 1st red deals	18	5	0	18	10	0
„ „ „ battens	16	15	0	0	0	0
„ „ white deals	11	10	0	13	5	0
„ „ „ batts	10	15	0	0	0	0

Free on railway trucks.

NEW SOUTH WELSH RAILWAYS.—The works on railway extensions in hand in New South Wales are being steadily proceeded with, and there is a prospect of two sections being shortly opened for traffic. The western line will be completed in a few days to Blayney; it will also be opened to Orange in February, 1877. The Blayney extension will add 27 miles to the present length of the Great Western system. The Great Southern line was opened in October to Binalong, a further distance of 14 miles; and in January, 1877, it will be further completed to Murrumburrah. When the latter section is ready for traffic, the length of the Great Southern will be carried to 228 miles. With regard to the third trunk line of the colony—the Great Northern Railway—it is expected that an extension to Quirindi, 25 miles in length, will be ready in January, 1877.