THE GOHNA LANDSLIP AND FLOOD.

It will be remembered that a mighty landslip occurred in the end of the year 1893 in one of the outliers of the Himalaya Mountains, on the north-west frontier of India. This, by blocking up the Birahi Gunga, one of the tributaries of the river Ganges, led to the formation of a large lake whose waters threatened, as soon as they had accumulated sufficiently to overtop the obstruction caused by the landslip, to overwhelm the valley below. The story is now two years old, yet so slowly do the official mills grind that up to the present—as we believe—no authoritative report has been presented to the public of the occurrence, and the measures adopted to meet the catastrophe. The first complete account of the event has come to us in a paper read before the Imperial Institute by the Secretary of the Indian Section, in the absence of its author, Mr. J. H. Glass, C.I.E., a chief engineer of the Bengal Public Works.

Seldom has the paternal care with which the Government of our Indian Empire safeguards its subjects been more clearly exemplified than in the case before us, when an enormous volume of water suddenly hurled itself along the river valley at the dead of night, raising the river in many places more than 100ft. above the level of ordinary flood, yet without causing, so far as is known, the loss of a single human life.

Gohna, where the landslip happened, is a small village of 200 souls situated in latitude 30 deg. 22 min. 18 sec. N., and longitude 79 deg. 31 min. 60 sec. E. in Garhwal, in the N.W. Province of British India. It lies on the right bank of the Birahi Ganga, a tributary of the Alaknanda river, which, after its junction with the Bhagirathi at Deopryag, sixty-two miles above Hardwar, is henceforth known as the Ganges.

At Hardwar, 150 miles below Gohna, the river passes through the last gorge in the hills and debouches on the plains of Northern India. Between these two places its course lies in narrow ravines, and this part of the river, famous as the resort of Hindoo pilgrims, is along its margin studded with sacred stations and holy shrines, between which streams of devotees pass to and fro.

The valley in general is sparsely inhabited, Srinagar, with a population of 2000, being the largest town, and the cultivation scant; yet in case of an unexpected release of the accumulated waters, owing to the presence of the pilgrims and the surrounding circumstances, the loss of life might have been immense, and the destruction of property would have been enormous if sufficient and timely precautionary measures had not been adopted.

Just below Hardwar, at Maiapur, on the river, are situated the headworks of the great Ganges Canal, and serious injury to this work would have caused enormous loss to the Government and the agricultural community, as well as doing incalculable damage to the country below, over which so large an area of cultivation with its revenue is dependent on irrigation by the canal.

The problem, therefore, that the Government set before itself in dealing with the catastrophe was to prevent, if possible, all loss of life among the pilgrims and villagers on the road leading to the shrines and in the valley, and to save from destruction, as much as could be done, all public and private property within the probable range of the avalanche of waters that was expected to result from the bursting of the dam formed at Gohna.

In connection with the measures to be adopted, the first and most important point to decide on was the period the lake would take to fill and overflow. In the nature of the case the data on which to base calculations were most insufficient; yet it speaks well for the care and judgment of the engineers that, when the surveys and contours of the basin were effected, and the rainfall and snowfall during the year on the catchment duly considered, the forecast of the date on which the barrier would be overtopped was only ten days earlier than the date—the 25th of August—on which the event acually occurred. The 15th of August was thus the date fixed as that by which all preparations for the overflow should be complete.

The first and chief precautionary measure was the construction of a telegraph line between Gohna and Hardwar, following the river course, and having stations at all important points along the line. It was decided that there should be in all ten telegraph signalling stations, selected with regard to their importance as camps or halting places for the pilgrims on their journey along the river. This provision, besides relieving the suspense both of the public and officials at the most critical periods, and facilitating operations generally, avoided the necessity that would have otherwise existed of closing the road along the valley used by the pilgrims; to have stopped all traffic would have inflicted great hardship on the people and been an extremely unpopular measure. This road admits only of foot traffic, but the Government has spent considerable sums of money on its improvement. Suspension bridges have been built, precipitous paths eased off and rendered safe, and bazaars established along it to provide the pilgrims with supplies. It was decided to dismantle the permanent suspension bridges along the road, and replace them by temporary rope structures, and this was done except in two cases, where at the special request of the local authorities, two bridges were left, which, in their opinion, were safely beyond any flood likely to occur. As a result, these bridges were completely wrecked.

Further, it was arranged to erect masonry signal pillars in the valley at a level of 200ft. above ordinary flood from Gohna to Srinagar, and at 100ft. above the same datum in the valley below Srinagar. These pillars were 4ft. square and 6ft. high, and were erected at all villages and camping grounds; and elsewhere at intervals of half a-mile; they marked a limit below which it would be unsafe for people and their property to remain after warning of the approach of the flood had been issued.

So much for the precautions above Hardwar; below it the safety of the headworks of the Ganges Canal demanded earnest attention, as a heavy flood bursting into the canal might not only carry the headworks away, but also seriously injure the great torrent works and falls as far as Roorkee. The following protection works were therefore carried out:—A massive crate dam filled with heavy boulders was constructed between the river weir and the canal head, with embankments leading to the rising ground to prevent the headworks from being outflanked by the flood. The canal head-gates were strengthened to make them better able to resist the exceptional head of water against them. Subsidiary boulder "bunds," or banks, were erected to prevent outflanking, and other minor provisions adopted. In the low lands, in the ninth mile of the canal, and immediately above the embankment of the Solani Aqueduct in the sixteenth mile, the canal banks were lowered so as to provide temporary escapes, which would relieve the canal and thus possibly aid in saving the great masonry works on the canal lower down at Roorkee, in case of the flood bursting into it at the headworks.

According to native reports—for no European, scientific or otherwise, visited the site till some time afterwards—what happened at Gohna was this:—In September, 1893, an enormous mass of material from the mountain of Maithana, on the right bank of the Bhirai Gunga, slipped into the river; and again in October of the same year there was another great fall. The mountain itself is 11,000ft. high, and the part of it from which the mass fell is 4000ft. above the bed of the stream. The material consisting of earth and rock came down with a deafening noise, and the neighbourhood for miles around was enveloped in clouds of dust, which whitened ths ground and the branches of trees like a fall of snow. The magnitude of the barrier formed across the stream by the landslip may be judged by the following rough measurements: The height was 900ft., the length measured across the gorge was 3000ft. along the top, and 600ft. at the bottom; and in cross section it was 2000ft. at the top and 11,000ft. at the base, so that the side slopes must have been about one in five.

It was calculated from the contoured map of the valley, prepared by Lieut. Crookshank, R.E., the officer in charge of the operations, that the area of the lake which would be formed, when the water was at the level of the top of the dam, would be thirty-seven millions of square feet, or say, 1¼ square miles and its contents roughly estimated would be 16,650 millions of cubic feet. Its catchment was about ninety square miles, and was bounded on the north by a snow-clad ridge of the Himalayas rising to altitudes of 21,200ft. above the sea level.

The longitudinal bed fall of the Birahi Gunga is about 250ft. per mile at Gohna, and its course bends nearly at a right angle immediately below the site of the slip. It runs entirely through ravines with steep precipitous sides, grass covered at the base, and higher up clothed with oaks, firs, and rhododendrons.

The phenomenon of the landslip was adjudicated by an expert of the geological department to have been due to a combination of causes; such, for instance, as the alteration of the chemical condition of the substance of the strata, the solution of substance and reduction of friction among the beds by the action of water, all of which tended to prepare the mass for motion, while the expansion resulting from atmospheric effect, with changes of temperature seconded by hydrostatic pressure, may most probably have caused an impulse in the direction of least resistance, and thus produced the slip. An interesting report on the subject is published in the records of the Geological Survey of India, in which the author of the paper concludes with the following words:—"It may be of interest to remind the general reader of the fact that the folding of the Himalayan range having continued to times geologically recent, if not still in action, there has resulted a condition of strain frequently manifesting and relieving itself by earthquakes; and of steep slopes with rushing torrents, frequently resulting in landslips. When subsequently the inequalities of level have been sufficiently reduced by denudation, the slope will be more stable, rivers less violent, and the scenery tamer—a condition of affairs exemplified by the more geologically old-fashioned peninsular portion of India. Water, the great agent of denudation, has by its chemical and physical action been the cause of the landslip at Gohna."

The periodical rains commenced early in June, but before the end of July all arrangements were completed. The waters of the lake had for some time back been rising rapidly, owing to heavy rain and the melting of the snow on the mountains, and on the 9th there was a downpour on the dam itself. On the 10th of August the first symptoms of the approaching collapse developed themselves in the shape of a serious slip of the down stream face of the dam, leaving an almost perpendicular scarp of some 400ft. high. The section thus exposed showed a layer of stones at the top resting, so far as could be seen, on pulverised rock.

The first note of warning was in consequence of this slip telegraphed on the 11th August down the river to all concerned. Percolation became very copious, and a considerable stream, about 300 cubic feet per second, was to be seen running over the boulders of the former river bed laid bare by the slip of the dam. The water level was at this time within 50ft. of the top of the dam, and it was estimated that in fifteen days the overflow would take place.

On the 22nd, Lieutenant Crookshank essayed to hasten events by making a small cut through the crest of the dam, and thus hoped to produce the overflow early in the morning of the 24th, it being important that the flood should take place in the daytime; but owing to increased percolation and diminished rainfall in the interval, the lake rose more slowly than expected, and the first overflow did not take place till 6.35 o'clock on the morning of the 25th of August.

At first the destructive action of the water was slight, but before long the immensely increased percolation caused a rapid cutting back of the dam, and at 2 p.m. a message was despatched down the line announcing that the flood might be expected during the night. Unfortunately, at this time a thick mist had descended on the scene, and all the provisions for observing the subsidence of the water in the lake, and the action of the flood when passing over the dam, in the shape of masonry bench marks, were rendered nearly useless. These bench marks were placed on the top of the down stream face of the dam, at 50ft. apart, and numbered consecutively in large figures so as to be plainly observable from the sides of the valley. Their object was to allow of a reliable record being made of the way in which the water, when discharging itself, cut away the material of the dam. The rate at which the water of the lake subsided was to have been recorded every hour by observations of other bench marks placed on the hill side, and as the valley had been carefully contoured at verticals of 1ft., the outflow could have been easily calculated. In addition to the above arrangements at the lake, other bench marks were placed at observing stations down the river. By numbers on these the rise of the floods passing could be accurately observed by daylight, and at night lighted lanterns were placed on them at vertical intervals of 10ft.; the lights, as the waters rose, were extinguished, and thus the flood heights could be estimated.

At 11.30 p.m. a loud crash was heard, and in spite of the mist and rain, the air was filled with a fine dust which rose from the site, and so far as could be ascertained, the dam was completely breached, a fact at once telegraphed down the valley. The rush of water was very great, but owing to the atmospheric conditions it was impossible to gauge the discharge. At five in the morning, although the valley was full of mist and the light very unsatisfactory, it became evident that a considerable fall had taken place in the level of the lake, and the authorities at Hardwar were warned to expect a great flood. It was calculated that 10,000 millions of cubic feet of water had been discharged in the space of 4½ hours, as the lake had fallen 390ft. At the gorge immediately below the dam, the flood rose to 260ft. over its ordinary level. The valley was filled up with huge blocks; and the bed of the river was raised some 234ft., by a substantial weir with a long gentle slope stretching far down the valley. At thirteen miles down, the river bed was raised 50ft. by the *débris* deposited, and the flood reached a height of 160ft. above its ordinary level.

All down the valley, for fifty odd miles, the flood rose from 113ft. to 140ft., causing serious damage. Even at Shrinugar, seventy-two miles from the landslip, the flood, which was first observed at 3.25 a.m., attained a maximum height of 42ft. above ordinary flood level. Here the damage done was great. The entire town, with the Rajah's palace and the public buildings, were destroyed, and a thick layer of stones, sand and mud, deposited over the area. Several small villages in the valley, which here opens out into a large amphitheatre of between three and four miles long and one mile wide, were completely swept away. The flood reached Hardwar, 150 miles from Gohna, at 8.45 a.m. on the 26th August, and obtained a maximum height of 11ft. above the ordinary flood level. Fortunately, the main river was low at the time—lower, in fact, than at any time during the previous month. Had the extra Gohna flood arrived on top of one of the very heavy normal floods of the previous thirty days, the canal must have suffered grave disaster. As it was, considerable damage was done. The revetment walls at Hardwar and the marginal "band" or dam were topped, and the diversion channel breached. Four out of seven of the sluices in the Maiapur dam were put out of action by the *débris* brought down, and though the crate dam was not topped, yet some water broke into the canal through the head. In the town itself the flood is reported to have stood 6ft. deep in the main streets. The velocity of the torrent was gauged by observing the time that blocks of wood or other floating bodies took to pass between fixed points of known distances apart. By this method it was estimated that the average velocity of the flood in the upper seventy miles of its course was 26ft. per second, but in the stretch of twelve miles below Gohna it is considered that a maximum of at least 40ft. per second must have been attained.

At Srinagar a curious phenomenon occurred. Below the town the open valley contracts suddenly, at the Jakhni Gorge, and the bed is narrow and the sides precipitous. The effect of this conformation was that the flood water after spreading out at Srinagar was abruptly contracted at the gorge and a strong swirling backwater current was set up. The furious rush of this eddying water was terrifying in the darkness of night close below the observers, and many who had been securely placed in temporary shelter huts fled in terror still higher up the mountain side.

Although the greatest care was taken to keep down the expenditure, and every proposal was submitted to the strictest scrutiny, yet the total of the loss to Government and the outlay in measures for the protection of the life property of the people, the former of which formed a first consideration, amounted to Rs. 2,500,000. Of this sum the destruction of bridges and buildings down the valley as far as Hardwar may be taken as Rs. 100,000. The cost of the telegraph line and the housing of the staff engaged in the operations amounted to about Rs. 90,000, and the protection work, added to the repairs of the damage done by the flood to the Ganges Canal, is estimated at Rs. 50,000. The loss caused to private individuals has not been estimated.

The loss of life has been nil, if we except the case of the Gohna fakir and family; these perished in the slip of the dam slope on August 11th, a result due to their own fatuous obstinacy, and not necessarily a consequence of the flood. The fakir had persisted in remaining in a very dangerous position below the dam, though he had repeatedly received orders to leave it. He and his family had twice been forcibly removed; but each time they had returned, and were eventually overwhelmed in the slip, which we have described as taking place in its rear slope previous to the total failure of the dam.

One of the results of the landslip from the mountain is that a lake of considerable size has been established at Gohna. Its dimensions are about two miles long by a mile wide, and it has a maximum depth of 300ft. The large rocks and residual *débris* have been so consolidated and packed by the flood, that they now form a massive and solid dam or weir which is not likely to be disturbed, so that the lake is probably a permanent one, and Gohna may one day prove a pleasant resort from the plains below.

Naturally, while the preparations to meet the flood of 1894 were in progress, many criticisms were made on the operations in the public papers, and much advice was offered to the Government, both publicly and privately.

The chief question taken up by the influential section of the public was the advisability of cutting a channel through the dam to facilitate the escape of the water before it reached the full height of the obstruction. This proposal was set aside for the reason that the mass of water which would in any case be headed up, and must eventually cut through the upper layers of the dam, would cause a serious flood of practically the same intensity as if the dam were untouched, and because of the great expense, if not the impossibility, of making a sufficient cut within the time available. For example, a cut of, say, 50ft. deep would have still left over 700ft. of water in the lake, and have had no appreciable effect in lessening the flood; while the whole army of labourers to do the work would have had to be imported, housed, and fed in an almost inaccessible country during a season of heavy rainfall, at an estimated cost of three lakhs of rupees or more. Considerations, too, in connection with the danger at the temporary headworks, which are put up yearly at Hardwar for the purpose of supplying the Ganges Canal with water in the dry season, led Government to reject the proposal as a wasteful extravagance with no practical advantage.

Various other suggestions were rejected for different reasons, and some persons even urged that there would be no cutting back and no flood, but that the water would quietly pass over the crest of the dam and down the face of the talus, and so into the regular river channel, producing no more damage than an ordinary flood.

Other objectors urged that the velocity of twenty miles an hour, at which rate the flood was calculated to escape down the river, was exaggerated and impossible. Some ridiculed the provision of the safety pillars as an arbitrary and absurd arrangement. And the construction of the telegraph was set down as a wasteful extravagance, and the dismantling of the bridges was held to be quite unnecessary. However, the success which attended the operations sanctioned by Government was greater than could have been anticipated, and no higher testimony is possible to the efficiency of the protective measures, and to the care with which they were carried out, than that the people themselves recognise and are grateful for the consideration they have received in the precautions which were taken for their safety. We have no doubt that the recollection of the beneficent care shown by Government for the preservation of their lives and the protection of their property will remain for ever fresh in their memories. It speaks well for the administration of Sir Charles Crosthwaite, K.C.S.I., that the situation was so promptly and firmly grasped, and to prove that such has been the case, and to judge of what might have happened otherwise, we have only to compare the record of this flood with that of 1868. The latter flood was due to a similar cause, viz., the bursting of a lake, probably also formed by a landslip, at no great distance from Gohna, and it does not appear that any precautions, such as in the present instance, were taken to meet it. At that time Sir Henry Ramsay was Commissioner at Kumaon, and in reporting the occurrence of the flood to Government, he stated that several bridges along the valley had been carried away, and that some houses, crowded at the time by pilgrims on their way, were submerged. The accumulated waters, he adds, came down so suddenly at night that there was no warning, and only a few pilgrims —most likely awakened by the noise of the rushing waters—were able to run up the hill and escape; all the others with the houses were swept away. Much animal life was lost and a considerable amount of property destroyed.

THE ENLARGEMENT OF LIVERPOOL-STREET STATION, GREAT EASTERN RAILWAY.

BRIDGE AT WORSHIP-STREET.

IN carrying out the extensive works in connection with the widening of its metropolitan terminus, the Great Eastern Railway Company found it necessary to bridge over, stop up, divert, and otherwise unavoidably to interfere with several of the old streets, lanes, passages, and thoroughfares situated in the line of the new route. Among other collateral undertakings, three large over bridges were required to be built to carry Worship-street, Primrose-street, and Skinner-street, across the numerous lines of track all converging towards, and having for their common focus, Liverpool-street Station. All these three structures are on the skew, that at Worship-street, which we now intend describing and illustrating, forming an angle of 60 deg. with the line of roadway overhead. A general elevation of the bridge is shown in Fig. 1, and a plan in Fig. 2. From the former figure it will be seen that the main girders belong to what is known as the bastard type, that is, a form which is a cross between the horizontal lattice or open web girder, with parallel booms, and the bowstring. While, therefore, embodying in its design and construction the characteristics of the straight lattice, so far as the lower boom and web bracing are concerned, it trenches upon the bowstring type by the curvature of the upper boom. The vertical members shown in Fig. 1 are necessitated by practical requirements connected with the peculiar double section of the booms, which will be apparent when we proceed to treat of the details of their construction. Besides, vertical members are common to both types. Theoretically, the result of curving the upper boom of an open web girder is to increase the stresses towards the ends of both booms, while at the same time relieving the diagonal struts and ties in the web generally of a portion of the shearing stress. Practically, the effect is to impart a more graceful appearance to the contours of the structure, as in the example before us. Besides, the amount of curvature is small, and not sufficiently great to occasion much alteration in the nature of the stresses.

The span of Worship-street bridge is 73ft. on the square and 85ft. 7½in. on the skew. The height from rail level to the lowest point of the lower boom of the main girder is 14ft., and the distance from the same datum to the level of the roadway 20ft. 3in. At the centre, including cover plates, the depth from out to out is 10ft. 2in., diminishing to 7ft. 2in. at the ends over the bearings. From centre to centre the main girders are 43ft. 2in. apart, which dimension allows for a roadway 24ft., and two footpaths, each 8ft. wide respectively. The vertical members or diaphragms, which connect the two separate sections of the upper and lower booms, divide the span of the main girders into eleven bays, consisting of a pair of diagonal struts and ties riveted together at their central intersection. All the bays, except the two short ones forming the ends of the girders, are 8ft. in width, and, where the dividing diaphragms are riveted to the lower booms, the cross girders are attached. There are thirteen of these altogether, of which nine in the general plan, Fig. 2, run from one main girder to the other, and the remaining four rest partly upon girders and partly upon the abutments. A general cross section on the square, in Fig. 3, shows the double section of the upper and lower booms of the main girders, the cross girders, which are of the solid web or plate description, and a section of the side screens and supports. Over the bearings at the abutments the manner in which the bed plates and ends of both main and cross girders are arranged is indicated in Figs. 4 and 5, while Fig. 6 is a section through the line A A in Fig. 5, and shows the construction of the abutments, counterforts, and their foundation of concrete, 2ft. 3in. in thickness.

A half elevation of one of the principal girders, 97ft. 7½in. in total length, is given in Fig. 3*a*, a half sectional and half plan, or an inside and outside plan of the booms, in Figs. 7 and 11, together with elevations to a distorted scale of the number of plates and angle irons composing the upper and lower booms in Fig. 4. There are in each boom, not including the long extra plate doing duty as a cover plate or wrapper over all, seven horizontal flange plates, all 1ft. 6in. in width by ½in. in thickness, and varying in length from 29ft. 10in. to 10ft. 10in., riveted to the angle irons of the flanges by rivets ⅞in. in diameter, with a pitch of 4in. from centres. The flange angle irons, which are four in number, two to each separate section of the booms, are 4in. by 4in. by ½in.

In Fig. 3*a*, the diagonal struts are lettered S and the sloping ties T, and they both vary in dimensions, and consequently in sectional area, according to their position in the girder. For instance, the ties increase from 7in. by ⅝in. at or near the centre of the main girders to 1ft. 3in. by 1⅛in. at the ends. It will be observed that in the central bay, counting the whole number as thirteen, which includes the semi or incomplete bay over the east abutment, both the diagonal bars are ties, and each 7in. wide by ⅝in. thick, thus giving a gross sectional area of nearly exactly one-fourth of that of the diagonal ties in the end bays. In girders of the description under notice in which the dead load, that is the insistent, weight of the principal girders, and in fact of the whole superstructure together, may be regarded as uniformly distributed, and also when it bears a fairly high ratio to the rolling or live load, the stresses on the central diagonals of the web are comparatively small. When the girder is used solely to support a uniformly distributed dead or static load, there is theoretically no stress on the diagonals under notice, but it is as well even in an instance of this description not to adhere too closely to the abstract dictates of theory. As a case in point, we remember many years ago a young engineer, very zealous and energetic in matters pertaining to the designing and construction of girders, had some lattice girders built for carrying a large water tank, in which the central diagonal bars were absolutely left out. They were passed, it is true, after some difficulty, by the superintending engineer, but it was stipulated that for the sake of appearance, wooden bars were to be inserted, painted and fashioned so as closely to resemble their iron neighbours.

Apologising for our brief digression, we now return to the main girders of the bridge at Worship-street, and for further details refer our readers to Figs. 5—11. It will be seen from them that each main girder consists essentially of a pair of single open web girders, placed side by side and separated by a space equal to 1in., and as the boom of each girder is 1ft. 6in. broad, the distance between their centres is 1ft. 7in., and the total width from out to out 3ft. 1in. If, therefore, the girder had been in one piece—that is, if the booms had been continuous over their whole available width, a plate 3ft. in breadth would have been required. Unfortunately, the time by which the bridge had to be constructed did not permit of plates of this somewhat exceptional width being obtained, so that the engineer decided to build up the section in the manner described. In addition, therefore, to the plates and angle irons already specified, we have to add two vertical plates to each entire boom. These plates have, except over the bearings, a uniform depth of 1ft., but vary in thickness from ⅝in. at the centre to 1⅛in. in thickness at the ends of the girders, corresponding with respect to these dimensions with those similarly belonging to the respective diagonal tie bars, to which they are riveted by strong gusset pieces. Over the bearings these vertical plates have their depth increased to 1ft. 6in. The form and size of these latter vary with the width of the tie bars, and their thickness increases slightly towards the ends of the girders from ½in. to ⅝in. The ties, twelve in number, all pass outside the struts, and it will be observed from an inspection of Figs. 5 and 6, that neither the ties nor the struts extend down the sides of the vertical plates or between the angle irons of the flanges, but terminate flush, or nearly flush, with the free or uncovered edges of the vertical plate. On the other hand, the solid plate diaphragms extend in both the upper and lower booms to the angle irons of the flanges, as shown by the letters D in Figs. 5 and 3*a*, which represent them in front elevation, sectional plan, and in cross elevation in the plane of a transverse section of the main girder. The diaphragms which bridge over—that is, which are carried across the space of 1in. between the two separate parallel girders constituting the single main girder—are built of eight angle irons, each 3in. by 3in. by ½in., two plates 1ft. ½in. by ½in. riveted in between them, and covered at their joint in the centre of the space of 1in., already described, by a cover plate on each side of the joint, 8in. broad by ½in. in thickness. In order to make the diaphragms extend the whole distance between the angle irons of the flanges, the angle irons of the diaphragms are cranked so as to clear the vertical plates of the flanges.

In Figs. 8 and 9 are given an elevation and section of the struts comprised in the web of the main girders, which are all similarly built up, although varying in length and other dimensions. The section of struts 1 and 2 is made up of a pair of outside or flange plates 1ft. by 1⅛in., two tee irons 6in. by 4in. by ⅝in., cross braced in elevation by three tee irons 4in. by 2in. by ⅜in., or four diagonal flat bars 3in. wide by ⅜in. thick. These dimensions for the bracing are constant for all the struts, but in strut 3 the thickness of the outside plates is reduced to 1in., and that of the longitudinal tee irons to ½in. In strut 4 the corresponding scantlings are, outside plates 10in. by 1in., and tee irons 6in. by 3in. by ½in., which in struts 5 and 6 are reduced to 7in. by 1in. by ¾in. respectively, and 6in. by 3in. by ⅜in. in both instances. The tee irons of all the struts are bent to allow the plates to pass in between the gusset pieces. Cast iron bed-plates—see Figs. 6 and 7—having a length of 5ft. 6in., a breadth of 4ft. 9in., and a thickness of 4in., are bolted to the abutments with two holding-down bolts, each 2¼in. in diameter, and form the bearings for the ends of the main girders. Temporary brackets, B in Figs. 3*a* and 5, were riveted to the ends of the main girders for the purpose of fixing them in position, but were subsequently removed when the bridge was completed. In Fig 10 is a transverse section on the square of the general disposition of the cross girders and the roadway and footpaths of the bridge. The cross girders, seen partly in elevation in Fig. 10, and partly in cross section in Fig. 12, are of the plate type, 40ft. 1in. in span, 3ft. 9in. deep at the centre, and composed of horizontal flange plates 1ft. 6in. by ½in., angle irons 3½in. by 3½in. by ½in., and a web plate ⅜in. thick at the centre, increasing towards the ends of the girders to ½in. At intervals of every 4ft. along the rib of the girder vertical stiffeners are riveted on both sides, consisting of plates 1ft. in breadth by ⅜in. in thickness, which are covered again by tee-irons measuring 6in. by 3in. by ⅜in. The spaces of 4ft. between the vertical stiffening plates and tee-irons decrease towards the ends of the girder to 3ft. 8in., 2ft. 8in., and 1ft. 4in. In all plate girders it is near the bearings where the rigidity of the web becomes of chief importance, and the necessity for vertical stiffeners the most urgent.

Considering the roadway for the moment as distinct from the footpaths, upon the cross girders are placed, every 4ft. apart, rolled steel joists 8in. deep by 5in. wide over each flange, and where their joints occur they are riveted together over the cross girders by a pair of cover plates 8in. by 6in. by ⅜in.—Fig. 12. Over the rolled steel joists are riveted to them, with rivets ⅞in. in diameter, wrought iron buckled plates 4ft. by 4ft. and ⅜in. thick, and with a rise or camber at the centre of 2½in.—Fig. 13. Transversely the rolled steel joists are connected together by tee-iron bearers 5in. by 3in. by ⅜in., shown by the letter T in Figs. 13 and 14, to which the other fillets of the buckled plates are riveted. A substratum of concrete overlaid by wooden sets—Figs. 10—completes the formation of the roadway, and the same figure shows the construction of the footpaths, which is as follows:—A strong rolled steel joist 12in. deep by 5in. in width, is carried by a wrought iron bracket or knee piece riveted to the stiffening tee-iron of the cross girder. To the upper flange of this joist are riveted the adjacent fillets of the two buckled plates supporting the materials of the footpaths, which consist of dry filling and concrete flushed over a layer of asphalte. In Figs. 3, 10, and 15, the side screens are shown, which, while doubtless an unavoidable item in the construction of the bridge, detract very much from its appearance. Fig. 15 is an elevation of one bay of the parapet or screen on the inside or roadway. Fig. 16 is a section of the cast iron moulding forming the upper edge of the parapet; and Fig. 17 is a section and elevation of the moulding around the edges of the panels in Fig. 15.

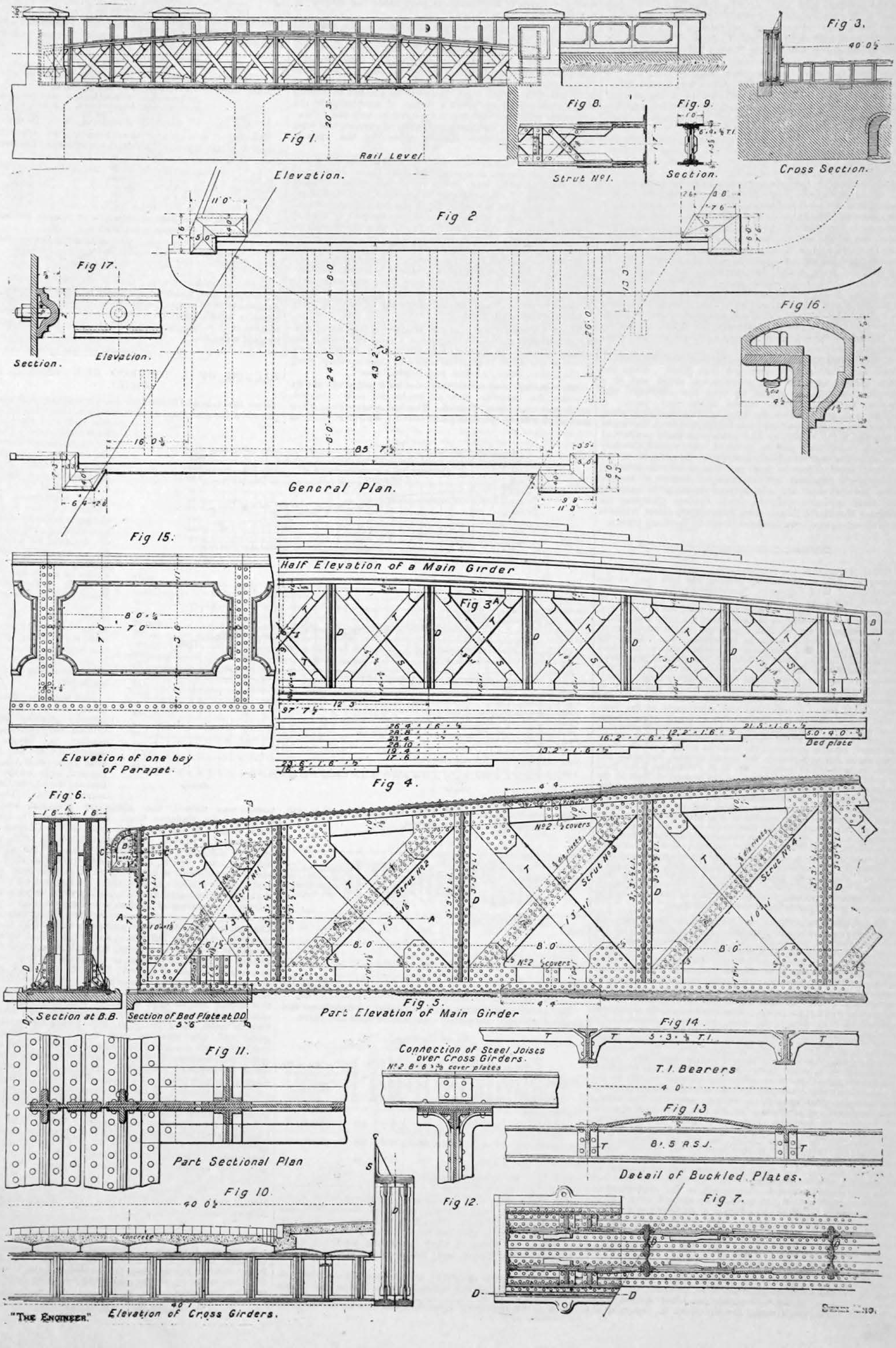
Although all the work in connection with the enlargement of the terminus was of a heavy and onerous character, yet at any rate, so far as bridges are concerned, that at Worship-street may be considered to have carried off the palm. In Fig. 1, is shown in dotted lines the original contours of the old bridge of two skew arches turned in brick, which previously spanned the tracks, with clear openings of 27ft. each on the square. Between parapets the width of the old bridge was 40ft., but if the depth of the warehouses on either side be added on, the total width amounted to 70ft. As it would have been impracticable to accommodate the number of new tracks fantailing into the enlarged terminus under the narrow area afforded by the two old skew arches, it was determined to demolish the structure altogether, including the central pier, which was of dimensions sufficient to absorb some twelve lineal feet in the cross section of the permanent way. The demolition or removal once accomplished, the restoration of the thoroughfare upon wrought iron girders spanning the entire width of line at this point would have, under ordinary circumstances, been unattended with any engineering difficulty especially worth recording. But the problem assumes a very different aspect when the work it embraced necessitated the execution of it without in any way interfering with the ordinary traffic of the railway below, and in a great measure with that above. To carry on to a successful termination the destruction of the old and the erection of the new bridge in a single span, when about eight hundred trains every twenty-four hours had to be allowed an uninterrupted passage during the operation, was the feat to be accomplished by the Great Eastern Railway and its contractors.

For the information respecting this stage of the work we are indebted to Mr. H. L. Batting, of the firm of The Horseley Company, Limited, of Tipton, Staffordshire, and Victoria-street, Westminster, who were the contractors for the construction and erection of all the ironwork, not only for the present bridge, but also for the adjacent similar structures at Primrose and Skinner streets. In commencing the work of destruction, the warehouses already referred to were first demolished, and a temporary bridge of timber was built to carry the water and gas mains which supplied the districts on the north-east side of the extension with those requisites demanded by modern civilisation. In addition to serving the purpose described, the temporary structure acted as a bridge for pedestrians until the original thoroughfare was completely re-opened for traffic; for it was never entirely closed during the whole of the work, except for a very brief interval of time, which will be subsequently alluded to. It should be mentioned here, before proceeding further with our description, that no less than three separate authorities or parties were concerned, and took an active part in the execution of the works in connection with the removal and re-erection of Worship-street bridge. They were the Great Eastern Railway, the Horseley Company, and the contractors for the earthwork, brickwork, and foundations, Messrs. Mowlem and Co., who carried out, with the exception of the ironwork, the building of the new parcels' office already described and illustrated in THE ENGINEER. Having cleared away the warehouses, the contractors were at liberty to utilise the space thus acquired for

LIVERPOOL-STREET STATION, GREAT EASTERN RAILWAY—WORSHIP-STREET BRIDGE

MR. WILSON, M. INST. C.E., ENGINEER

(*For description see page* 414)



the erection of the two main girders, of the largest of which we have given general and detail drawings in the present article. While so doing, the roadway had to be kept clear for the passage of the ordinary traffic. To those acquainted with the locality, the necessity for regulations so stringent with respect to the non-interruption with the ordinary road traffic, is not quite apparent. A small detour, with a correspondingly small sacrifice of time, would cause but a very insignificant interference with the main arterial routes, although, it must be admitted, the vehicular traffic in and about Bishopsgate, Norton Folgate, and Shoreditch is of both a frequent and heavy description. No sooner had the main girders been built *in situ*, than it became necessary to cut away the arches and all the brickwork underneath. This duty devolved upon the railway company and the resident engineer, Mr. Sherlock, and the district engineer, Mr. Wilmer, under the engineer-in-chief, Mr. Wilson, who had the charge of the work.

In order to protect the incoming and outgoing trains from the fall of the old materials, which were now nothing more than so much useless *débris*, old rails, iron odds and ends, balks and half balks of timber of a handy length, and scantlings and timber lagging, were pressed into the service, and a strong and substantial screen shield or platform was speedily interposed between the demolition above and the steam locomotion beneath. The steel wedge, the hammer and the pick were now brought into requisition, the side portions of the arches cut away, and the new main girders lowered down upon their bedstones. Under the powers of its Act of Parliament the company were able to stop the entire traffic of the roadway for a period not exceeding 168 hours. This brief interval was thus allotted among the different parties engaged in the work:—Messrs. Mowlem and Co., to remove all pitching, old material, and cart away earth, 24 hours; the Great Eastern Railway, to cut away completely all the brickwork of the arches and remove the shield, 96 hours; the Horseley Company, to fix all the cross girders and platform, 48 hours; total, 168 hours.

A few words must be said respecting the manner in which the cross girders were got into place. When the main girders were fixed in position, a rough sort of a travelling gantry was rigged up over the roadway, and running along the upper booms at a slow pace. A special goods train hauled the cross girders, weighing some five tons each, underneath the new bridge, and from the trucks they were lifted bodily by the gantry to their permanent position on the main girders, to which they were ultimately riveted in the manner already described. In addition to the ironwork required for the three new bridges over the terminal enlargement, supplied by the Horseley Company, Messrs. John Mowlem and Co. used a large quantity in carrying out their contract with the Great Eastern Company for widening the thoroughfares from Bishopsgate-street Without to Globe-road, and from Bethnal Green to Hackney Downs.

ROYAL METEOROLOGICAL SOCIETY.—The monthly meeting of this Society was held on Wednesday evening, the 15th inst., at the Institution of Civil Engineers, Westminster; Mr. E. Mawby, president, in the chair. Mr. W. Ellis, F.R.S, read a paper on the "Mean Amount of Cloud on Each Day of the Year at the Royal Observatory, Greenwich, on the average of the Fifty Years, 1841-90," in which he showed that a principal maximum occurs in winter and a principal minimum in autumn, with a secondary much less pronounced maximum in summer and a secondary minimum in spring. There is, however, considerable irregularity in the succession of daily values, the differences between which on consecutive days are, in numerous cases, relatively large. Cloudless days are most numerous in spring and autumn, and least so in winter and summer; days of little cloud are somewhat less numerous in winter as compared with other parts of the year, whilst days of medium cloud are much more numerous in summer than in winter. Days of much cloud are nearly equal in amount in all parts of the year, whilst overcast days are much more numerous and nearly equal in amount in the first and fourth quarters of the year, much less numerous in the second quarter, and again less numerous in the third quarter. Mr. E. D. Fridlander, B.Sc., gave an account of "Some Observations of the amount of Dust in the Atmosphere, made at Various Places during a Voyage Round the World in 1894-5." The experiments, which were made with a form of Aitken's pocket dust counter, showed that there are often considerable variations in the number of dust particles in a very short space of time. Not only did dust occur in the air of inhabited countries, over the water surfaces immediately adjoining them, and up to an altitude of 6000ft. or 7000ft. amongst the Alps, but it was also found in the open ocean, and that so far away from any land as to preclude the possibility of artificial pollution, and its existence has been directly demonstrated at a height of more than 13,000ft. Major H. E. Rawson, F.R. Met. Soc., gave an "Analysis of the Greenwich Rainfall Records from 1879 to 1890, with Special Reference to the Declination of the Sun and Moon."

BIRMINGHAM ASSOCIATION OF MECHANICAL ENGINEERS.—A paper was read before this Association at its last meeting by the first president of the society, Mr. Thomas Meacock, on "The Application of Electricity to Motive Power Purposes." The author treated the subject under the following four divisions:—(1) The application of electricity to tramcar propulsion; (2) to factory driving; (3) to domestic uses; (4) general application. Upon the topic of tramcar propulsion, the author defined the position of the three parties interested in tramways, viz., the tramway companies, the corporate Councils, and the public. The former having the paramount question of first cost or capital outlay to consider, turned to the overhead trolley electric system for the equipment or re-equipment of their lines, as the only system at present available which can be laid at comparatively moderate cost. The corporate councils finding the electric conduit system too costly, finally sanctioned the overhead trolley scheme. The public invariably petitioned against the overhead trolley scheme, but up to the present time had not been able to find a substitute, first cost being the barrier to other systems for ordinary services. The author then described a system devised by his own firm which removed the barrier of excessive first cost, gave no obstruction above the street level, and was perfectly insulated. He trusted that shortly the scheme would be put to practical use. Treating the question of factory-driving, the author whilst admitting that the application of an electric motor to each individual machine was the ideal system, still in practice he suggested a judicious grouping of the machines, with light line shaft and electric motor to each group, as the most practical scheme as regards first cost, maintenance, and efficiency. After going somewhat fully into the question of electricity as a motive power, he described a regulating slipping device he had designed for relieving the motor of all shocks from the machinery. Upon the third topic—the application of electricity to domestic purposes—he maintained that the time had now arrived when the great boon of electricity, now only available in towns, leading hotels, and public institutions, should be within reach of residents in suburban and rural districts. Mr. Meacock proposed a scheme of what he termed electrical colonisation, or grouping of, say, a dozen residences, having a common generating station, with attendant, which would supply the electricity for the group of residences.

EXPERIMENTS WITH ACCUMULATORS FOR LIGHTING RAILWAY CARRIAGES.*

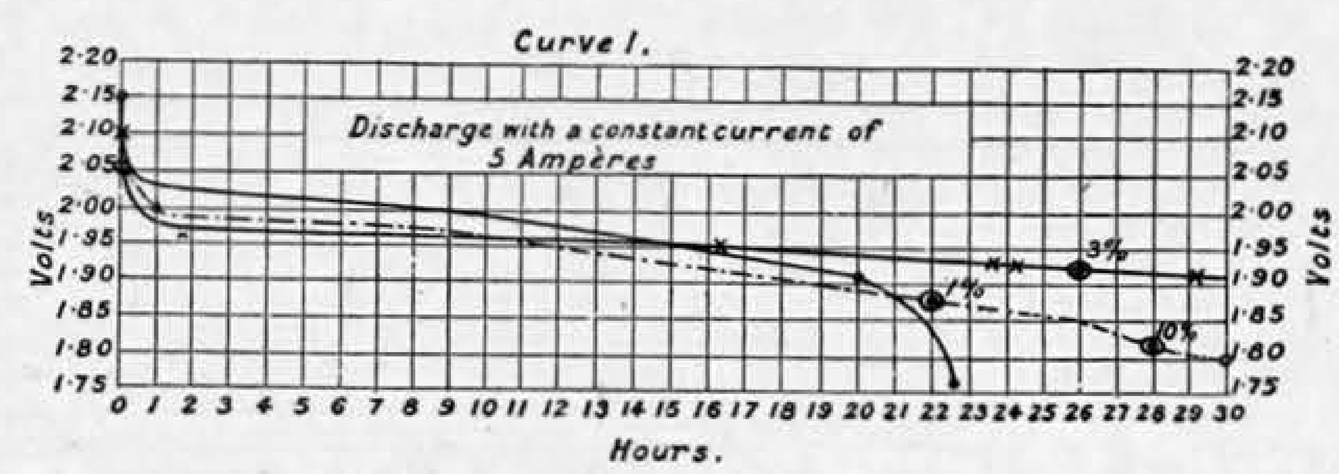
DURING the past year a series of exhaustive experiments was carried out by the officials of the Hungarian State Railways on the lighting of railway carriages by electricity, and several systems of accumulators were made the subject of examination.

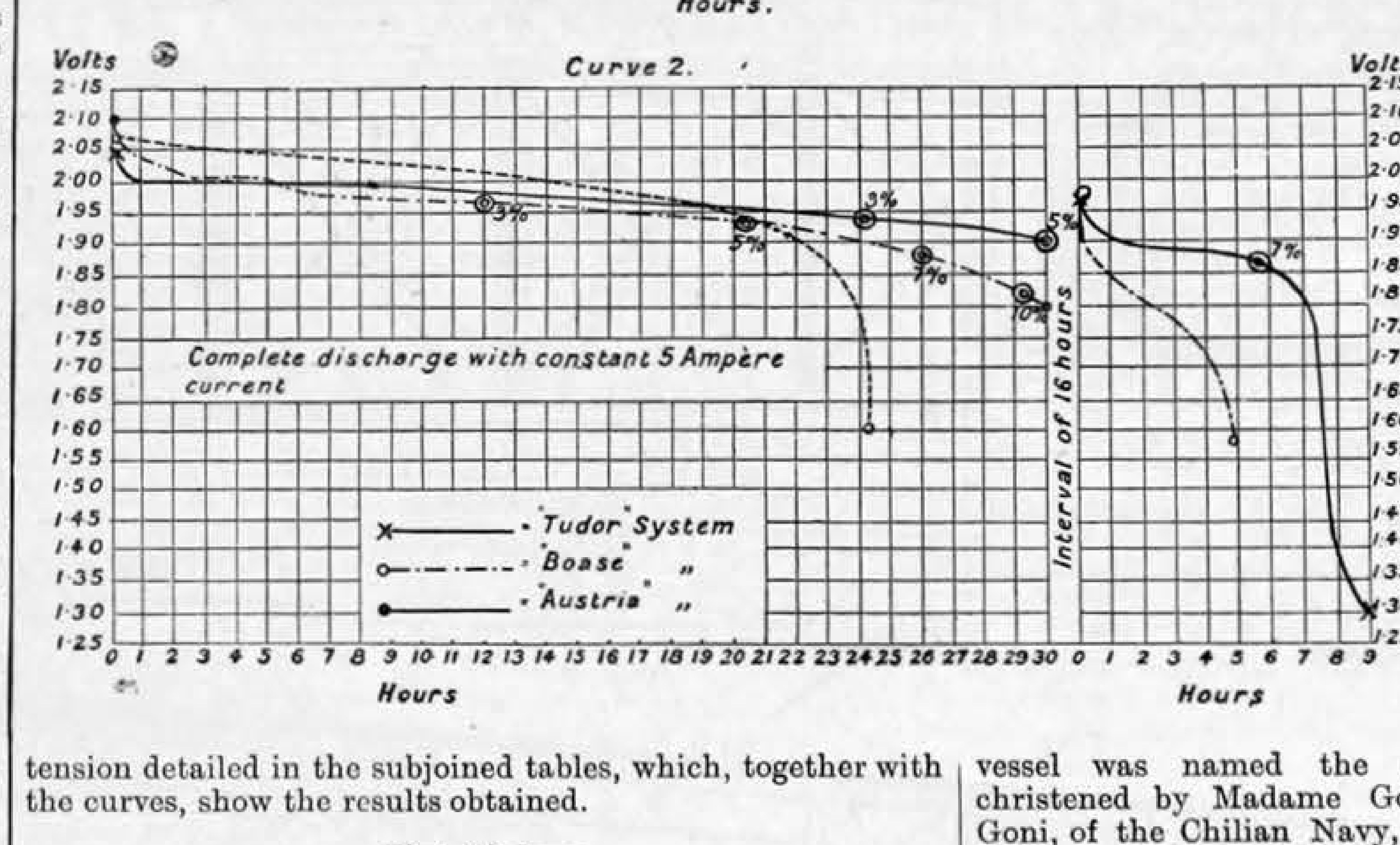
The conditions operating when vehicles in motion are to be illuminated differ appreciably from those obtaining in the case of stationary installations. In the latter event the weight of the accumulators is practically of little moment, and the diminution of the tension of the current as the discharge progresses can be easily compensated by the addition of reserve cells. This must, however, be avoided in railway work, as entailing too great a degree of complexity in the apparatus and inconvenience in application, and the following essentials, viz., lightness, regularity of current, and high capacity, are therefore insisted upon by the railway authorities.

Some makers endeavour to conform to the first-named condition by employing comparatively light plates containing very little metallic lead, but a great proportion of more active "paste." To this category belong the Austria and Boese accumulators. On the other hand, the Accumulator Manufacturing Company at the Hague adhere for railway work to a modification of their Tudor battery, wherein the plates have a very large surface, their capacity being increased by the superimposition of suitable "paste," with the object of reducing to a minimum the decrease of current while discharging. The importance of this latter condition is considerable, a diminution of 5 per cent. from the initial strength of the current being sufficient to lower the candle-power of the lamps to such a degree as to reduce the battery below the limit of practical efficiency.

These two competitive systems being at disposal, a comparative examination of their respective merits fell within the scope of the experiments alluded to above, the batteries subjected to the different practical tests and measurements being of the Tudor, Boese, Austria, and Bristol types.

After having been in constant use for a period of over six months the batteries were all discharged and recharged, until gas was freely evolved. The discharging was then proceeded with at the strength of current, and until the final





tension detailed in the subjoined tables, which, together with the curves, show the results obtained.

First Discharge.

System.	Strength of discharge current in ampères.	Final tension in volts per cell.	Guaranteed capacity in ampère-hours.	Actual capacity in ampère-hours.	Percentage diminution in tension.	Percentage of guaranteed capacity.	Density of the electrolyte at completion of discharge.
Tudor ..	5	1·85	150	150	3·3	100	16° and 15° Bé
Boese ..	5	1·80	150	150	10·0	100	14½° Bé
Austria ..	5	1·80	180	112	11·8	62	16½° and 16° Be
Bristol ..	4	1·80	37·5	8·5	7·3	23	could not be measured

The accumulators were then fully charged once more and finally discharged completely—see second table and curve.

Second Discharge.

System.	Strength of discharge current in ampères.	Final tension in volts per cell.	Guaranteed capacity in ampère-hours.	Actual capacity in ampère-hours.	Percentage diminution in tension.	Percentage of guaranteed capacity.	Density of the electrolyte at completion of discharge.
Tudor ..	5	1·85	150	184	7·5	123	13° Bé
Boese ..	5	1·80	150	161	11·8	108	—
Austria ..	5	1·80	180	119	12·8	66	—
Bristol ..	Not	tested	any fur	ther.			

After proceeding with the discharge for thirty hours, a rest of fifteen hours was allowed, and then discharging was resumed until complete. Finally a cell was selected from each of the batteries that had been in use for six months, and was taken to pieces to allow its eternal condition to be examined. The Tudor and Boese alone passed this test satisfactorily.

The tables below show the actual capacity—as obtained from the analysis of the curves—of the Tudor and Boese accumulators, at reductions of voltage amounting to 3, 5, and 7 per cent. respectively.

Initial tension per element in volts		3 per cent.	5 per cent.	7 per cent.
	Boese 2·000 / Tudor 1·985			
Final ditto	Boese	1·940	1·900	1·860
	Tudor	1·925	1·886	1·846
Actual capacity in ampère-hours.				
	Boese	72·5	107·5	132·5
	Tudor	146·3	above 150·0	above 157·0

Initial tension per element in volts		3 per cent.	5 per cent.	7 per cent.
	Boese 2·040 / Tudor 2·000			
Final ditto	Boese	1·9788	1·938	1·8972
	Tudor	1·9400	1·900	1·8600
Actual capacity in ampère-hours.				
	Boese	52·5	100·0	127·5
	Tudor	131·3	167·5	181·3

Mean value of the foregoing measurements:—

	At 3 per cent. Ampère-hours.	At 5 per cent. Ampère-hours.	At 7 per cent. Ampère-hours.
Boese	62·50	103·75	130·00
Tudor	138·80	about 167·50	181·30

The Tudor accumulator thus possesses an appreciably higher absolute capacity than the Boese battery. The weights of the accumulators used were:—

Tudor 12 elements in 6 troughs of 2·44 kilos. per trough = 264 kilos.*
Tudor 12 " " 6 " " 2·36½ " " " = 219 " †
Boese 12 " " 6 " " 2·28 " " " = 168 "
Austria 12 " " 2 " " 6·64 " " " = 128 "
Bristol 48 " " 8 " " 6·27¾ " " " = 222 "

Under equal conditions of reduction of tension the weight per ampère-hour of capacity is thus:—

	At 3 per cent. Kilos.	At 5 per cent. Kilos.	At 7 per cent. Kilos.
Boese	2·688	1·619	1·290
Tudor	1·578	about 1·307	1·208

Therefore within the permissible limit of reduction, viz: 5 per cent., the Tudor accumulator is, notwithstanding its greater absolute weight, lighter in proportion to its effective capacity than the Boese battery, and it is only when the reduction of voltage amounts to 7 per cent. that the relative weights coincide.

* First pattern. † Second pattern.

LAUNCH OF A TORPEDO GUN VESSEL FOR CHILI.

THE Birkenhead Ironworks are at present very actively employed in the construction of war vessels of various types for our own naval service and for several friendly Powers, for whose navies as well as our own the acquisition of the most modern type of fighting ship of the very highest speed is of paramount importance, as is evidenced by the fact that the great majority of vessels now building at those works are designed for a speed of 30 knots, while there is nothing at present on the stocks of a less speed than 21 knots. A fortnight ago Messrs. Laird floated out of one of their building docks, H.M.S. Mars, of 14,900 tons and 12,000 indicated horse-power, which is now under the 90-ton crane in the west float, receiving the remainder of her machinery.

Last week they launched a very fast and formidable torpedo gunboat for the Chilian Government, very similar in design and dimensions to the Almirante Lynch and Almirante Condell, built by the same firm for the Chilian Government in 1890. The new vessel was named the Almirante Simpson, and was christened by Madame Goni, wife of Captain Luis A. Goni, of the Chilian Navy, late head of the Chilian Naval Commission in Europe. Her length over all is 240ft. with a beam of 27ft. 6in., and a depth of 16ft., and she measures 858 tons, o.m. She is, of course, constructed of steel. She has a forecastle and a half poop which provide good accommodation for officers and crew, there is a fore-and-aft bridge at the height of forecastle deck connecting with the poop, and to this level the casings of hatchways and engine-room skylights are carried, the openings on main deck level being water-tight. The hull is sub-divided into numerous water-tight compartments by transverse bulkheads, and longitudinal bulkheads divide the two sets of engines, and extend along the outer sides of the machinery spaces, so that great power of flotation is insured in case of injury. The side and deck plating abreast the machinery spaces are of increased thickness to afford protection, and the coal bunkers are also arranged with this object, and of large capacity. The armament, of the most recent type, will consist of one bow and two broadside torpedo tubes, two 4·7in. guns, four 3-pounder quick-firing guns, and two machine guns and mining plant. The machinery will consist of two sets of Messrs. Laird's high-speed triple-expansion engines, developing about 5000 indicated horse-power collectively, driving twin screws, and designed to give the vessel a speed of 21 knots. The boilers are four in number, of the Normand tubulous type, with a working pressure of 200 lb. per square inch. Range of action at 10 or 11 knots speed, about 4000 knots.

Among those present were Admiral Uribe, chief of the Chilian Naval Commission; Sir E. J. Reed, K.C.B., consulting naval architect; Captain Luis A. Goni, of the Chilian Naval Commission; Captain Romulo Medina, C.N.; Mr. J. Forbes, inspecting engineer; Mr. Bernal, engineer; Mr. C. B. Nichols, Mr. T. H. Wells; Mr. Cockbain, Chilian Consulate, Liverpool; Mr. Moller, Chilian Consul, Manchester, and Mrs. Moller; Mr. Meyer, German Vice-consul; Mons. Sève, Belgian Consul-General, &c.

TRADE AND BUSINESS ANNOUNCEMENT.—The Harrison Engine Company, Limited, has taken over the business of the Harrison Patent Steering Engine Company, Limited, and appointed Mr. R. W. White managing director—for many years with Messrs. Hulse and Co., Manchester.

* G. Klose, "Zeitschrift des Oesterreichischen Ingenieur-und Architekten Vereines," xlviii. No. 7.

COMPOUND EXPRESS ENGINE, GREAT SOUTHERN AND WESTERN RAILWAY.

ABOUT five years ago the Great Southern and Western Railway Company converted one of its standard goods engines into a compound on the Worsdell and Von Borries plan. A pair of cylinders 18in. and 26in. diameter by 24in. stroke was substituted for the two 18in. cylinders. The compound cylinders were adapted to the existing standard crank centres, and with the 5ft. 3in. gauge, this left space for the low-pressure valve to be placed between the cylinders, in which position it is driven direct, the high-pressure valve is placed on the top of its cylinder and is driven with a rocking shaft. This arrangement enabled the standard motion to be retained, so that practically the engine could be altered to simple again at any time by changing the cylinders.

The pressure was purposely kept the same as in the standard goods engines, viz., 150 lb., in order to see whether the engine showed any economy due to the compounding alone. The result has been that the engine, which has now been at work for five years, shows a saving in coal consumed of about 10 per cent. as compared with other engines doing the same work. The cost for repairs, and lubrication, &c., has not been greater than in the case of other engines of the company's standard goods type.

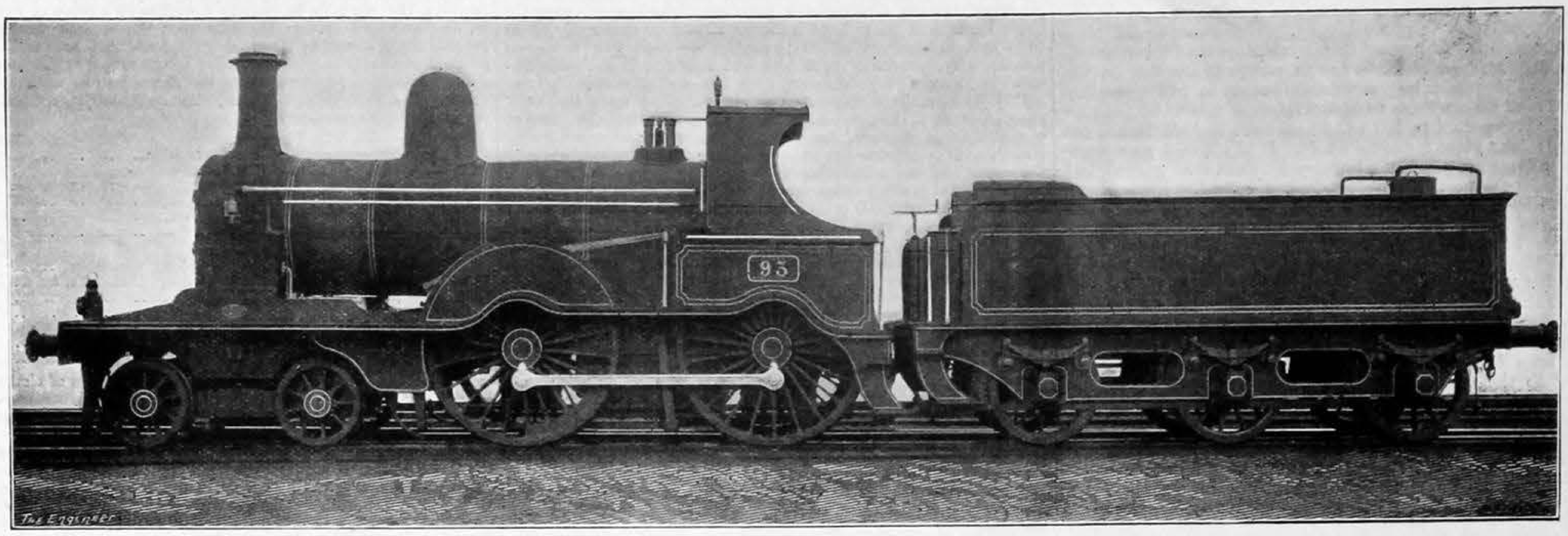
Mr. Ivatt considered the results obtained with the goods-engine after an extended trial, sufficiently encouraging to warrant him in recommending his directors to sanction the construction of a compound express engine, of which we give on page 424 an elevation, and in a future impression we shall publish sectional drawings.

The chief dimensions are as follows:—Cylinders 18in. and 26in. by 24in. stroke. Wheels, 6ft. 7½in., four coupled. Heating surface: fire-box, 112 square feet; tubes, 824 square feet; total, 936 square feet; grate area, 18¾ square feet; steam pressure, 150 lb. Weight of engine in working order, 40 tons, distributed as follows: on bogie, 15 tons; driving, 13 tons; trailing, 12 tons. These weights are light compared with those common on many English lines, but the engine is designed for running on a 74 lb. rail. The engine is built under the Worsdell, von Borries and Lapage's patents, with an arrangement of change valve designed by Mr. Ivatt. This valve, of which we give a section, allows the engine to be worked "simple" or "compound" at will. It is actuated by a small lever and rod from the foot-plate, which, by suitable valves admits steam to a cylinder on the spindle of the change valve, and so moves it to either position, the movement being controlled by a dashpot. When in the "simple" position the valve opens a communication from the high-pressure exhaust to the blast pipe, round the underside of the high-pressure cylinder; at the same time it closes the communication from the high-pressure exhaust to the low-pressure steam chest, and opens a connection for live steam from the steam pipe to the low-pressure steam chest. This supply of live steam is wiredrawn so as not to exceed about 75 lb. pressure on the low-pressure side, and the low-pressure cylinder and steam chest are, as usual, provided with relief valves, set to blow at 75 lb. in case the pressure should exceed that amount.

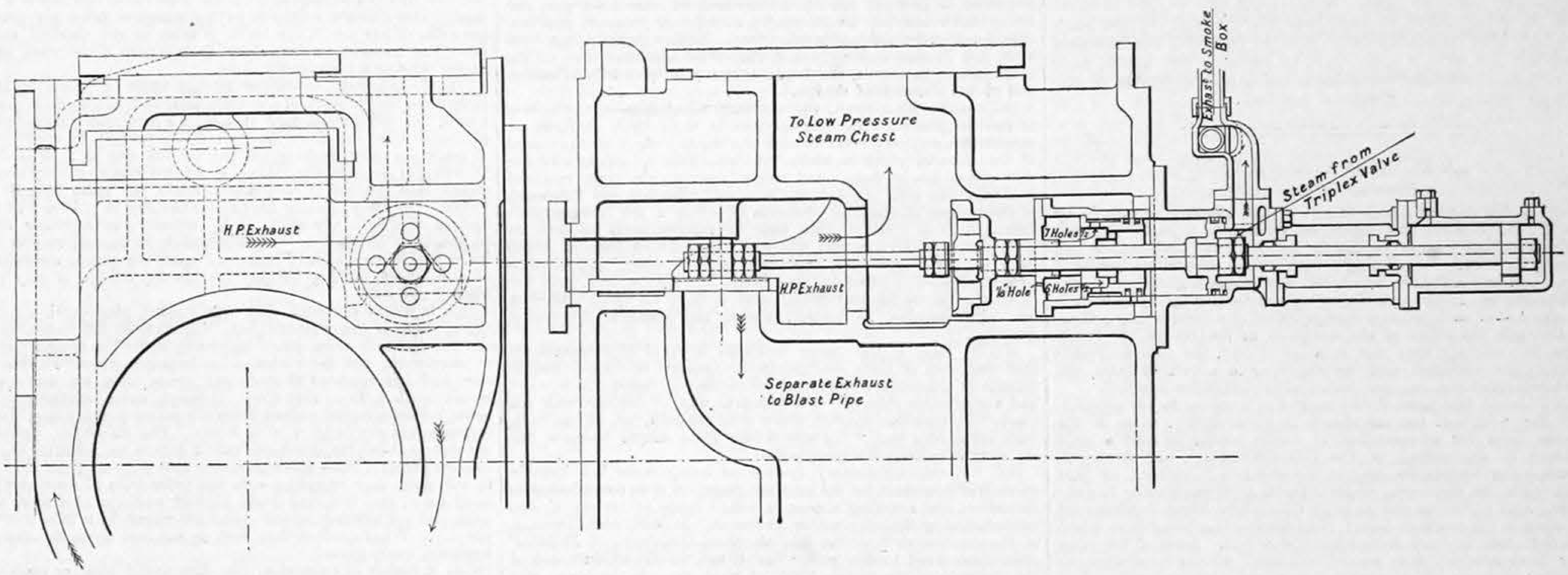
In ordinary working the engine is always run compound, and starts without any trouble, but for starting on an incline, or for getting away quickly with a heavy train, the arrangement for working simple is of great advantage, and enables the engine to exert as much power as a simple engine with two 18in. cylinders and the same steam pressure. The arrangement is also exceedingly handy for shunting; there is no steam locked up in the receiver, and the engine does not, in steam-shed phraseology, "beat two or three times after steam is shut off."

The working of the change valve is entirely in the hands of the driver. Mr. Ivatt does not believe in the theory that it is not advisable to give the driver the power of working simple if required. To argue that the driver of a compound engine so fitted is likely to work the engine simple any longer than is absolutely necessary, is about the same as saying that the driver of an ordinary engine cannot be trusted to pull the reversing gear up as soon as possible.

The engine has only been at work about eight months, consequently no accurate information as to comparative consumption of coal, &c., is yet available. She is doing the same work as other express engines with similar boiler and pressure, but with cylinders 18in. by 24in., four coupled, with same size of wheel.



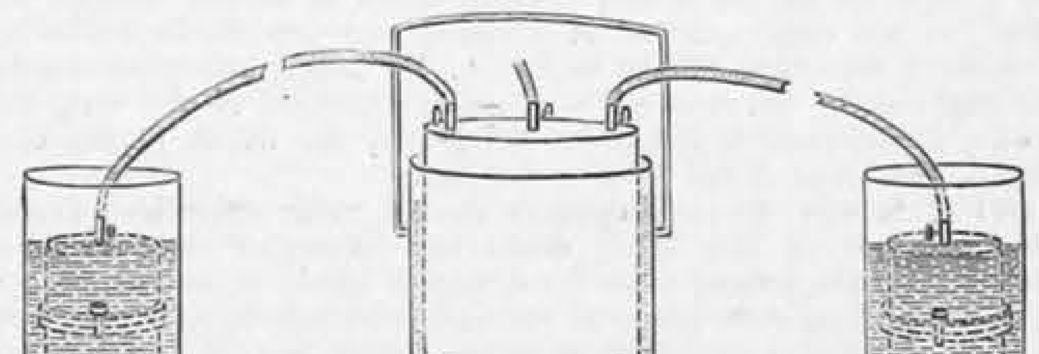
COMPOUND EXPRESS ENGINE, GREAT SOUTHERN AND WESTERN RAILWAY, IRELAND



IVATT'S COMPOUND ENGINE CHANGE VALVE

COMMERCIAL VALUE OF ACETYLENE.

THE first practical demonstration, says a French correspondent, of the illuminating qualities of acetylene gas produced by the contact of calcium carbide with water was made at the meeting of the French Société du Gaz in June of last year. It was then generally admitted that the new gas was destined to revolutionise the existing systems of lighting, but few people could have anticipated that it would have made so much progress as a commercial product in the short time that has elapsed since then. The experiments carried out at the meeting were necessarily imperfect, and the amount of smoke given off by the flame had, of course, to be suppressed before the gas could be used for lighting purposes. This has been done simply by the employment of a special burner in which the orifice is smaller than in the ordinary gas burner. This economy is indeed one of the features of acetylene, for with one kilo. of calcium carbide and 500 grammes of water the amount of gas produced is 300 litres, and this, it is stated, will provide a light equal to fifteen ordinary gas jets for six hours, while, if a smaller burner is used, the duration is, of course, much greater. To give a comparison between the cost of ordinary gas and acetylene in France, where the latter is now being produced upon something like a commercial scale, it may be said that the price of coal gas per carcel hour is one centime, while acetylene gas costs 3·2 centimes, but as acetylene is so much more powerful, the two gases work out in practice to about the same figure. While admitting these enormous advantages, the question was raised in the early stages of development whether acetylene was not more poisonous than ordinary gas, but experiments have shown, it is said, that there must be at least 40 per cent. in the atmosphere before it can be dangerous, and its presence can be distinguished long before it attains to this proportion. In burning it has no perceptible odour whatever.



Another advantage claimed for acetylene, so far as lighting is concerned, is that it gives off very little heat, and this naturally tells against its employment for the many domestic purposes to which ordinary gas is applied upon such a large scale in France. Nor can it be compared with coal gas for the driving of motors, though it is believed that when acetylene comes to be generally adopted it will be used for cooking, heating, and power purposes simply by consuming the new gas in larger quantities than ordinary gas to give the same caloric result. But, for the moment, the only scope that is opened to acetylene is for lighting. The chances of explosion are held to be not greater than with ordinary gas, and it may even be deemed safer on account of the fact that it is produced upon a much smaller scale. This facility of manufacture is one of the arguments urged for acetylene. By the aid of small appliances the gas may be produced in any household, and may be manufactured as required on steamboats and trains. A great many such appliances have already been constructed, in which the chief objects aimed at are that they should occupy very little space, that they may be placed in the care of any servant or labourer without fear of accident, and that they should be very cheap. Until lately the appliances, such as those manufactured by MM. Escher Wyss and Co., of Zurich, have run into very high figures, but now acetylene producers, claimed to be of equal quality, are sold for about a sixth of the amount, while the cheapest on the market, having a capacity of 1 kilo. of calcium carbide, and providing a light equal to ten ordinary burners for six hours, is priced at £6. These appliances are now being supplied by a company which has just been formed in Paris under the title of Le Gaz Acétylene.

The company is placing on the market an apparatus known as an "At Home," and composed of a gas-holder and one or two producers, according to whether the supply is to be continuous or not. The producer contains a closed cylinder, into which an iron wire receptacle holding the calcium carbide is introduced. The two parts of the cylinder are brought together by catches which make it water-tight. The cylinder is then just covered with water which finds its way inside by means of a small pipe. The gas-holder is constructed upon the ordinary principle, and the pressure is so adjusted that when the bell rises the water cannot enter into the calcium carbide receptacle. Upon its descending, however, the water enters the producer in just the quantity necessary to again fill the gas-holder, and so on until the whole of the carbide is decomposed. When a constant supply is needed the installation comprises two producers, so that on one becoming exhausted the tap connecting it with the gasometer is closed and the other producer is put into communication. The Company Le Gaz Acétylène possesses several other patents, notably the Boesmann apparatus, and another. The former will supply gas for from 200 to 1500 burners. A very simple form of home acetylene gas make was recently illustrated in the *Scientific American*. The company has also been experimenting with liquid acetylene under pressure, varying from 25 to 50 atmospheres, but in consequence of this great pressure it has not been thought advisable to use the liquid, the more so as the gas is produced in the apparatus described under a pressure of not more than 20 centimetres of water. Now that the necessary appliances for producing acetylene are on the market, or will be in a short time when Le Gaz Acétylène will be manufacturing ten producers a week, the only difficulty lies in procuring sufficient quantities of pure calcium carbide. At present its manufacture is very restricted, but a large number of works are in course of erection on the Continent for producing carbide, and when in full operation the price of 70 centimes to 1f. a kilo. that has to be paid for carbide is expected to fall to 50 centimes, though this is not likely to take place for some while. It is yet still possible to procure large supplies at a lower price than that quoted, but the quality is very inferior, producing only 150 litres of gas a kilo. instead of 300 litres. A good deal has been said of late as to the large quantities capable of being produced in America, but so far not a single kilo., it is said, has found its way to Europe. On this side, it would probably be extremely difficult for the moment to secure supplies of ten tons a day. One of the problems which Le Gaz Acétylène has set itself to solve is the finding of a portable lamp, but there are a great many difficulties in the way of this being done. Such lamps have been constructed, but they are entirely impracticable owing to their liability to explode. As to the future of acetylene, there can be little doubt but that in course of time it may be employed for lighting purposes upon a very considerable scale. For the moment, it cannot come into competition with ordinary gas for town lighting in Paris, owing to the fact that not only is the latter more suitable for cooking and heating, but the monopoly of lighting is enjoyed by the Paris Compagnie du Gaz, and no change is likely to take place until the monopoly expires, by which time the price of calcium carbide may be so cheap that the new concessionaires may see it to their advantage to employ the new gas, the more so as no great change in the present system of piping is necessary. In laying down new installations for acetylene smaller pipes need only be used, with a consequent economy in cost, while the manufacturing plant is, of course, infinitely more simple and less costly. The aim of Le Gaz Acétylène is, therefore, to supply the new gas in places where there is no ordinary gas or electricity, and the directors think that it is especially adapted to luminous advertising, and to other purposes where the ordinary gas does not give a sufficiently brilliant light. It is significant of the interest that is being taken in acetylene that though the company has only been recently formed it is yet receiving innumerable demands for information from all parts of the world, and, according to our correspondent, there is a prospect of the new gas taking up a prominent position.

A PIECE-RATE SYSTEM.*

(*Continued from page 392.*)

(28) A still further improvement of this method was made by Mr. F. A. Halsey, and described by him in a paper entitled, "The Premium Plan of Paying for Labour," and presented to this society in 1891. Mr. Halsey's plan allows free scope for each man's personal ambition, which Mr. Towne's does not.

(29) Messrs. Towne and Halsey's plans consist briefly in recording the cost of each job as a starting-point at a certain time; then, if, through the effort of the workmen in the future, the job is done in a shorter time and at a lower cost, the gain is divided among the workmen and the employer in a definite ratio, the workmen receiving, say, one-half, and the employer one-half.

(30) Under this plan, if the employer lives up to his promise, and the workman has confidence in his integrity, there is the proper basis for co-operation to secure sooner or later a large increase in the output of the establishment. Yet there still remains the temptation for the workman to "soldier" or hold back while on day-work, which is the most difficult thing to overcome. And in this, as well as in all the systems heretofore referred to, there is the common defect, that the starting point from which the first rate is fixed is unequal and unjust. Some of the rates may have resulted from records obtained when a good man was working close to his maximum speed, while others are based on the performance of a medium man at one-third or one-quarter speed. From this follows a great inequality and injustice in the reward even of the same man when at work on different jobs. The result is far from a realisation of the ideal condition in which the same return is uniformly received for a given expenditure of brains and energy. Other defects in the gain-sharing plan, and which are corrected by the differential rate system, are:—(*a*) That it is slow and irregular in its operation in reducing costs, being dependent upon the whims of the men working under it; (*b*) that it fails to especially attract first-class men and discourage inferior men; (*c*) that it does not automatically ensure the maximum output of the establishment per man and machine.

(31) Co-operation, or profit-sharing, has entered the mind of every student of the subject, as one of the possible and most attractive solutions of the problem; and there have been certain instances, both in England and France, of at least a partial success of co-operative experiments. So far as I know, however, these trials have been made either in small towns, remote from the manufacturing centres, or in industries which in many respects are not subject to ordinary manufacturing conditions.

(32) Co-operative experiments have failed, and, I think, are generally destined to fail, for several reasons; the first and most important of which is, that no form of co-operation has yet been devised in which each individual is allowed free scope for his personal ambition. This always has been and will remain a more powerful incentive to exertion than a desire for the general welfare. The few misplaced drones, who do the loafing and share equally in the profits with the rest, under co-operation are sure to drag the better men down towards their level.

(33) The second and almost equally strong reason for failure lies in the remoteness of the reward. The average workman—I don't say all men—cannot look forward to a profit which is six months or a year away. The nice time which they are sure to have to-day, if they take things easily, proves more attractive than hard work, with a possible reward to be shared with others six months later.

(34) Other and formidable difficulties in the path of co-operation are the equitable division of the profits, and the fact that, while workmen are always ready to share the profits, they are neither able nor willing to share the losses. Further than this, in many cases it is neither right nor just that they should share either in the profits or the losses, since these may be due in great part to causes entirely beyond their influence or control, and to which they do not contribute.

(35) When we recognise the real antagonism that exists between the interests of the men and their employers, under all of the systems of piece-work in common use; and when we remember the apparently irreconcilable conflict implied in the fundamental and perfectly legitimate aims of the two—namely, on the part of the men: *The universal desire to receive the largest possible wages for their time*; and on the part of the employers: *The desire to receive the largest possible return for the wages paid*; what wonder that most of us arrive at the conclusion that no system of piece-work can be devised which shall enable the two to co-operate without antagonism, and to their mutual benefit!

(36) Yet it is the opinion of the writer that even if a system has not already been found which harmonises the interests of the two, still the basis for harmonious co-operation lies in the two following facts:—First, that the workmen in nearly* every trade can and will materially increase their present output per day, provided they are assured of a permanent and larger return for their time than they have heretofore received; secondly, that the employers can well afford to pay higher wages per piece even permanently, providing each man and machine in the establishment turns out a proportionately larger amount of work.

(37) The truth of the latter statement arises from the well-recognised fact that, in most lines of manufacture, the indirect expenses equal or exceed the wages paid directly to the workmen, and that these expenses remain approximately constant, whether the output of the establishment is great or small. From this it follows that it is always cheaper to pay higher wages to the workmen when the output is proportionately increased; the diminution in the indirect portion of the cost per piece being greater than the increase in wages. Many manufacturers, in considering the cost of production, fail to realise the effect that the *volume of output has on the cost*. They lose sight of the fact that taxes, insurance, depreciation, rent, interest, salaries, office expenses, miscellaneous labour, sales expenses, and frequently the cost of power—which in the aggregate amount to as much as wages paid to workmen—remain about the same whether the output of the establishment is great or small.

(38) In our endeavour to solve the piece-work problem by the application of the two fundamental facts above referred to, let us consider the obstacles in the path of harmonious co-operation, and suggest a method for their removal.

(39) The most formidable obstacle is the lack of knowledge on the part of both the men and the management—but chiefly the latter—of the quickest time in which each piece of work can be done; or, briefly, the lack of accurate time-tables for the work of the place.

(40) The remedy for this trouble lies in the establishment in every factory of a proper rate-fixing department; a department which shall have equal dignity and command equal respect with the engineering and managing departments, and which shall be organised and conducted in an equally scientific and practical manner.

(41) The rate-fixing as at present conducted, even in our best managed establishments, is very similar to the mechanical engineering of fifty or sixty years ago. Mechanical engineering at that time consisted in imitating machines which were in more or less successful use, or in guessing at the dimensions and strength of the parts of a new machine; and as the parts broke down or gave out, in replacing them with stronger ones. Thus each new machine presented a problem almost independent of former designs, and one which could only be solved by months or years of practical experience and a series of break-downs. Modern engineering, however, has become a study, not of individual machines, but of the resistance of materials, the fundamental principles of mechanics, and of the elements of design.

(42) On the other hand, the ordinary rate-fixing—even the best of it—like the old-style engineering, is done by a foreman or superintendent, who, with the aid of a clerk, looks over the record of the time in which a whole job was done as nearly like the new one as can be found, and then guesses at the time required to do the new job. No attempt is made to analyse and time each of the classes of work, or elements of which a job is composed; although it is a far simpler task to resolve each job into its elements, to make a careful study of the quickest time in which each of the elementary operations can be done, and then to properly classify, tabulate, and index this information, and use it when required for rate-fixing, than it is to fix rates with even an approximation to justice, under the common system of guessing.

(43) In fact, it has never occurred to most superintendents that the work of their establishments consists of various combinations of elementary operations which can be timed in this way; and a suggestion that this is a practical way of dealing with the piece-work problem usually meets with derision, or, at the best, with the answer that "It might do for some simple business, but my work is entirely too complicated."

(44) Yet this elementary system of fixing rates has been in successful operation for the past ten years, on work complicated in its nature, and covering almost as wide a range of variety as any manufacturing that the writer knows of. In 1883, while foreman of the machine shop of the Midvale Steel Company, of Philadelphia, it occurred to the writer that it was simpler to time each of the elements of the various kinds of work done in the place, and then find the quickest time in which each job could be done, by summing up the total times of its component parts, than it was to search through the records of former jobs, and guess at the proper price. After practising this method of rate-fixing himself for about a year, as well as circumstances would permit, it became evident that the system was a success. The writer then established the rate-fixing department, which has given out piece-work prices in the place ever since.

(45) This department far more than paid for itself from the very start; but it was several years before the full benefits of the system were felt, owing to the fact that the best methods of making and recording time observations of work done by the men, as well as of determining the maximum capacity of each of the machines in the place, and of making working tables and time tables, were not at first adopted.

(46) Before the best results were finally attained in the case of work done by metal-cutting tools, such as lathes, planers, boring mills, &c., a long and expensive series of experiments was made, to determine, formulate, and finally practically apply to each machine the law governing the proper cutting speed of tools; namely, the effect on the cutting speed of altering any one of the following variables; the shape of the tool—*i.e.*, lip angle, clearance angle, and the line of the cutting edge—the duration of the cut, the quality or hardness of the metal being cut, the depth of the cut, and the thickness of the feed or shaving.

(47) It is the writer's opinion that a more complicated and difficult piece of rate-fixing could not be found than that of determining the proper price for doing all kinds of machine work on miscellaneous steel and iron castings and forgings, which vary in their chemical composition from the softest iron to the hardest tool steel. Yet this problem was solved through the rate-fixing department and the "differential rate," with the final result of completely harmonising the men and the management, in place of the constant war that existed under the old system. At the same time the quality of the work was improved, and the output of the machinery and the men was doubled, and in many cases trebled. At the start there was naturally great opposition to the rate-fixing department, particularly to the man who was taking time observations of the various elements of the work; but when the men found that rates were fixed without regard to the records of the quickest time in which they had actually done each job, and that the knowledge of the department was more accurate than their own, the motive for hanging back or "soldiering" on this work ceased, and with it the greatest cause for antagonism and war between the men and the management.

(48) As an illustration of the great variety of work to which elementary rate-fixing has already been successfully applied, the writer would state that, while acting as general manager of two large sulphate pulp mills, he directed the application of piece-work to all of the complicated operations of manufacturing throughout one of these mills, by means of elementary rate-fixing, with the result, within eighteen months, of more than doubling the output of the mill. The difference between elementary rate-fixing and the ordinary plan can perhaps be best explained by a simple illustration. Suppose the work to be planing a surface on a piece of cast iron. In the ordinary system the rate-fixer would look through his records of work done by the planing machine, until he found a piece of work as nearly as possible similar to the proposed job, and then guess at the time required to do the new piece of work. Under the elementary system, however, some such analysis as the following would be made:—

Work done by man.	Minutes.
Time to lift piece from floor to planer table..	—
Time to level and set work true on table	—
Time to put on stops and bolts	—
Time to remove stops and bolts	—
Time to remove piece to floor	—
Time to clean machine	—
Work done by machine.	**Minutes.**
Time to rough off cut ¼in. thick, 4ft. long, 2¼in. wide	—
Time to rough off cut ⅛in. thick, 3ft. long, 12in. wide, &c. ..	—
Time to finish cut 4ft. long, 2¼in. wide..	—
Time to finish cut 3ft. long, 12in. wide, &c.	—
Total	—
Add ——per cent. for unavoidable delays	—

It is evident that this job consists of a combination of elementary operations, the time required to do each of which can be readily determined by observation. This exact combination of operations may never occur again, but elementary operations similar to these will be performed in differing combinations almost every day in the same shop. A man whose business it is to fix rates soon becomes so familiar with the time required to do each kind of elementary work performed by the men, that he can write down the time from memory. In the case of that part of the work which is done by the machine, the rate-fixer refers to tables which are made out for each machine, and from which he takes the time required for any combination of breadth, depth, and length of cut.

(49) While, however, the accurate knowledge of the quickest time in which work can be done, obtained by the rate-fixing department and accepted by the men as standard, is the greatest and most important step towards obtaining the maximum output of the establishment, it is one thing to know how much work can be done in a day, and an entirely different matter to get even the best men to work at their fastest speed or anywhere near it.

(50) The means which the writer has found to be by far the most effective in obtaining the maximum output of a shop, and which, so far as he can see, satisfies the legitimate requirements, both of the men and the management, is the *differential rate system of piece-work*. This consists briefly in paying a higher price per piece, or per unit, or per job, if the work is done in the shortest possible time, and without imperfections, than is paid if the work takes a longer time or is imperfectly done.

(51) To illustrate:—Suppose twenty units or pieces to be the largest amount of work of a certain kind that can be done in a day. Under the differential rate system, if a workman finishes twenty pieces per day, and all of these pieces are perfect, he receives, say, 15 cents per piece, making his pay for the day $15 \times 20 = 3$ dols. If, however, he works too slowly and turns out, say, only nineteen pieces, then, instead of receiving 15 cents per piece he gets only 12 cents per piece, making his pay for the day $12 \times 19 = 2{\cdot}28$ dols., instead of 3 dols. per day. If he succeeds in finishing twenty pieces, some of which are imperfect, then he should receive a still lower rate of pay, say, 10 cents or 5 cents per piece, according to circumstances, making his pay for the day 2 dols., or only 1 dol. instead of 3 dols.

(52) It will be observed that this style of piece-work is directly the opposite of the ordinary plan. To make the difference between the two methods more clear: supposing, under the ordinary system of piece-work, that the workman has been turning out 16 pieces per day, and has received 15 cents per piece, then his day's wages would be $15 \times 16 = 2{\cdot}40$ dols. Through extra exertion he succeeds in increasing his output to twenty pieces per day, and thereby increases his pay to $15 \times 20 = 3$ dols. The employer, under the old system, however, concludes that 3 dols. is too much for the man to earn per day, since other men are only getting from 2·25 dols. to 2·50 dols., and therefore cuts the price from 15 cents per piece to 12 cents, and the man finds himself working at a more rapid pace, and yet earning only the same old wages, $12 \times 20 = 2{\cdot}40$ dols. per day. What wonder that men do not care to repeat this performance many times!

(53) Whether co-operation, the differential plan, or some other form of piece-work be chosen in connection with elementary rate-fixing, as the best method of working, there are certain fundamental facts and principles which must be recognised and incorporated in any system of management, before true and lasting success can be attained, and most of these facts and principles will be found to be not far removed from what the strictest moralists would call justice.

(54) The most important of these facts is, that *men will not do an extraordinary day's work for an ordinary day's pay*, and any attempt on the part of the employers to get the best work out of their men and give them the standard wages paid by their neighbours will surely be, and ought to be, doomed to failure.

(55) Justice, however, not only demands for the workman an increased reward for a large day's work, but should compel him to suffer an appropriate loss in case his work falls off either in quantity or quality. It is quite as important that the deductions for bad work should be just, and graded in proportion to the shortcomings of the workman, as that the reward should be proportional to the work done. The fear of being discharged, which is practically the only penalty applied in many establishments, is entirely inadequate to producing the best quantity and quality of work; since the workmen find that they can take many liberties before the management makes up its mind to apply this extreme penalty.

(56) It is clear that the differential rate satisfies automatically, as it were, the above conditions of properly graded rewards and deductions. Whenever a workman works for a day—or even a shorter period—at his maximum, he receives under this system unusually high wages; but when he falls off, either in quantity or quality, from the highest rate of efficiency, his pay falls below even the ordinary.

(57) The lower differential rate should be fixed at a figure which will allow the workman to earn scarcely an ordinary day's pay when he falls off from his maximum pace, so as to give him every inducement to work hard and well.

(*To be continued.*)

* Presented at the Detroit meeting of the American Society of Mechanical Engineers.

* The writer's knowledge of the speed attained in the manufacture of textile goods is very limited. It is his opinion, however, that owing to the comparative uniformity of this class of work, and the enormous number of machines and men engaged on similar operations, the maximum output per man and machine is more nearly realised in this class of manufactures than in any other. If this is the case, the opportunity for improvement does not exist to the same extent here as in other trades. Some illustrations of the possible increase in the daily output of men and machines are given in paragraphs 78 to 82.

Leeds Association of Engineers.—The annual meeting for the election of officers was held April 16th. The following were elected to serve for the ensuing twelve months:—President, Mr. James Bowers; vice-president, Mr. William Sheldon; committee, Messrs. T. Craister, Robert Lupton, and Alfred Towler; librarian, Mr. W. J. Dickinson; auditor, Mr. A. J. Balkwill; treasurer, Mr. W. H. Drake; hon. secretary, Mr. George W. Blackburn. A vote of thanks to the retiring officers was passed, on the motion of Mr. J. C. Jefferson, seconded by Mr. Alfred Atkinson, and acknowledged on their behalf by Mr. Samuel Thornton, the retiring president.

RAILWAY MATTERS.

IT is stated that a new express service from London to Paris, and *vice versâ*, *viâ* Folkestone and Boulogne, has been finally decided upon. It will be inaugurated on July 1st. Leaving London at half-past three and Paris four at p.m. respectively, the passengers will arrive at their destinations about half-past eleven at night.

IT is stated that the North Metropolitan and the London Street Tramways have jointly agreed to sell their undertakings to the London County Council at once, and to pay a sum of £600,000 for the fourteen years' lease to be granted to them. This will be equivalent to 9 per cent. on the capital outlay. The committee of the Council have completed negotiations for leasing other tramways, which will return 5 per cent. on the capital outlay.

IN Victoria a gauge of 5ft. 3in. has been adopted, while in New South Wales that known as the standard gauge, 4ft. 8½in., has been taken. The private line, Deniliquin to Moama —New South Wales—is laid to the Victorian gauge. South Australia has both the 5ft. 3in. and the 3ft. 6in. In Queensland the narrow gauge of 3ft. 6in. has been adopted throughout, and in Western Australia both the Government and private lines are laid on the narrow gauge of 3ft. 6in.

THE many accidents to railway servants have caused frequent expressions of regret in the reports of the Board of Trade. Particulars are given in the recent returns as to the different classes concerned in the accidents during the past year. Of the 442 who were killed, 117 were men employed on the permanent way, 49 were porters, 37 were labourers, 35 were brakesmen and goods guards, 30 were firemen, 26 were shunters, and 22 were engine drivers. In a section of the report which enumerates the accidents to servants in the employ of railway companies or contractors, such accidents being caused by the travelling of trains or the movement of vehicles used exclusively upon railways, it is shown that 75 were killed and 648 injured during shunting operations. Sixteen were killed and 331 injured while coupling or uncoupling vehicles, and 93 were killed while walking or standing on the line on duty.

THE record of train accidents in the United States in February includes 34 collisions, 91 derailments, and four other accidents, a total of 129 accidents, in which 37 persons were killed and 107 injured. These accidents are classified by the *Railroad Gazette* as follows:—Collisions: Trains breaking in two, 2; misplaced switch, 3; failure to give or observe signal, 6; mistake in giving or understanding orders, 3; miscellaneous, 5; unexplained, 15; total, 34. Derailments: Broken rail, 3; defective bridge, 2; defective switch, 1; broken wheel, 7; broken axle, 8; broken truck, 3; fallen brakebeam, 2; boiler explosion, 1; misplaced switch, 1; careless switching, 1; unfastened switch, 1; animals on track, 1; landslide, 5; washout, 2; flood, 1; malicious obstruction, 2; accidental obstruction, 4; ice, 1; wind, 1; unexplained, 42; total, 91. Other accidents: Boiler explosion, 1; broken side rod, 1; various breakages of rolling stock, 2; total, 4. Total number of accidents, 129.

ON Monday, at the House of Commons, a deputation, representing the ratepayers of Sligo and Enniskillen, waited upon Mr. Hanbury, Secretary of the Treasury, for the purpose of opposing the proposed purchase of the Sligo, Leitrim, and Northern Counties Railway of Ireland by the Great Northern and Midland Railway Companies of Ireland. Sir Henry Gore Booth laid before Mr. Hanbury a short history of the formation of the line, and explained how it came to be in financial difficulties, as a result of which the Treasury, who had found some portion of the capital, applied about two years ago for tenders for the purchase of the line. The Great Northern and Midland Companies replied offering to purchase it for about £130,000, which was about one-third of the original cost of the undertaking. Sir Henry strongly urged the Treasury not to accept the offer, chiefly on the ground that the sale would result in a monopoly, with the evil consequences of increased rates, and of preventing the development of the district. Mr. Hanbury, in the course of a brief reply, said he was strongly in favour of not selling the line. He should be glad to receive details of the scheme of reconstruction, to which he would give his best attention.

THE importance of railways in the development of Australia cannot be over estimated, as owing to the absence of natural waterways, almost all the traffic from the interior has to be carried by rail. The four principal cities of the Colonies are in direct railway communication; and viewed from the "population per mile of line" point, Australia can boast even now of being better served by its railways than any country in the world. New South Wales has at present 146½ miles of railway under construction; Victoria, 15½ miles authorised; Western Australia is pushing on with 382 miles of additional lines, 57 of which were to be opened in December last. The railways of Australia practically represent the assets for the national debts of each Colony. It is agreed that to a certain extent the railway administration should be separated from politics; the construction and direction of new lines may well be left to Parliament to determine, but the management of the lines and control of the railways daily working are matters for skilled and capable railway managers, untrammelled by the exigencies that political consideration would often cause to influence the political mind. These views have been given effect to in Victoria, South Australia, New South Wales, and Queensland, which provided to a certain extent for the management of the railways on commercial as separate from political lines. Each system was placed under the control of three commissioners, who had large powers to administer free from political interference, and the generally expressed opinion is that the system worked well. Victoria, however, amended her Railway Act of 1883 by limiting the powers of the Commissioners, and giving the Minister for Railways of the day greater power to interfere in the management. But this change has not brought about the desired result, and the Act is being again amended.

FOUR persons killed, a dozen seriously injured, and fifty others hurt more or less severely, is, says the *Railroad Gazette*, the result of the collision of electric cars at St. Louis, on March 8th. Recklessness, either of officers in failing to prescribe rules, or of motormen, generally ignorant, in carrying them out, is apparent on electric railroads all over the country, and collisions or runaways illustrating it occur every few days; but fortune favours the fatuous, fatalities are few, and the lessons bearing on future practice seem not to be heeded. Here, however, is a flagrant case, in many respects typical. The road—the St. Louis and Kirkwood —runs, a part of the way at least, on its own right of way, separate from the street, so that cars can be run as fast as may be desired. Grades are steep and cars pretty heavy, so that high speed down grade is easily made. The *Republic* reporter timed several cars and found them making forty miles an hour. The manager has had no experience on standard railroads, entrusts cars to men hired without adequate inquiry, and has no printed regulations. A written memorandum of some kind is given to motormen. Ruling trains are required to wait three minutes at meeting points, and those going in the opposite direction indefinitely; but it appears that this last provision is modified most of the time so as to permit an inferior train to proceed cautiously after ten minutes. Trains appear to be run in this way without any supervision, and inferior trains are in the habit of "stealing switches" whenever it seems desirable. An attempt to do this—to reach the next meeting point before the ruling train gets there, while the whereabouts of the latter is wholly unknown—was what caused this collision. To cap the climax, says the *Gazette*, the passengers on these forty miles an hour trains are allowed to crowd the front platforms of the cars.

NOTES AND MEMORANDA.

THE weekly return of the Registrar-General shows that the deaths registered last week in 33 great towns of England and Wales corresponded to an annual rate of 19·0 per 1000 of their aggregate population.

IN London 2836 births and 1654 deaths were registered, or 87 above and the deaths 27 below the average numbers in the corresponding weeks of the last ten years. The annual death-rate per 1000 from all causes, which had been 17·9, 17·9, and 20·3 in the preceding three weeks, fell again last week to 19·4

CHLORIDE of lime, Traube has pointed out, provides the means of obtaining a germ-free drinking water, and has proved its utility by practical experiments. His tests were not conducted with pathogenic germs, though he concluded from his experiments that, used in the proportions he advocates, it would be fatal to all kinds of bacilli.

STERNBERG and Delettre have, according to the *Moniteur de la Ceramique et de la Verrerie*, invented a new process for the production of refractory material. They claim that by adding 10 to 15 per cent. of asbestos, either fibrous or pulverised, the material is made more fire-proof and durable. The addition of asbestos is made while the clay, or whatever earth is used, is being mixed. Bricks produced from this material are said to prove excellent in the construction of converters, retorts, melting pots, &c.

IN the French journal, *L'Industrie Velocipédique*, experiments by M. Wallington with ignition tubes for gas engines are referred to, and the mixture of materials for porcelain tubes which he has found to be best is given. It is as follows: Kaolin 62 parts, 4 chalk, 17 sand, and 17 feldspar. Each of these constituents is ground in water separately, and these waters, whilst all the fine particles are carried in suspension, are mixed together and decanted into a settling tank. After subsidence, the fine material obtained is moulded into tubes, which are at first air dried. They are then baked in clay cylinders for about fifteen hours with a wood fire. The cost is high, but the durability is high also.

REFERRING to statements advanced at the 1895 meeting of the Bavarian Society of Applied Chemistry—*Chem. Zeit.* 19, 1452—Mr. R. Kissling points out that the amount of paraffin in burning oils is very slight, and can, in any case, only affect the consumption of the oil—not its illuminating power. In connection with the assertion that Ohio oil containing a large proportion of sulphur is now in the market, necessitating the examination of such oil for the detection of sulphur, he remarks that those who ought to know deny that refined Ohio oil is dealt in in Germany, but that even if it be, the desulphurising processes this oil undergoes in refining render it undistinguishable from the Pennsylvania oil, containing but little sulphur.

THE velocity of an earthquake-wave within a short distance from the epicentre is so difficult to ascertain on account of the large error resulting from a small error in the recorded times, that all estimates with an approach to accuracy are of value. In the Brescian earthquake of November 27th, 1894, good time-determinations were obtained at ten stations, all within 445 kiloms. from the epicentre. Assuming the velocity to be uniform in all directions, Dr. M. Baratta calculates it to be 1·411 kiloms. per second. Taking account of the nature and extent of the rock traversed by the earth wave, he also finds the average velocity to be ·782 kiloms. per second in alluvium, and 1·569 kiloms. per second in the older and more coherent rocks. The large scale experiments made at Holyhead by Mallet gave these results for sand, slightly discontinuous and discontinuous rocks. They were published in the "Transactions" Royal Society in 1873.

AT a recent meeting of the Philadelphia Academy of Natural Sciences, General Isaac J. Wistar made a communication on the apparent capricious distribution of iron oxide as colouring matter in the rocks of the anthracite coal region. At several points, apparently, the accessible supply of iron was exhausted by complete distribution in the strata under process of deposit with intermediate and subsequent periods during which new supplies appear from some source not yet clearly explained. Professor A. P. Brown stated that it had been suggested by Russell that the red colour of certain formations may have originated from the subaërial decay of iron bearing rocks, and the subsequent deposit of this material as sediment forming the red rock. As far as the ash of coal is concerned, it is probable that the colour is due to the way in which pyrites is contained either in the coal itself or in the slate adjoining. Coal containing separable pyrites would give white ash, while if the pyrites is intimately mixed in the coal the ash will be red.

A NOVEL series of exepriments is in progress at Wesleyan University, Middletown, Connecticut, to determine the nutritive and caloric value of food, and many other questions relative to nutrition and other vital processes. Quoting some source not named *Nature* says:—"For this purpose a calorimeter is employed, consisting of a copper-lined box, measuring inside 7ft. by 4ft. by 6½ft., thus giving 182 cubic feet of air, within which space a man is confined for several days at a time. It is fitted with glass windows of three thicknesses. Fifty litres of air per minute are pumped in. Food is passed in three times a day through an air-tight tube, and is carefully weighed, as are all the exudations and excretions, and the quantity of heat is measured. A telephone enables the subject to converse with the outer world. The experiments are conducted by Pro. Wm. O. Atwater, and the expense is shared by the Department of Agriculture of the United States Wesleyan University, and the Stores Experiment Station at New Bethel. A careful record is kept of every action of the subject—of his hours of sleep, minutes of exercise, respiration, appetite, &c. To this end there are two watchers and two assistants, a watcher, who is a professor in the university, and an assistant being constantly present."

THE Department of State in Washington has published reports from Magdeburg, Dusseldorf, Frankfurt, and Stettin dealing with the slag cement trade. This cement, it seems, is made by mixing pulverised hydrate of lime with basic blast furnace slag, which has been granulated, dried, and reduced to powder by grinding. It is used for certain purposes as a substitute for Portland cement, for it is about 20 per cent. cheaper, and being of lower specific gravity, "spreads farther," so that on the whole the economy in using it is 30 to 40 per cent. It is also alleged that the mortar is more tenacious and elastic, and thus is more suitable for the foundations of bridges and other structures liable to unequal strain or to the shock of passing trains or vehicles. It was originally suggested by the excellent cement obtained from mixtures of hydraulic lime and *puzzolani* or pulverised lava, which was first produced in Germany in 1863. The essential element in basic slag for making cement is silicic acid in proper proportions, and then this must be "live" and in a condition to unite readily and firmly with the lime, while the slag must contain a due proportion of magnesia and not an excess of some impurity which will resist the combination and sooner or later cause crumbling or disintegration. In Western Germany there is only one small district—in the Saar Valley—where slag of perfect quality is produced, and here the slag cement manufacture is concentrated in the hands of two firms. This cement seems to be regarded with some suspicion by engineers, who will only use it when they know where, by whom, and from what materials it has been manufactured. When of good quality it may be used with advantage where the work will always be moist and protected from the sun. The consul at Magdeburg says the industry is dying out in Germany owing to the opposition of Portland cement, lack of support from the Government, and stagnation in the building trade; a factory opened at Stettin some years ago failed. In Germany it is generally called puzzolan cement.

MISCELLANEA.

MESSRS. EARLES' SHIPBUILDING AND ENGINEERING COMPANY, of Hull, have received an order from the Admiralty to construct two 30-knot torpedo boat destroyers.

EVEN experienced carriers get into trouble under the present traction on roads regulations. At the Mansion House the Fardell Traction Haulage Company, Limited, were fined in all £10, with £10 10s. costs, for having on five occasions in March last used a traction engine in the City without being licensed by the Corporation under the Highway Act.

IN reply to a correspondent, writing on high and low tension currents, the Board of Trade replied that they have been informed of nine cases of fatal accidents to employés at generating or transforming stations where high-pressure alternating currents are used, but that no instances have been reported in the case of low-pressure continuous currents. It may also be true that the Board of Trade have heard of the drowning of many people in the sea, but none in street gutters.

THE new American torpedo boats or destroyers—for they are of 180 tons displacement—differ, according to the *Naval and Military Record*, from most other craft of their kind in that they have built-up forecastles, very much like our "catchers" of the Alarm, or 810-ton type. These forecastles gave them a freeboard forward of no less than 12ft. 6in., and should render them excellent boats for sea work. The speed is to be 26 knots, with 3200-horse-power and 395 revolutions. The armament consists of four 1-pounders and three torpedo-tubes, one being astern and two *en echelon* nearly amidships. There are three funnels and two conning towers.

A SHOLAPUR correspondent writes to the *Bombay Gazette*:—"As a sign of the times, we hear that a patriotic and leading native of Pandurpur has opened a shop for the sale of country-made mill and hand-woven cloths in that town, and laid in a stock of over ten thousand rupees worth of cotton and woollen fabrics, in order to help the masses to patronise Indian industries only. His example is being followed in numerous other places. As these patriots are mostly wealthy men, content with the smallest profits to merely cover cost, it is probable that Manchester has raised a hornet's nest, and given an impetus to Indian, Chinese, and Japanese trade which it never contemplated, and from which it will suffer in the end."

SOME floods prevention works are much wanted in Canada. Damage amounting to a million dollars has been done in the eastern townships by floods, the worst which have been experienced for twenty years. The town of Richmond and part of Sherbrooke have been submerged, and hundreds of families have been driven from their homes. Many mills and factories on the banks of the St. Francis River have been swept away, and the Quebec and the Central and Drummon County Railways have been crippled, iron bridges having been demolished. Twenty-four houses were swept away from St. Anne's and Isle de Grace on the 20th inst. The loss of life is fortunately very slight considering the serious character of the flood.

ON January 7th, 1890, the Egyptian Government, having received the assent of the European Powers, issued a decree levying a tax of 1½ millièmes—about 3s. 10d.—per ton on shipping entering and leaving the harbour, to become payable when a new pass having 300ft. width and 30ft. depth should be completed. This is now officially declared as accomplished, and that the tax will be levied from May 1st next, when compulsory pilotage dues will be abolished. The expense of excavating the pass was estimated at £60,000, to be borne equally by the Government and shipping, the latter to contribute £3000 additional for two years' interest. The tax is to cease absolutely so soon as it has realised the amount of £33,000 with 5 per cent. interest, and a special half-yearly report is to be published showing the receipts. The *Times* Cairo correspondent says the Government bears the expense and responsibility of keeping the new pass lighted at all times, and it is already freely used by ships entering and leaving during the night.

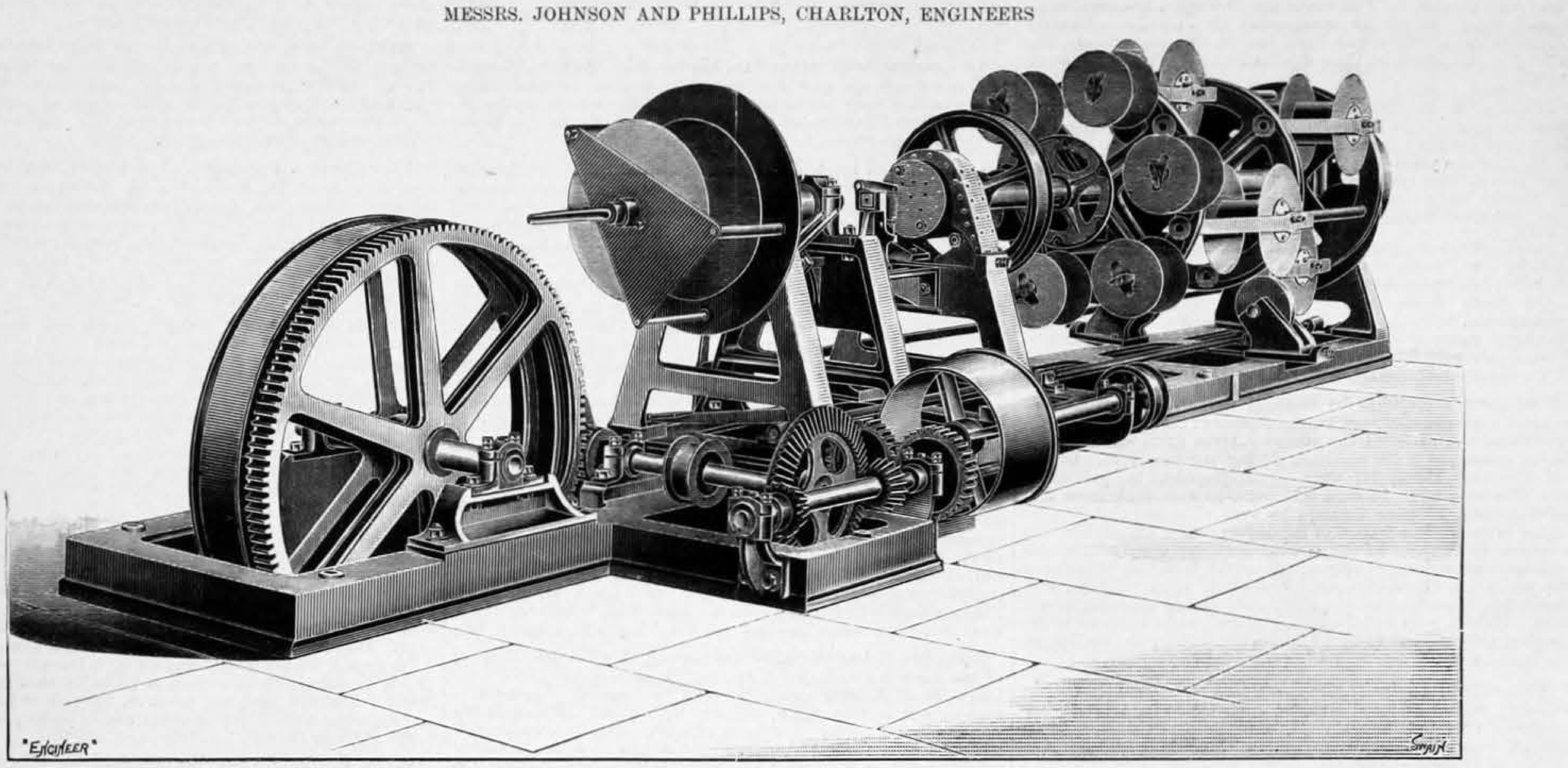
IT is stated, the *Dover Standard* is authoritatively informed, that the Kent Coalfields Syndicate have definitely entered into a contract with a firm of mining engineers in the north of England to sink two colliery shafts at Hongham, two miles west of Dover. The shafts are to be 20ft. in diameter, and are to be sunk within twelve months. It is intended to make further borings. The syndicate consists of the following gentlemen:—Mr. Philip Stewart Mackenzie Arbuthnot, West Hoathley, Sussex; Mr. Richard Berens, St. Mary Cray, Kent; Mr. George Frederick Fry, Dover Harbour Commissioner; Mr. Frederick Pitts, County-chambers, Cornhill, London; and Sir Henry Beyer Robertson, Palé, Merionethshire. The experts calculate that there is sufficient coal in the measures already discovered, taking an area of not more than 6000 acres, to supply about 3000 tons a day for seventy years. The coal-bearing district in Kent is estimated at about 150 miles in length by about five or six miles in breadth.

A GREAT engineering work of immense importance to the city of Venice has just been completed. Fifty-eight years ago, in order to prevent the damage caused by the occasional overflowing of the river Brenta, the Austrian Government, on the recommendation of the celebrated engineer Paleocapa, carried out certain works by which the mouths of that river were carried into the Chioggia Lagoon, some distance south of their original outlet. Since then the alluvium brought down by the river has threatened to convert a portion of Chioggia Lagoon into a fever-breeding swamp; and also to cause serious damage to the whole Venice Lagoon by silting. It was accordingly decided to construct a new channel for the Brenta, sixteen kilometres in length, giving the river a direct outlet into the sea near Brondolo, still further south. The scheme, which was estimated to cost eight million lire, and was begun in 1884, has now been brought to a successful conclusion. The new channel, by means of subsidiary canals, also provides a fresh outlet for the Bacchiglione and other rivers formerly flowing into the Venice Lagoon.

IN the course of a lecture on "Recent Chemical Progress," given on the 16th inst. at the Royal Institution, Professor Dewar, F.R.S., commented on the great future opened out to synthetical chemistry by the employment of the temperature of the electric arc. Some of the most interesting results had been obtained from the electric furnace by the French chemist, M. Moissan, in the shape of carbides, stable bodies produced by the combination at high temperatures of carbon with various metals. Many of these carbides were decomposed by water, the hydrogen of the water combining with the carbon to form hydrocarbons. Thus with water some carbides, such as that of calcium, gave acetylene; others, like that of aluminium, gave marsh gas, while others again gave these and other gases, and, what was most wonderful, liquid petroleums. It was a curious fact that many years ago Professor Mendeleef speculated that the only reason for the immense localisation of petroleum at Baku was that it was being generated there—he suggested by the action of water on carbides. His idea was rather smiled at then, but now it was his turn to smile. When acetylene was heated to a dull red heat, it was polymerised to benzene. Benzene was the basis of all the new modern colours, and thus by three direct stages we were able to reach the nucleus of all the colours hitherto manufactured from coal-tar products. First there was the combination of lime and coke in the electric furnace; secondly, the decomposition of the carbide thus formed by water; and thirdly, the transformation into benzene of the resulting acetylene by means of heat. Professor Dewar concluded by briefly discussing some of the properties of acetylene, explaining, among other things, the cause of its extraordinarily great luminosity as due to its peculiar endothermic structure.

COMBINED CABLING AND SERVING MACHINE

MESSRS. JOHNSON AND PHILLIPS, CHARLTON, ENGINEERS



COMBINED CABLING AND SERVING MACHINE.

SOME time ago we promised our readers particulars of a machine of this description, supplied by Messrs. Johnson and Phillips, of Charlton, to H.M. Postal Telegraph Department, for cabling their gutta-percha covered cables, and at the same time serving them with compounded tape. This machine, which we now illustrate, is arranged for cabling seven wires, *i.e.*, laying six wires round one, and at the same time laying a yarn in the recess formed between each pair of wires, so that when the cable is taped it forms a more perfect round.

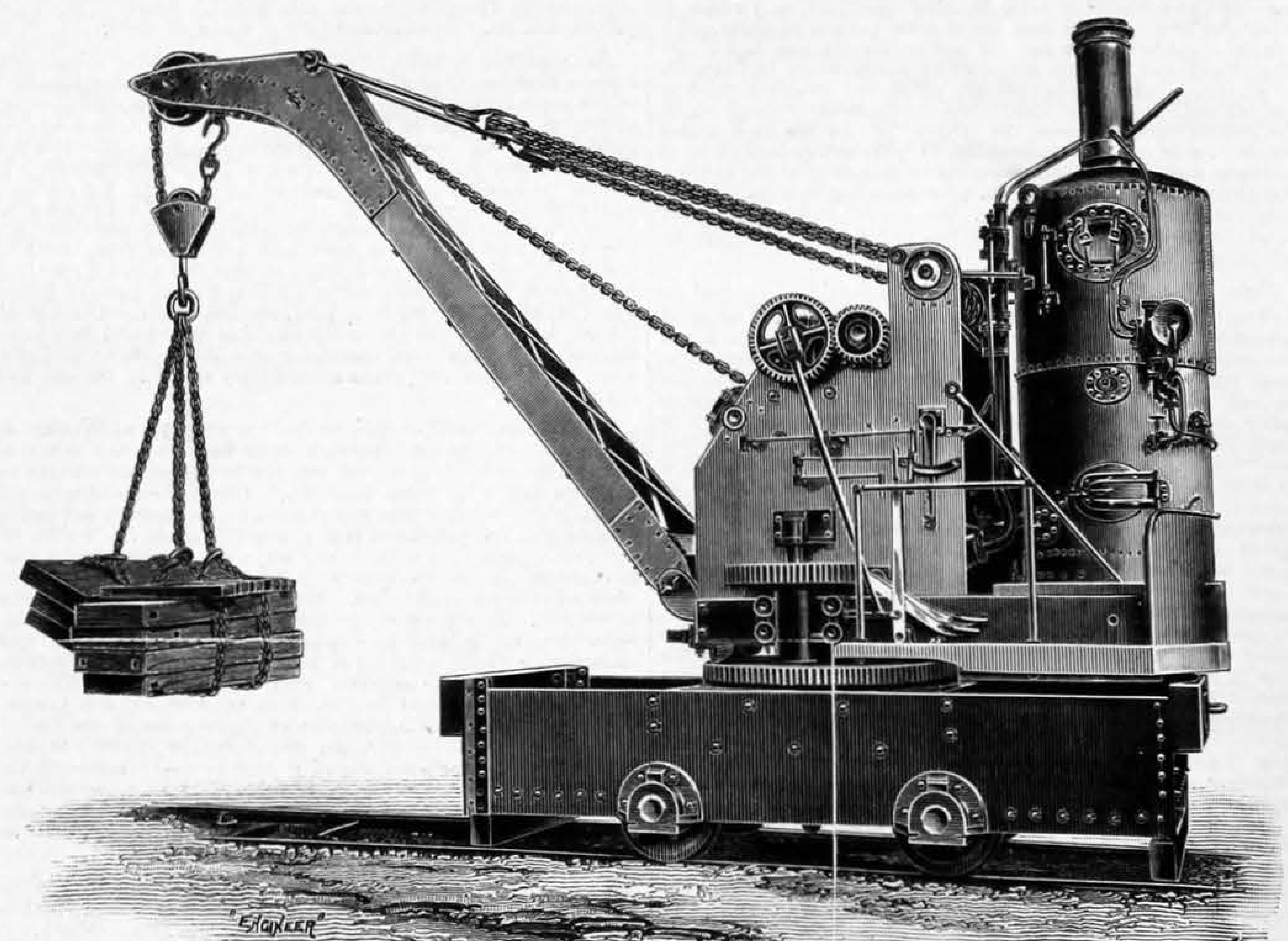
The machine is erected on a strong cast iron bed-plate, and the six wire bobbins—arranged in two bays—are carried in forged wrought iron fliers between three discs, the third disc also carrying the six yarn bobbins. The central hollow steel shaft runs in a large gun-metal stepped bearing at one end, and the "lay-head" end and the central disc run on anti-friction rollers. The draw gear is driven from the "lay-head" end of this shaft by means of a belt driving on to a countershaft carried from the bed-plate of the machine. The motion is transmitted to the draw-through drum by means of spur and bevel gearing, change wheels being provided to give the requisite length of "lay" for the different sizes of wires. The taping head is designed to serve various widths of tapes, and for that purpose is driven by means of coned pulleys, which allow the "lay" and "lap" of the tape to be adjusted very minutely.

The bobbin of tape, as will be seen, is arranged concentrically with the cable, the tape being led from the bobbin by means of a series of rollers, &c., down through a slotted guide on to the cable. The wire bobbins are each arranged to hold one mile of gutta-percha covered wire, and the yarn and tape bobbins respectively hold sufficient tape to "worm" and "serve" this length of cable. The diameter of the tape bobbin is 21in.; the radius described by the taping head, measured over the guide rollers, is 16in., and the speed of this head is about 500 revolutions per minute. The central hollow shaft is 3in. diameter, and runs in large gun-metal stepped plummer blocks, having bearings two and a-half diameters long. All the bobbins are provided with means for adjusting the tension on the various wires, yarns, &c., as may be desired. The finished cable is led from the draw-through drum on to a receiving drum placed a few feet distant from the cabling machine, from which it is driven by means of a belt. This apparatus is provided with an automatic guiding-on and flaking gear, which is not shown in the illustration.

Besides the above-described machine we understand that Messrs. Johnson and Phillips have supplied H.M. Postal Telegraph Department with a four-wire combined cabling and serving machine, all complete with the necessary bobbin winders, swifts, and automatic winding and coiling gear, for making the finished cable up into coils, and have fitted it up at the Mount Pleasant factory.

CONDENSERS FOR ROLLING MILL ENGINES.

MR. ROBERT J. WORTH, of Worth, Mackenzie, and Co., Limited, engineers, Stockton-on-Tees, at the monthly meeting of the Middlesbrough District Association of Foremen Engineers and Mechanical Draughtsmen, read a paper on "The Application of Condensers to Rolling Mill Engines." He remarked that, owing to the fact that steel was rapidly superseding iron, the rolling mills no longer had that superabundance of steam which formerly was raised by the waste heat from the puddling furnaces. Economy of steam in rolling mill engines was formerly a matter of no consequence, but now it was becoming one of primary importance. The difference between a rolling mill with engines of the type usual in the North of England, and a mill laid out on the best system for economy of steam was, he believed, just the difference between one that barely paid and one that returned a good profit to the owners. Thus, if an engine of the usual size, with a pair of 42in. cylinders and 5ft. stroke reversing, were taken, the difference in the steam consumption between the ordinary type and a fairly economical type would be equivalent to a saving of about 5700 lb. of coal per hour during the time the engine was actually running. If the engine ran six hours per shift, and ten shifts per week, and the value of the coal delivered were 8s. per ton, there would be a saving of £61 per week, or on a year of forty-eight weeks £2920. By the alteration of a cylinder and the addition of a condenser to a smaller engine, a larger proportion of saving in steam had actually been effected. Mr. Worth showed that the lighter an engine was loaded the greater the saving in steam consumption, and, as in a "pull over" or "crab reversing" mill, the time during which the engine was running empty or lightly loaded formed a very large proportion of the total running, the saving with mills of this type and with engines well up to their maximum work would be very great. There were circumstances, however, when the saving effected by the use of a condenser was greater and more important than those mentioned, and these were when the engine was under its work, and when the workmen, in consequence, had to wait a considerable time for the engine to get up speed. The additional power and speed would generally be from 40 to 50 per cent., and that would represent a great saving in labour. The main engines using less steam would leave more for the auxiliary engines, and a more regular pressure would thus be maintained in the boilers. The author recommended Korting's ejector condenser on account of its great simplicity, the absence of any working parts, and the fact that it needed no attention.



LOCOMOTIVE STEAM CRANE, MESSRS. MARSHALL, FLEMING, AND JACK, ENGINEERS

LOCOMOTIVE STEAM CRANE.

THE above engraving illustrates a handy size of locomotive steam crane, one of a class specially designed for use in steel works; it lifts and travels with 10 tons at 14ft. radius on 4ft. 8½in. gauge of rails. As very quick speeds are required, combined with immunity from breakages, all parts are made with an ample margin of strength. The framing of body and carriage is constructed of heavy steel plates, and the gearing throughout is of Siemens cast steel. The jib is swan-necked, to give plenty of clearance for the load at a short radius and under limited head room, and the radius is adjustable by worm gear from the engines. The carriage is provided with feet, so that should the crane leave the rails it cannot sink or overturn.

The makers, Marshall, Fleming, and Jack, of Motherwell, N.B. have been very successful in keeping pace with the ever-growing demands of steel works engineers for faster and heavier lifting machinery, and have supplied cranes of the above type for loads up to 20 tons to leading steel makers.

THE CRYSTAL PALACE SCHOOL OF ENGINEERING.—On Friday last Mr. A. T Walmisley, M. Inst. C.E., engineer to the Dover Harbour Board, distributed the certificates obtained during Easter term by students at the Crystal Palace School of Practical Engineering. In the course of his address he said that they had to congratulate themselves on the results of the first term of their twenty-fourth year. Very few people had any idea of the amount of educational work carried on at the Palace. Old students from that school were to be found exercising their profession all over the world, and no small portion of the success which had been attained was due to the personal influence which the principal, Mr. J. W. Wilson, had exercised over the 1172 students who had passed through the school since its foundation. In the first term of 1872, when the school was established, they had fifteen students. This term they numbered seventy-one. They demanded an entrance examination as a test of proficiency in general education. The Institution of Civil Engineers did the same for their class of students since the year 1889, when the Institution had 967 students on their books. The students' class at the Institution was established in 1867. Of course many had become transferred to corporate membership upon attaining the proper age, and the present number of students was 877. He strongly recommended all those who wished to come to the front in the profession to join the Institution of Civil Engineers as students as soon as they could, and felt sure the technical training they received at the Palace would prove an additional testimonial for their nomination, although the Council of the Institution of Civil Engineers simply demanded proof of a sound general education, and did not specially insist upon proof of previous technical education. He advised the students not to run away with the idea that what they had learned was incapable of improvement, and he strongly urged them not to put blind faith in formulas, but to examine each case on its merits. At the close of the distribution, Mr. G. T. Rait, chairman of the Palace Company, thanked Mr. Walmisley on behalf of the directors, and the proceedings terminated.

SOME MORE STEAM CARRIAGES.

THE two steam carriages illustrated by the engravings now published are of considerable interest, as showing the direction which design took from twenty to thirty years ago, or a quarter of a century after the very different designs of Hancock, Gurney, James, Hill, Macerone, Church, and others had been given up for various reasons, though they had been perfectly satisfactory as indicating the practical lines on which coaches could be thereafter built. Reasons other than mechanical or structural caused the cessation of efforts in this direction, and except spasmodically little was done for a quarter of a century, and then most of the designs were rather of the carriage for a steam engine and boiler than a comfortable passenger carriage operated by a steam engine. The engine was in many cases much better from the steam engine designer's point of view, but in nearly all cases the useful work done by Hancock, Gurney, and others, with reference to the boiler, was ignored, and no real progress from the carriage point of view was made, the weight of the engine and boiler and gear being excessive, much of it being due to the boiler, which in most cases was either the modern locomotive or the then modern vertical boiler, with large unstayed or unbalanced surfaces requiring heavy plates. Many of these steam carriages of a quarter of a century ago were from the mechanical engineer's point of view successful, and as they played an important part historically they are of interest even now in part as illustrations of what could be done or might be done, and partly as showing what not to do.

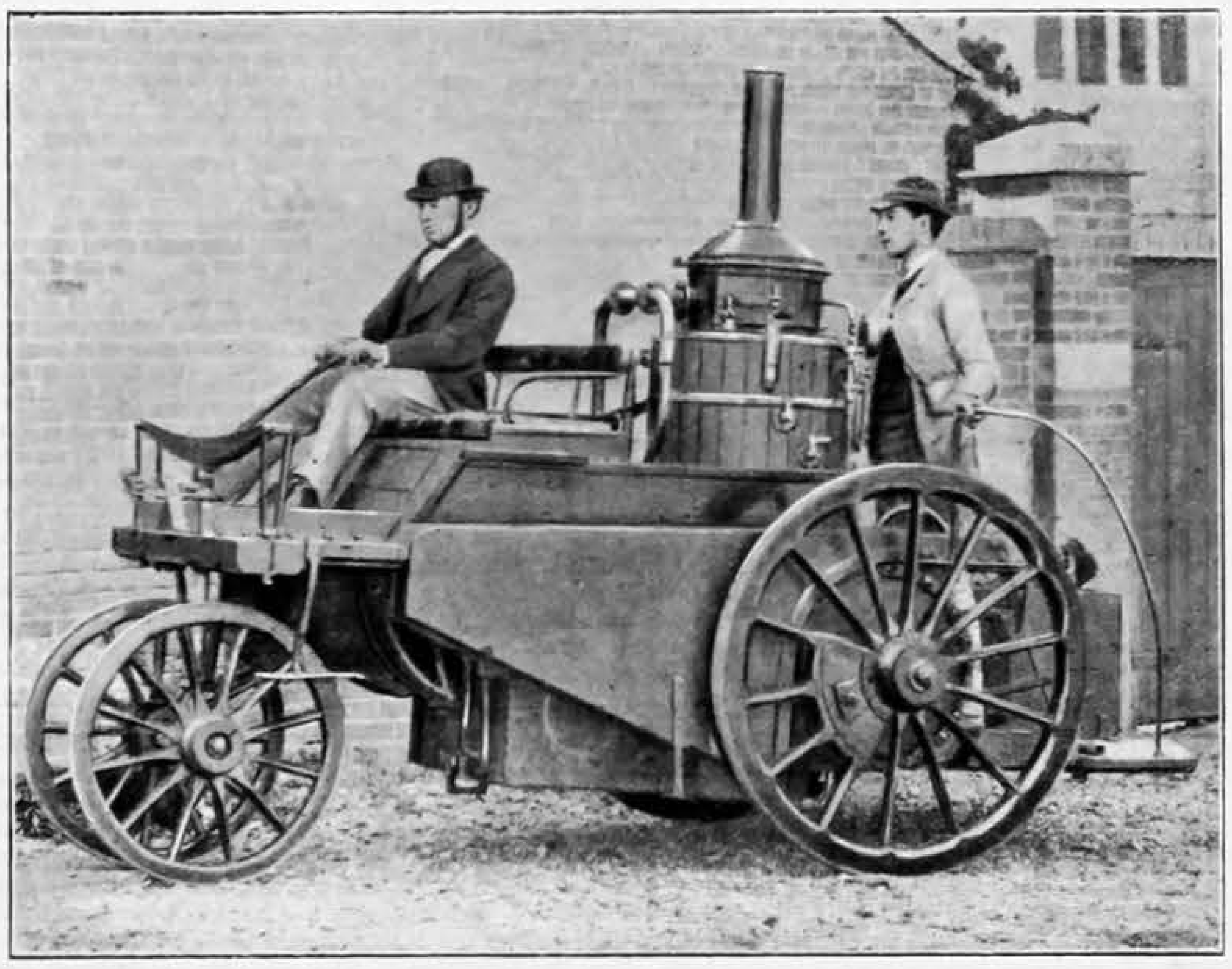
MR. NEVILLE GRENVILLE'S STEAM CARRIAGE, 1875

One of these shown by side and end views is of a steam carriage still existing. It was built for Mr. R. Neville Grenville, of Butleigh Court, Glastonbury, in 1875, by Messrs. T. Cooke and Sons, York. The boiler is a Shand and Mason cross-tube steam fire-engine type. It had a single inverted cylinder bolted outside of the boiler 5in. diameter by 6in. stroke. But this was found unsatisfactory, and was altered to two cylinders of the same size, and geared to half the original speed, and placed horizontally, the ratio of crank shaft to driving wheels being now 4 to 1. The driving wheels are 4ft. diameter with 3in. tires, and are solid disc wheels of teak. These, no doubt, are heavy, but the reason they were made so was that Mr. Neville Grenville heard that others had had trouble with spokes working loose. He questions now if this is really the fact, but the disc wheels are very easy to clean. The second motion shaft is linked to the driving axle at the right-hand end, and rises and falls with it by the action of the springs. The left-hand end has a ball-and-socket bearing, so the effect of this is slightly to throw the gear teeth across each other, but in the same plane, so no ill results and no wear are perceptible. In this way the difficulty attaching to the use of springs and gearing is perfectly overcome. The steering wheel is 2ft. 6in. diameter, with a 3in. tire, and works well. At first there was an arrangement for turning the exhaust into the tank when necessary; but this was not wanted, and, as it was at times inconvenient, it was taken off, and an exhaust tank and feed heater put on instead, the water from the condensed steam running back into the water tank. The boiler is fed by a pump and by an injector. The weight with coal and water is 45 cwt. The tank holds 55 gallons. The boiler heating surface is fire-box 13ft., tubes 16ft.; total, 29 square feet. The grate area is 2¼ square feet. The carriage is still in working order, and Mr. Grenville ran it in the last few weeks 120 miles. The following is the account of the last two runs from Mr. Neville Grenville's diary, which will give an idea of what the carriage will do.

Saturday, April 4th, 1896.—"After lunch to Baltonsborough with steam carriage; went to several places there and did my business and back by five. Distance run, seven miles."

Tuesday, April 7th, 1896.—"Mr. Pinney came at 9.30 a.m., and we started with steam carriage at 9.45, George Mildred with me in front, and Noble firing, Mrs. N. G. and Mrs. Audry with us as far as the Horse and Lion; we on through Glastonbury and to Polsham; stopped there for five buckets of water, and on to Wells, arriving at the Palace at 10.50—ten miles in sixty-five minutes, including stops for horses, water, and at railway level crossing. Called on the Bishop as I promised, and took him and some friends for a run round the Palace. One of them thought I was a bagman come to try and sell the carriage to the Bishop for him to use in inspecting the diocese! Put up at the stables, Pinney and I to County Council meeting. . . . Barstow tells me he has been to London to see autocars, but did not get any satisfaction, so told him to come home on mine. After the meeting Sir R. Paget, Hobhouse, Dyke, Colonel Clarke, and other County Councillors came and had a ride, and were much pleased. Left for home at 4.40, having on board Barstow and Gibbons extra; a good run to Glastonbury; dropped Gibbons at Edgarley at 5.25, and on *viâ* Baltonsborough, stopping a few minutes for five buckets of water; arrived home at 6 p.m. Fourteen miles in eighty minutes, including stoppages and slowing down. Total run out, ten miles; home, fourteen miles; run in Wells, one mile; total, twenty-five miles. Coal burnt, 155 lb., equal about 6 lb. per mile, including getting up steam twice, as being some hours in Wells I let the fire out. We need not have taken any water on the road either way, but thought we would be on the safe side. Water used for the twenty-five miles, about fifty-five gallons at most each way, or 1100 lb., not including drain from the feed-heater, which I had no means of measuring."

Mr. Knight's carriage, illustrated by the accompanying engravings, is one to which reference has several times been made, and it further shows the lines on which the designers of a quarter of a century ago chiefly worked. There are some points of interest and of guidance in them, although now we must look upon all these as rather vehicles for an engine, its gear and a boiler, than as a carriage. It was made by Mr. J. H. Knight, of Farnham, and was commenced in 1868. It was first fitted with one cylinder and a fly-wheel, but the difficulty of starting on inclines was considerable, and a second cylinder was added, the ratio of the gearing being reduced to 1 to 4, instead of 1 to 6, which was the ratio as originally arranged with the single cylinder.

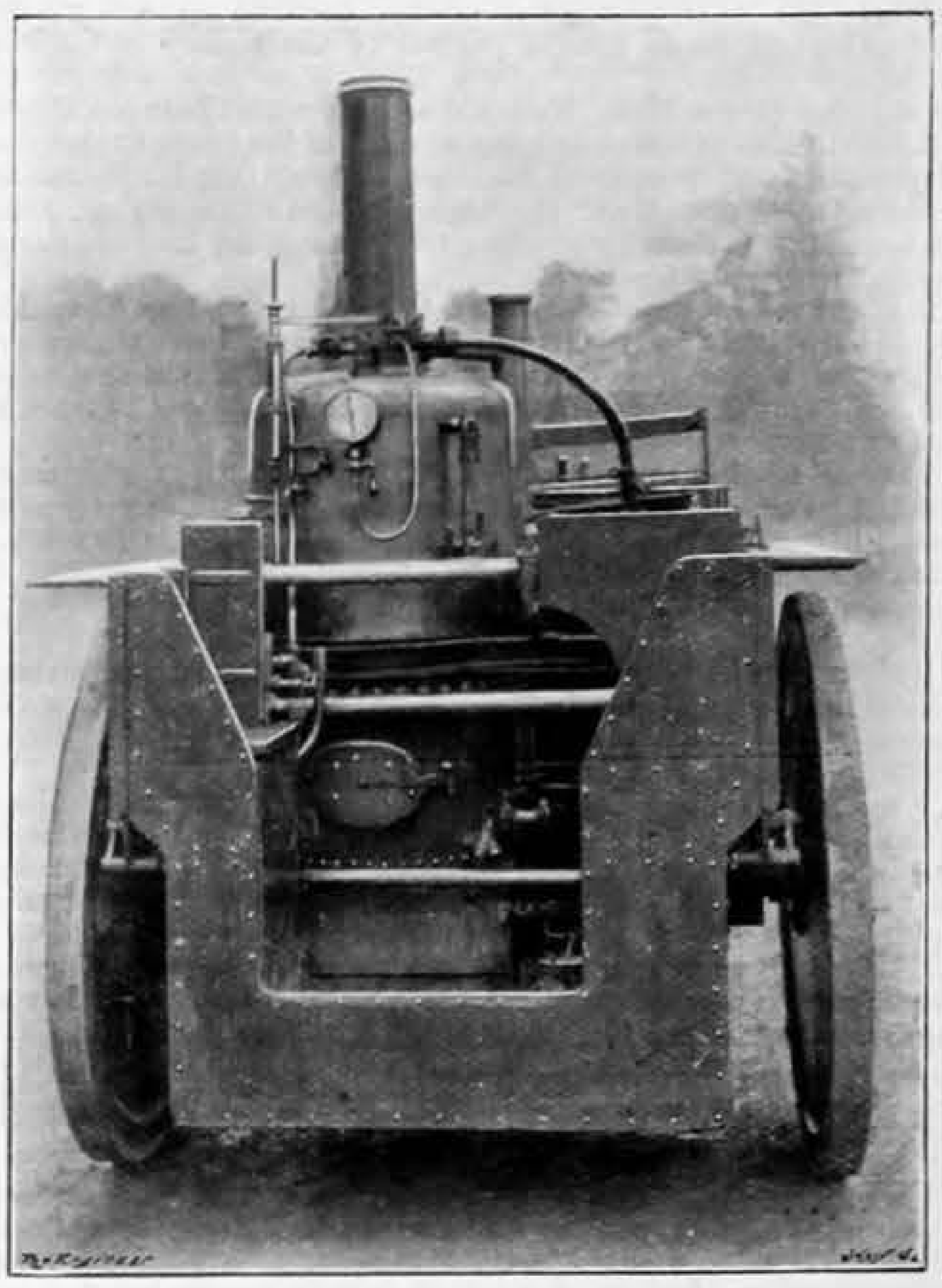


MR. KNIGHT'S STEAM CARRIAGE, 1868

The cylinders were 5in. by 7in., and were fitted between two angle irons, which formed the frame of the machine. They were fitted with link motion, the reversing quadrant and the steam lever being on the steersman's right. The steering wheels, 2ft. 8in. diameter, were on a gauge of 2ft., the hind wheels 4ft. diameter and 4ft. 2in. gauge. The steering wheels were moved by a tiller with a cross handle, but the tiller moved through an arc of twice the radius of the steering wheels; the steersman had thus good control over the carriage, and but little muscular effort was required in steering. Only one wheel was the driving wheel, and this was found sufficient for all practical purposes; it was only found to slip on wet grass. In motor carriages with one driving wheel it seems advisable, at least for use in England where vehicles pass one another on the left, to have the driving wheel on that side, for it is sometimes necessary to leave the crown of the road in passing, and if the right wheel be the driver there might be some difficulty in regaining the hard road. The boiler, originally a multitubular, was afterwards altered into a "Field," with about 26 square feet of heating surface. A tank under the engines carried 40 gallons of water, sufficient for six or seven miles' run. Coal for fourteen or eighteen miles was carried. The brake was worked by the stoker; the boiler was fed by one feed pump and a donkey pump; the weight in running order was 32 or 33 cwt. Three people sitting side by side were accommodated on the seat.

In fair running order the speed was eight to nine miles an hour. A small four-wheeled chaise, carrying three passengers, was often towed by it, and except on steep hills it did not appear to make any perceptible reduction to its speed. Unfortunately it was somewhat noisy in running, and a very sharp blast was necessary. To keep steam coal had to be used, as there was not draught enough to burn coke.

After being in use as a steam carriage for three or four years, it was sold. The purchaser converted it into a small traction engine. Writing of it Mr. Knight says:—



MR. NEVILLE GRENVILLE'S CARRIAGE, 1875

"I think this is a fair account. Some of these details are from memory. The carriage was so frequently altered that drawings would only show it as it was once."

HORSELESS CARRIAGE NOTES.

AN interesting lecture on "Horseless Carriages" was delivered on the 10th inst. before the Belfast Philosophical Society at Belfast by Mr. John Brown, the honorary treasurer. The latter part of the lecture dealt with modern horseless carriages, and necessarily with those of German, Swiss, and French make. Mr. Brown exhibited his own Serpollet steam carriage, purchased from M. Doarzan, of St. Omer. At the close of the lecture, Mr. George Andrews moved the following resolution:—"That this meeting approves of the proposed modification of the Locomotive Acts so as to promote the use of mechanically propelled carriages on public roads, subject to suitable provisions for the safety and convenience of the public." Such an amendment of the Acts as the resolution approved was, he considered, necessary. Though all sorts of motors might not be an unmixed benefit to the public, yet he felt, and he thought it was the feeling of the meeting also, that if these machines could be used safely in other countries they could be used with equal safety in this, and though they might be unsuitable for crowded towns, there could not be any reasonable objection to their use under proper provisions in the country districts. Professor Everett seconded the motion. He believed he was right in saying that a measure for the amendment of thy Acts on the lines of the resolution was at present in the wae of being passed in the Lords, and he hoped it would pass the Commons also, as he believed these carriages had a great future before them. The resolution was passed unanimously.

THE letter we publish on another page from Mr. Flood-Page draws particular attention to the questions which concern the construction and working of electrically-propelled vehicles, and no doubt his contentions will be supported by a great number, although the means of economical applications of electricity for this purpose are not very obvious except over a limited field where the many virtues of an electric motor outweigh the disadvantages of accumulators. This field, although limited at present to the short distance runs of vehicles for town and suburban use, will no doubt widen as accumulators are further improved, and as the necessity for the weight which high discharge capacity requires is lessened by improvements in the means of transmission, so that the maximum power used is never much in excess of the mean.

THERE is a question to which Mr. Flood Page does not allude, although it is one which must receive attention, namely, the proposed refusal of permission to allow one vehicle to haul another. It is, perhaps, early in the days of our hoped-for freedom from trammels which restrict mechanical and industrial enterprise in the design and use of self-propelled vehicles as they do in no other country, to ask for more than the Bill now in Parliament proposes to give; but we must not overlook the fact that it may in the first few years of the use of self-propelled carriages be very necessary to be able to make one haul another which has been disabled, or run short of current, or other power source.

THE haulage of a vehicle by a self-propelled carriage or by a separated light motor carriage, is according to present intentions, barred. This is presumably with the object of preventing anything like traction engine or road locomotive trains. With this object most people will sympathise, but it is undesirable it should also prevent the production of a satisfactory motor vehicle, which, though detachable from the passenger carriage or goods van it hauls, may when coupled to it form a complete whole. Such an arrangement offers some advantages and provides the means of using existing carriages, and of having spare motors, so that time occupied in their repairs shall not be idle time for the vehicles also.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

HORSELESS CARRIAGES.

Sir,—I am sending you a cutting from *L'Industrie Vélocipédique*, containing Mons. M. Mallet's account of his inspection of the Cugnot steam carriage, in which you will see he does not give all credit to his "Compatriotes," neither does he give the glowing description one reads from a perusal of the history of Cugnot's carriage.

I am glad to see Mons. Mallet share the credit between Cugnot and Trevithick. Cugnot had the support of the State to carry out his experiments; Trevithick had not, although the latter was one of the greatest pioneers of the high-pressure steam engine, steam road carriage, railway locomotive, traction engine, &c., and similar developments in latter-day use.

It is sad to conceive that such a "grand esprit" as Trevithick should have passed the latter years of his life in poverty and misery, and saved a pauper's funeral by subscription of his shopmates, and—as I am informed—without a stone or monument to mark his resting place.

I should be glad to see a subscription raised for a suitable monument to be erected in honour of the great inventor of motor road vehicles.

Chas. T. Crowden.

Beeston, Notts, April 10th.

"La voiture de Cugnot.

"M. Mallet, ingénieur est allé examiner l'ancêtre de nos automobiles actuelles, le voiture de Cugnot, remisée au Conservatoire des Arts et Métiers, et rend compte de sa visite, comme suit, dans le *Bulletin de la Société des Ingénieurs civils de France.*"

"Nous ne cacherons pas que nous avons été profondément étonné. Certes, ce qui concerne le véhicle et même la machine proprement dite n'est pas mal combiné, surtout si on tient compte de l'époque et du peu d'expérience de l'auteur, mais la partie capitale, la chaudière, laisse tout à désirer.

"On a fréquemment signalé les mauvaises proportions du générateur, la disposition peu favorable du foyer, le peu de résistance de la chaudière pour soutenir l'effet de la vapeur, &c., mais ce n'est pas tout; dans la machine qui est au Conservatoire, et qui est, dit-on, la seconde machine de Cugnot—nous ignorons totalement comment était faite la première—il est absolument impossible de comprende comment on aurait pu mettre de l'eau dans la chaudière et faire du feu sous celle-ci. D'abord le générateur en forme d'ellipsoïde de révolution ne possède que deux ouvertures, l'une à la partie supérieure pour conduire la vapeur à la machine, l'autre directement en dessous et au fond fermée par un bouchon à vis assez mal placé au plus vif du feu—si ce feu pouvait être vif. On ne pourrait donc introduire d'eau qu'en démontant le tuyau de vapeur. Cette opération, délicate avant l'allumage, serait impraticable en route pour refournir de l'eau à la chaudière à mesure de l'évaporation. D'autre part, la chaudière est entièrement entourée d'une enveloppe en tôle fermée de toutes parts, sauf en haut où il y a deux petites cheminées, et sur le côté où est une porte pour introduire le combustible; il n'y a ni grille ni place pour la mettre, le fond de l'enveloppe étant à 0·22 m. seulement en contre-bas du fond de la chaudière. Par où l'air destiné à la combustion pourrait-il s'introduire?

"Cette chaudière, telle qu'elle est actuellement et telle que la représentent les dessins du portefeuille, ne pourrait donc fonctionner en aucune manière, à moins qu'on ne suppose que le foyer agissait comme dans un samovar, et alors quelle production de vapeur pouvait-on espérer? Nous laissons de côté l'absence de soupape de sûreté et de tout moyen propre à faire connaître le niveau de l'eau dans la chaudière.

"Ce sont, quelque importants qu'ils soient, des détails bien secondaires en présence des imperfections radicales de ce générateur, qui nous semblent entraîner une impossibilité de fonctionnement. Il semblerait vraiment que la chaudière dont nous nous occupons, n'a jamais été achevée ou n'a pas été faite pour fonctionner; si on ajoute qu'elle reproduit tous les dèfauts qu'on avait signalés dans le générateur de la première voiture, on reconnaîtra qu'il y a là un mystère auquel nous n'avons jamais vu faire la moindre allusion dans tout ce qui a été écrit sur la machine de Gugnot, même par des èctivains très éminents.

"Toute autre était la voiture de Trevithick qui a circulé en 1803 pendant plusieurs mois dans les rues de Londres en portant huit ou dix personnes, et en marchant à des vitesses de 8 kilomètres à l'heure qui pouvaient facilement être portées au double. Cette voiture était parfaitement pratique et, si elle n'a pas eu de succès durable, il ne faut pas en chercher la raison autre part que dans l'épuisement des ressources de l'auteur, epuisement qui l'obligea à chercher ailleurs un travail plus immédiatement rémunérateur. La mélancolique devise de Bernard Palissy, encore un inventeur méconnu, *pôvreté empeshe les bons esprits de parvenir*, a trouvé là une application de plus. La voiture de Trevithick n'eut pas la chance d'être conservée comme celle de Gugnot, elle fut vendue à la ferraille et le moteur fut utilisé pour actionner un laminoir à cintrer les cercles de roues chez un fabricant de voitures.

"Nous croyons équitable de partager entre Cugnot et Trevithick mais dans des proportions inégales, d'avoir été les pionniers de la locomotion mécanique sur les routes, l'un ayant fait le premier véhicule à vapeur qui ait existé, l'autre le premier qui ait fonctionné régulièrement et avec un plein succès sur des dispositions et pour un but d'ailleurs entièrement différents de ceux du précédent.

"Ces deux hommes ont, de plus, partagé le même destin, celui d'être méconnus de leur vivant et peu favorisés par la fortune mais encore dans des proportions très inégales. En effet, Gugnot dont les travaux avaient été encouragés et même payés par l'Etat, les vit dans ses dernières années récompensés par l'obtention d'une pension; son œuvre a été pieusement conservée, sa mémoire honorée presque de suite après sa mort et ses mérites célébrés, peut-être avec quelque exagération.

"Trevithick, au contraire, passa ses dernières années et mourut dans la misère, fut enterré à la charité et quelques ouvriers qui avaient travaillé à la construction de ses machines durent se cotiser et payer une garde nocturne pour préserver ses restes contre les voleurs de cadavres. Il s'était vu refuser dans ses derniers jours un secours national qu'il avait sollicité et cependant cet homme avait inventé, ou tout au moins avait réalise pratiquement la machine à haute pression, la locomotive routière, la locomotive de chemin de fer, la drague à vapeur, les caisses à eau métalliques pour la marine, les bouées, mâts et vergues en fer, etc., toutes choses dont les résultats ont plus tard été immenses."

Mallet.

THE LIGHT LOCOMOTIVE BILL.

Sir,—The Light Locomotive Bill which was recently introduced in the House of Lords is of such vital importance to the electrical industry that perhaps you will find space for the following:—Mr. Chaplin received the deputation headed by Sir David Salomons on the 12th February, after which I had an interview with him, and I wrote to him at length on the following day. I need not, however, trouble you with my letter of that date or Mr. Chaplin's courteous answer. When, however, on the 30th March we were able to obtain a copy of the Bill, I wrote to Mr. Chaplin a letter—copy of which I enclose, together with his reply. I am glad to be able to add that on Tuesday last Mr. Chaplin and Lord Harris did me the honour of receiving me at the Local Government Board. I found them most anxious to do all in their power to meet the reasonable requirements of all the industries interested in this particular Bill. They, however, are of opinion that it is essential some restriction should be placed on weight, as otherwise they fear that heavy traction engines will be run about the country and through our towns at a considerable speed. I am glad, however, to be able to add that though they were not able, until after consulting with their technical advisers, to determine the exact limit of weight that the Government may think necessary, yet I have no doubt when the Bill is read a second time in the House of Lords we shall find, instead of two tons, if not five, at any rate four tons will be substituted. Mr. Chaplin said that this is a matter of experiment, and that the Government, while most anxious to assist the industries connected therewith in every possible way, felt that until some experience was gained on the subject, they must be very cautious. Electrical omnibus traffic can certainly be conducted with success with a weight of five tons, and I have very little doubt that even if we are restricted to four tons, we shall be able to do very well with this traffic in our London streets and in other towns.

S. Flood-Page.

[Copy.]

102, St. George's-square, S.W.,
April 1st, 1896.

LOCOMOTIVES ON HIGHWAYS.

Sir,—I have the honour to remind you of the interview which you accorded me, after you had received the deputation on the above subject, on February 12th, together with my letter of February 13th and the answer of your secretary thereto. I am afraid that in the multitude of the business connected with your department, you have overlooked your kind promise to bear in mind my representation as to the vital importance to the electrical industry of not limiting the weight of the omnibuses or carriages to be used in towns to two tons. I may state that this limit, which is unfortunately contained in the Bill, has created great consternation amongst those connected with the electrical industry! It was only the day before yesterday that we were able to obtain a copy of the Bill, and I have already received communications from several of the leading representatives of electrical work, suggesting my writing to the papers, holding meetings, &c. I have, however, such confidence in your promise as to feel assured that such public agitation will not be necessary. If this limit is maintained, it will practically exclude the use of electricity for horseless omnibuses, though it is undoubtedly the safest, cleanest, and best for such carriages.

On Wednesday last I was speaking at the meeting of the Associated Chambers of Commerce as one of the Council of the London Chamber, and remembering your promise that you would bear in mind my representations on this subject, I stated that we might look forward to this Bill with complete confidence that there would be no restriction put on horseless omnibuses not found necessary with the existing omnibuses, and no unnecessary interference with the natural development of the electrical industry as applied to omnibuses, &c., in towns. Judging from the welcome this announcement received from the delegates of the Associated Chambers, I have no hesitation in saying that if it had entered into my mind that this prohibitory restriction of weight would have found place in the Bill, I should have been able to get a resolution passed unanimously asking you to withdraw your present limit, if, in fact, you thought it essential that there should be any limit whatever, or any restriction beyond that for street traffic in London at the present moment. You are aware that laden wagons of sixteen tons are now legally permitted to traverse our streets, while the large three-horse omnibuses, weighing very many tons, are allowed the free use of the Paris streets.

This question is one of such absolutely vital importance to the electrical industry, which, as you are aware, has been most seriously hampered in this country by what is now recognised as erroneous legislation, that I do hope you will be able to remember your most kind promise to give effect to my representations, and that you will prevent the agitation which must immediately be excited if this most lamentable, unnecessary, and unjust restriction is maintained in the Bill.

Naturally I will not ask you to see me with one or two other representatives of the industry during the short Easter holidays, but I shall be most glad if, before any public meeting is called, you would see me with one or two representatives of the electrical and carriage building industries, so that if possible the necessity for this agitation may be done away with.

I have the honour to remain, Sir,
Your obedient servant,
(Signed) S. Flood-Page.

To the Right Hon. H. Chaplin, M.P., &c. &c.

[Copy.]

Local Government Board, Whitehall, S.W.,
April 2nd, 1896.

Dear Sir,—Mr. Chaplin desires me to reply to your letter on the subject of the Light Locomotives Bill.

The Bill has been introduced in the House of Lords in consequence of the pressure of other business in the House of Commons.

The question of the weight of the articles to which the Bill is to apply is a matter of detail, and Mr. Chaplin is perfectly ready to receive and consider suggestions on the subject, which is a new one to all concerned, and of which there has been so little practical experience. He has forwarded your letter to Lord Harris, who has charge of the Bill in the House of Lords, and from whom your suggestions will, he is sure, receive every attention.

When the Easter holidays are over, Mr. Chaplin will be very willing to see you, in company with Lord Harris, or to receive in writing any further statement on the subject which you may like to submit.

Yours faithfully,
(Signed) H. C. Munro.

THE LIQUEFACTION OF GASES.

Sir,—After careful perusal of both "Zero's" letters, I am still unable to agree with him. With your permission I will explain why.

When oxygen escapes at high pressure through a narrow orifice situated in a tube of some length, two things happen: (1) production of cold, owing to conversion of sensible heat into mechanical energy of motion of the issuing gas; and (2) production of heat, from reconversion of the mechanical energy into sensible heat. (Parenthetically, I may point out to "Zero" that the issuing gas does do external work, because it does not flow into a vacuum, but is opposed at least by the pressure of the atmosphere.) As a matter of fact, proved by experiment and observation, these two things neutralise each other within a few inches from the orifice, and therefore the temperature of the gas becomes substantially what it was before expansion. But only substantially; accurately speaking, it is rather cooler than it was, which means, of course, that energy has disappeared somehow. But as "Zero" says, "After the air has left the cooler, there is no possibility of escape of heat or energy in any form" from the apparatus proper. What then has become of it? There is only one way out of the difficulty; the missing energy must have gone in doing internal work on the gas itself. It is obvious that, if all the heat of the gas before expansion were restored after expansion, there could be no progressive cooling effect, since the regenerative coils would all be bathed in gas no cooler than the compressed gas contained in them.

This disappearance of energy in internal work is, of course, the Thompson and Joule effect, of which "Zero" appears to hold so poor an opinion. But liberal as he is in unsupported assertions that it has nothing to do with the matter in hand, he is very sparing of arguments. His only one, indeed, is that it is too trifling in amount to be of any commercial value. That may well be so, but its commercial value is not under discussion. Of course, the Joule effect is trifling, but so is the efficiency of the self-intensive refrigerating process, an ounce or so of liquid oxygen being all there is to show for the energy absorbed by a big compressor during twenty or thirty minutes' work. As to a satisfactory explanation of the effect I do not know, but I believe that Lord Kelvin, so far from patching up a theory to suit it, predicted its existence from theoretical considerations before it was experimentally discovered.

I was not concerned in my former letter to discuss questions of priority. It was only as some sort of reply to "Zero's" strictures on the shortcomings of "dogmatic science" that I pointed out that Professor Dewar had actually constructed a machine, giving progressive cooling by the expansion of gas through a small orifice, before Dr. Hampson had done so, and before his patent was published. Although at the time I wrote I find I was in error in stating that Dr. Hampson's patent had not been granted, my argument was quite valid, since the specification had not then been published, and was not till last Saturday. But as "Zero" has indulged in some comparisons, may I suggest that it is rather an abuse of language to say that Professor Dewar's apparatus differs from Dr. Linde's *chiefly* in the use of frigorific agents? One might as well say that the chief difference between a boy's toy steamer and an ironclad is that in one methylated spirit, in the other coal, is the source of power. If "Zero," in accordance with his own excellent suggestion about looking up the recent literature of the subject, will consult No. 158 of the Chemical Society's "Proceedings," he will find an illustration of an apparatus which works without frigorific agents, and probably does not weigh as many ounces as Linde's does hundredweights. That seems to me a more important difference than the use of initial cooling, while a yet more important one is the employment of vacuum vessels as a protection against heat. Of the latter device, which I imagine was the outcome of dogmatic thermodynamic reasoning, I noticed that Dr. Hampson very wisely made use in his apparatus shown at Brin's Works.

April 22nd. Cryos.

PERMANENT WAY.

Sir,—The correspondence on this subject will not be complete without a reference to the chairs. Since railways began these have not altered in any particular, except that they are heavier, being in all cases made of cast iron of the poorest quality.

It seems an extraordinary fact that in an age of steel a steel chair cannot be made commercially and mechanically to supersede the cast iron chair, the present cast iron chair being quite out of touch with other improvements in railway engineering. For example, many of the chairs weigh 56 lb. each—that is, 56 lb. of cast iron to support every 80 lb. or 90 lb. of steel rail. This is surely an enormous waste of material. It is not as if the weight of the chair were any advantage; quite the reverse. There would be less shock if there were no chair, or if the chair were made lighter and of stronger material, such as steel, which has the requisite properties for this purpose. The relative strength of the two metals being, say, 5 to 1, the steel chair might with safety be reduced to 20 lb. or even less, and still have ample margin for safety.

We platelayers experience daily the fact that when a vehicle leaves the rails, every cast iron chair that is touched by the tire flange is broken. This could not happen were the chairs made of similar material to that of the rails. It must not be forgotten that until broken chairs are replaced, traffic is suspended on the line. This causes much delay and trouble, and is noticeable every day where there is a lot of shunting, and where heavy mineral traffic is passed.

It seems a very curious thing that up till now a steel chair of sufficient merit has not yet been introduced. With our still increasing speeds and weights, its merits would be all the more appreciated. Railways were started with cast iron rails. What would we think of cast iron rails to-day?

April 20th. For the Platelayers.

Sir,—The interest that is now being directed to this subject by engineers is in itself an evidence of its importance. There is a new element in the question, which is likely to have an important bearing on the subject; I refer to a steel chair that is being laid down on some of the Northern and Scotch lines. The trials, which are of course of too short a time to arrive at a definite conclusion, have so far proved that it is vastly stronger than the old chair, having been submitted to some very rough work in the yards of several of the Lanarkshire steel works, where the derailing of wagons with heavy loads is an almost every-day occurrence.

One thing is clearly demonstrated, that the derailing of a train does not affect the steel chairs further than a slight indent on the base, where they are struck by the passing tire flange. The maker, a Glasgow firm, claims a deal for them; but time alone will soon disclose what, if any other merit beyond cheapness and strength, they may possess.

James Andrew.

Glasgow, April 19th

LOCOMOTIVE FIRE-BOXES.

Sir,—Referring to the letter from "Adriatic" on the above subject in your last issue, it is generally considered that direct stays for the crown of the fire-box are less than useless, owing to the fact that since the inner and outer fire-box shells are both attached to the fire-box ring at the bottom of the water space, the expansion due to the heat will be, in the case of the inner fire-box, in an upward direction, and as copper is frequently used for this portion of the fire-box, and as its coefficient of expansion is greater than that of iron or steel, the crown of the inner fire-box shell will approach to the upper part of the boiler; also the direct stays will expand and thereby cause a depression of the inner fire-box crown. Now, when crown or bar stays are used, since they support the flat surface of the inner fire-box crown and act independently of the upper part of the boiler in contradistinction to direct stays, they will not be affected by the expansion due to heat of the inner fire-box. It is also for this reason that sling stays are said not to be of much, if any, use. Even when steel fire-boxes are adopted the above action takes place to more or less extent, since the inner fire-box shell, being nearest to the source of heat, expands more than the outer shell, which is separated by the layer of water in the water space.

I agree with your correspondent with regard to the Belpaire type of fire-box, and do not see any advantage that it possesses over the ordinary type.

Edward J. M. Davies.

24, Harrington-square, London, N.W., April 18th.

THE JENNY LIND.

Sir,—A curious story has been circulated to the effect that the Jenny Lind locomotive was designed as the result of the heating of an outside axle-box. The driving wheels of a certain engine had inside and outside bearings. On one run one of the outer bearings heated, the journal was wrenched off, and the engine proceeded with her inside bearing only; thereupon the outside bearings were dispensed with, and behold the Jenny Lind.

The story is preposterous, and it has not the merit of being new. If your readers will turn to the "Life of Trevithick," published in 1872, they will find a somewhat similar story told of an engine running between Carlisle and Preston. In this case it was a leading axle, and there was not a smash, because "a small roundish knot, projecting from the end of the axle in the wheel boss, alone retained it in its place, while the torn-off bearing was embedded as a solid mass with the fused brass and iron of the axle-box."

I do not pretend to know who designed the Jenny Lind. I fancy the first idea of it was to be found in an engine by Gray on the Brighton line, but I feel quite confident that there is not a trace of truth in the broken axle story, which seems to have been taken without acknowledgment from Trevithick's work, vol. i., page 219.

There are multitudes of very incredible stories told about locomotives, such as that about the 6ft. driving tire left in the ditch at Tring, the driver knowing nothing about it till he got to Chalk Farm. A collection of them would be interesting; perhaps some of your readers will contribute one or two. This about the Jenny Lind may be taken as a sample.

L. and S. W.

St. Deny's, April 21st.

THE CRYSTAL PALACE.

Sir,—I am glad to see that you admit to your correspondence columns a discussion concerning the best way to get into the Palace. I have reason to think that the directors are not blind to the truth and if I am not mistaken, they have entertained proposals from more than one contractor, but negotiations have fallen through.

The problem is not easy of solution, unless the æsthetic is to be sacrificed. A line such as that suggested by your correspondent "Norwood" would be very ugly, unless a considerable sum was spent in ornamental screens. I am rather disposed to think that the construction of an iron viaduct, in strict keeping with the architecture of the Palace, extending from the present Low Level entrance and curving round at the west water tower, would be the best solution. No railway or vehicle would be used. Powerful lifts of the kind used for the electric railway at King William-street would be employed to raise visitors to the entrance end of the viaduct. As the dimensions of this last need not be great, it would not be expensive. I do not know the difference in levels precisely, but I fancy it is about 50ft.

Dulwich, April 20th. M. E.

Sir,—Referring to "Norwood's" letter in The Engineer of the 17th inst., I can, from personal experience, confirm all he says as to the difficulty of getting from the Low Level Station into the Crystal Palace. The remedy for this which I adopt, is to take the train from West Norwood Station to Gipsy Hill Station, and walk thence to the High Level Station. The walk is a pleasant one, on good footpaths all the way, and the distance traversed rather less than that entailed by walking up the many long passages and staircases from the Low Level Station. Others of my family do the same, and we save thereby time, money, and fatigue. I cannot understand the short-sightedness of the Crystal Palace directors in not providing some better mode of access than the existing one into the Palace from the Low Level Station.

London, April 18th. West Norwood, *ætat* 76.

CIRCULATION IN WATER-TUBE BOILERS.

Sir,—I beg leave to correct the statement made by "Old Tubulous" in your issue of last week regarding the behaviour of the models shown by Professor Watkinson at the Institution of Naval Architects. Being present all the time the models were working, both before and during the meeting, I noticed that out of the five models which were working, only in two of them did the tubes fracture. I also noticed that one of the models—that of the Babcock—was working continuously for about four hours without any of the tubes being fractured. Observer.

April 22nd.

THE INSTITUTION OF CIVIL ENGINEERS.

THE THIRLMERE WORKS FOR THE WATER SUPPLY OF MANCHESTER.

At the ordinary meeting on Tuesday, the 14th April, Sir Benjamin Baker, K.C.M.G., the president, in the chair, two communications, dealing respectively with the water supply of Manchester and Liverpool, were read.

In the first paper, on "The Thirlmere Works for the Water Supply of Manchester," by Mr. G. H. Hill, M. Inst. C.E., the Longdendale system of works, which, before the introduction of Thirlmere water, alone supplied the city, was first briefly described. The drainage area of Lake Thirlmere, the new source of supply, was 7400 acres, but the scheme included the taking of water from an additional area of 3600 acres. The geological formation was the lower silurian, and the water was remarkably clear, even in times of heavy flood. The mountains surrounding the lake were very precipitous, and the floods consequently very large. The rainfall varied between 100in. and 137in. in wet years, and between 60in. and 80in. in dry years; and the quantity of water available for the city, after giving 5½ million gallons per day as compensation to the river, was estimated at about 50 million gallons per day. The area of the lake in its natural condition was 328¼ acres, and when raised by the dam it would be 793 acres. The capacity of the reservoir then formed was more than 8000 million gallons, exclusive of the water below the surface of the original lake, which was not available.

The water in the lake was impounded by a masonry dam, the foundations of which were carried well into the rock, the maximum depth being 50ft. below the bed of the river. It was constructed of concrete, in which large masses of rock were imbedded, faced with heavy rock-faced masonry; and, to comply with the Act of Parliament, a public roadway had been made along the top. The discharge tunnel for carrying off surplus and compensation water was driven through the small isolated hill which rose on the centre-line of the dam. Upon it was sunk a shaft, in which the valves for controlling the water in the pipes laid in the tunnel were placed. The waste weir was constructed in the solid rock at one end of, and separate from, the dam; and a gauge basin, in which the compensation water could be measured, was provided. New roads, 7½ miles long, had been constructed round the lake.

The aqueduct to Manchester was 96 miles long, 14 miles of which was in tunnel, 37 miles in cut-and-over, and 45 miles in iron piping. It started at a circular straining well, lined with concrete and 40ft. in diameter, into which the water was admitted from the lake through a tunnel about 100 yards long. Upon this tunnel and adjoining the straining well was sunk a rectangular shaft lined with concrete in which the valves controlling the supply were placed. A hydraulic crane was provided for lifting the strainers in the straining well for washing, the valves were also worked by hydraulic power. The water after leaving the straining well entered the Dunmail Raise tunnel, 5188 yards in length. Some of the other long tunnels were the Moor Howe, 3040 yards; Nab Scar, 1419 yards; and the Skelgill, 1243 yards. Machinery worked by compressed air was largely used for driving the tunnels, which were lined with concrete sides and arching only where the nature of the ground required it, but the concrete invert was continuous throughout. Its internal width was 7ft. 1in., and the height 7ft.

The cut-and-cover portion of the aqueduct was constructed of concrete, the internal dimensions being the same as in the case of the tunnels. Manholes and ventilators were provided every quarter of a mile. The bridges were in all cases of masonry, and provision was made for emptying the aqueduct at convenient points. Throughout the tunnels and cut-and-cover the inclination was 20in. per mile.

Wherever the hydraulic gradient was intersected by valleys too deep to be crossed by bridges, five parallel lines of cast iron pipes were used, 40in. in diameter. As a first instalment of ten million gallons per day was at present only required by the city, only one of these pipes had been laid. They began, in the case of each syphon, in a rectangalar chamber, into which the concrete aqueduct discharged, and in which an automatic arrangement was placed at the mouth of each pipe to shut off the water from it in case of a burst. The total weight of one line of pipes, 45 miles long, was about 52,000 tons. The greatest care was taken in the manufacture, coating, testing, and handling of the pipes, each of which had a number cast on it, which was recorded, together with the tests applied, the dates, ultimate position on the aqueduct, and the name of the workman who made the joint. For turning angles, double-socketed bevel castings were used, about 12in. in length, and varying between 1 deg. and 10 deg. For larger angles a combination of these bevels was used, a spigot pipe 3ft. long being placed between each pair of bevels. All joints were run solid with lead, which was prevented from running into the pipe by a spring ring. The section of the lead was wedge-shaped, to avoid blown joints. The longest syphon, that crossing the valley of the Ribble, was 9½ miles in length, the greatest head of water being 427ft. at the crossing of the River Lune. At these crossings the pipes were carried by three 70ft. arches, each formed of cast iron ribs.

The number of valves on the 45 miles of piping was very large, and included stop valves and air valves, besides a large number of discharge valves, for emptying the pipes at convenient places. The self-acting valves had fulfilled their purpose perfectly in the case of the few bursts which had occurred, the water being completely shut off. The mechanism was set in motion by the increased energy of the water due to its greater velocity in the event of a burst: a pair of heavy weights was thus released, and closed a disc valve in the main, the operation being controlled and regulated by a cataract cylinder. An air vessel was provided to obviate shocks which might occur during the stoppage of the column of water; means were also provided for charging the air vessel. All stop valves, self-acting valves, and reflux valves were anchored, the latter in one direction only. Valve houses had been built over the large stop valves and self-acting valves, of sufficient size to cover the five lines of pipes; the roofs were of glass fixed in wrought iron framing; girders were fixed capable of carrying blocks and tackle for raising any part of the valves requiring repair.

The aqueduct delivered into a service reservoir at Prestwich, near Manchester, where a straining well was provided with lifting and washing arrangements.

The works had been let in nine and the ironwork in eighteen contracts. Portland cement concrete had been used throughout, the quantity being about 100,000 tons. The total cost of the works to the date of the opening was about £2,800,000, including Parliamentary expenses, which were exceptionally large. The complete scheme would cost about £4,400,000.

THE VYRNWY WORKS FOR THE WATER SUPPLY OF LIVERPOOL.

The second paper was entitled "The Vyrnwy Works for the Water Supply of Liverpool," by Mr. G. F. Deacon, M. Inst. C.E. The Vyrnwy reservoir, now known as Lake Vyrnwy, occupied the site of a post-glacial lake, which had been filled chiefly with alluvial detritus to a height of about 45ft. above the original water level. That level was maintained by a bar of rock at a narrow part of the valley such as was found in most glacial lake basins. On removal of the dislocated or otherwise unsound rock in this bar, a sound foundation was met with about 15ft. lower, so that the deepest part of the foundation was nearly 60ft. below the ground level; the height of the dam to the sill level being 84ft. above the river, and the water level above the lowest part of the foundation 144ft.

Below the sill of the dam and above the outlet to the aqueduct, Lake Vyrnwy contained 12,131 million gallons. Its area was 1121 acres, only reduced to 1036 acres 10ft. lower. An average cross-section did not differ widely from a figure with a horizontal base 2000ft. wide, having a depth of water over it of 70ft., and end slopes of 2½ to 1.

The author drew special attention to the methods adopted for securing water-tightness, and showed by the results obtained from this structure and from a concrete culvert—the walls of which were only 18in. thick—subject to a vertical pressure of water of 56ft., that concrete might be made perfectly water-tight by avoiding the use of so much water as to render it incompressible when first placed *in situ*, and by ramming it until the jelly-like condition indicative of incompressibility was obtained.

Thirty-three per cent. of the stones used in the dam weighed between four tons and ten tons each. The hearting-stones were roughly dressed on their beds, but were otherwise left quite rough. The face stones had rectangular faces, and no part of any stone was allowed to come within 1in. of any other stone. The stones and rock were rendered scrupulously clean with wire brushes and jets of water under pressure. The foundation rock was drained, except within about 15ft. of the face, by numerous funnels carried up to above the back-water level, and the total leakage from the central 8000 square yards of rock foundation, including that through the dam, if any, amounted to about two gallons a minute. The specific gravity of the rock of which the dam was built was 2·721, or 170 lb. per cubic foot; that of the concrete, when dry, averaged about 2·51, or about 156 lb. per cubic foot, and that of the whole dam was 2·595, or about 162 lb. per cubic foot, a figure ascertained by comparing the measured volume of the work with the total weight of the materials put into it, all of which were carefully weighed. Crushed rock was largely used in the preparation of the mortar.

The mode of securing water-tightness of the two culverts, 15ft. in diameter, through the dam was explained. The compensation water to the Vyrnwy and the Severn, of which it was a tributary, was 10 million gallons a day, and 40 million gallons a day in addition, during four successive days in each of the eight months from February to October inclusive. The modes of gauging were also set forth.

The aqueduct commenced at a valve-tower standing in the deep water of the lake, provided with strainers of copper wire gauze, which were removed, washed, and replaced wholly by hydraulic machinery. The outlet valves consisted of a series of short cylinders standing upon one another so as to form a vertical pipe, and the joint between any pair of such cylinders was capable of being opened very readily by hydraulic pressure. Thus the water was drawn off at any level desired. The aqueduct was constructed for the passage of 40 million gallons per day or more, with the exception of the iron syphon pipes and some other portions not required until later, and every part of the work now constructed would pass the full amount of between 13 million and 15 million gallons a day required as the first instalment of water. The gradient of the aqueduct being from 4·5ft. to 6·87ft. per mile, cast iron pipes under pressure had been used, except in the three tunnels constructed at the hydraulic gradient, and in certain special places where steel had been employed. Throughout the syphons the hydraulic gradient had been varied wherever it was economical to vary it, subject to the total loss of head amounting to whatever could be afforded in each case. All specially expensive parts, such as valves and pipes under heavy pressure or in tunnels, had been considerably reduced in diameter from that of the cheaper portions.

The filter-beds were at Oswestry, where a recording gauge gave full information as to the variations in the water passing through the aqueduct from time to time. The five balancing reservoirs on the aqueduct were generally described, and the Norton tank, where the balancing reservoir was at a height of 113ft. above Norton Hill, was particularly referred to. The tank contained about 650,000 gallons, and consisted mainly of a steel basin in the form of the segment of a sphere in tension, depending from a steel ring in compression, resting through the medium of an expansion ring, upon the masonry.

The six river crossings, thirteen railway crossings, and six canal crossings, including the Weaver Navigation and the Manchester Ship Canal, were generally described. The crossing under the river Mersey was the most difficult portion met with. The pipes had been originally intended to pass through the bed of the river, but Parliamentary exigencies rendered it necessary to submit to a reference clause which resulted in a tunnel having to be constructed through ground full of water under a head of 51ft. The work was, however, successfully performed by means of a shield, and was now in every respect satisfactory.

American Patents Records.—The U.S. Patent-office has issued 3075 patents for inventions, contrivances, and discoveries in telegraphy. Over 25,000 inventions for the manipulation of metals have been patented. There are 636 patented fuels or methods of preparing wood, coal, and coke for use. Over 16,000 patents have been issued for the various kinds of electrical appliances. There are 1771 patents on the mechanism employed in sinking artesian or oil wells. Railways and railway appliances are represented by 8334 models. The annealing and tempering of metals have called for much attention, no less than 736 devices for these purposes having been patented. There are 4240 models of patented pumps in the Washington office.

TRACTION ENGINES ON ROADS.

The Select Committee of the House of Commons appointed to investigate the working of the laws relating to the above subject sat again for the first time since the Easter vacation on Thursday, the 16th inst. The first witness called to give evidence was Mr. F. Bacon Frank, vice-chairman of the West Riding of Yorkshire County Council, and chairman of the Rural District Council. Mr. Frank stated that there were forty-nine traction engines licensed in the West Riding, the revenue derived from which was £450 annually, which amount he did not consider was sufficient to compensate for the damage done to the roads. He complained that Clause 23 of the Highways and Locomotives (Amendment) Act of 1878 was not clear enough, and, in consequence, did not work satisfactorily.

Mr. Trevor Edwards, the solicitor to the West Riding County Council, the next witness, considered that the maximum limit of speed might be increased in towns and villages from two to three miles an hour, but that on the country roads should be maintained at the present limit, viz., four miles. Asked regarding the number of men employed on each engine, the witness gave it as his opinion that the present number—three—was not too many. He recommended that the drivers, as well as the engines, should be licensed—a course he considered necessary for public safety. This licensing he would place in the hands of the county authorities, which bodies ought also to be allowed, as at present, to make bye-laws restricting the hours of operation of the engines. Other recommendations made by the witness were that no more than three wagons should be hauled by one locomotive, and the total length of such train, including engines, be not more than 54ft.; that in addition to the two lights carried on the front of the engine at nights, there should also be a red light carried at the rear; and that the clause relating to extraordinary traffic should be amended.

Mr. Hulton, Chairman of the Main Roads and Bridges Committee of the Lancashire County Council, having charge of 683 miles of main road and 834 miles of "secondary" roads, at an annual cost of £137,000 and £25,000 respectively, stated that the annual cost per mile of these roads varied between £20 and £600, according to the district. The cost of a licence taken out within the jurisdiction of this Authority was stated to be £5, while engines licensed by neighbouring counties could have their licences endorsed for a nominal fee of 10s. 6d. Mr. Hulton endorsed the recommendation of the previous witness regarding the increase of the maximum limit of speed in towns and villages, but considered that the working of Clause 23 of the 1878 Act was satisfactory. He did not think that uniformity of prohibited hours could be achieved, since the conditions necessary for working in different counties and county boroughs were so dissimilar. He recommended the legalising of the Bolton block tires, which had given great satisfaction in Lancashire.

Mr. J. Vickers Edwards, the surveyor to the West Riding of Yorkshire County Council, next gave evidence, in which he stated that their roads were of a condition quite suitable for ordinary horse traffic, but not strong enough for locomotives. He approved of the principle of the Bolton block wheel, but considered it very liable to get out of order, and consequently inflict much damage to the road surface.

At the proceedings of the Committee on Monday, the 20th inst., Mr. J. Moncur, surveyor of main roads, Staffordshire; Mr. Thomas, A.M. Inst. C.E., county surveyor, Buckinghamshire; and Mr. Phillips, county surveyor, Gloucestershire, were the witnesses examined. Mr. Moncur said there were a large number of locomotives at work in Staffordshire, and the prohibited hours of working were during the early part of the night. He would not advocate the increase of the maximum limit of speed, but would place the choice of type of wheels in the power of the Local Government Board. He would limit the use of traction engines to roads 18ft. and upwards in width, and thought it advisable to restrict the net loads hauled by engines up gradients of 1 in 10 to five tons. The other chief recommendations of witnesses were: that no more than three trucks should be allowed to be hauled by one engine, and that a red light be carried in the rear at nights. Mr. Thomas stated that there were forty engines licensed in Bucks, the licence fee being £3, and that there were no prohibited hours for working. He would increase the maximum limit of speed on country roads to six miles, but recommended no addition to the speed in towns and villages. His experience of the construction of wagon wheels showed that the tires were frequently too narrow, and suggested that they should have a clear inch in width for each ton carried. As regards the extraordinary traffic clause, he had no complaint to make, but thought that, with the increase of speeds indicated, the man in front of the engines might be provided with a cycle.

The last witness, Mr. Phillips, informed the Committee that there were no prohibited hours for working in Gloucestershire, and that no accidents had resulted from this arrangement. The licence fees varied from £10 per annum for engines of 10 tons and upwards, decreasing £1 per ton below this weight. Mr. Phillips recommended the alteration of the clause which specified that all wheels should be cylindrical; the registration of all road engines, including rollers and agricultural engines, and the insistence of the inspection of engines by the registration authorities. In place of the annual licence the witness proposed a novel scheme for levying a tonnage rate on the net loads hauled, and suggested as a reasonable rate ½d. per ton per mile. This would necessitate the forming of small sub-committees of County Councils, and the detective duties might be performed by the weights and measures authorities. He stated that by this arrangement about £700 per annum would be derived from the traffic in Gloucestershire, as against about £180 as at present with licence fees, and that owners had expressed themselves satisfied with the scheme, provided that the extraordinary traffic clause were abandoned. The witness stated that to raise the quality of the Gloucestershire roads, which had not yet been so treated, up to locomotive standard, would involve the expenditure of about £500 per mile, or £250,000 altogether, a sum which he did not consider ought to come out of the pockets of ratepayers.

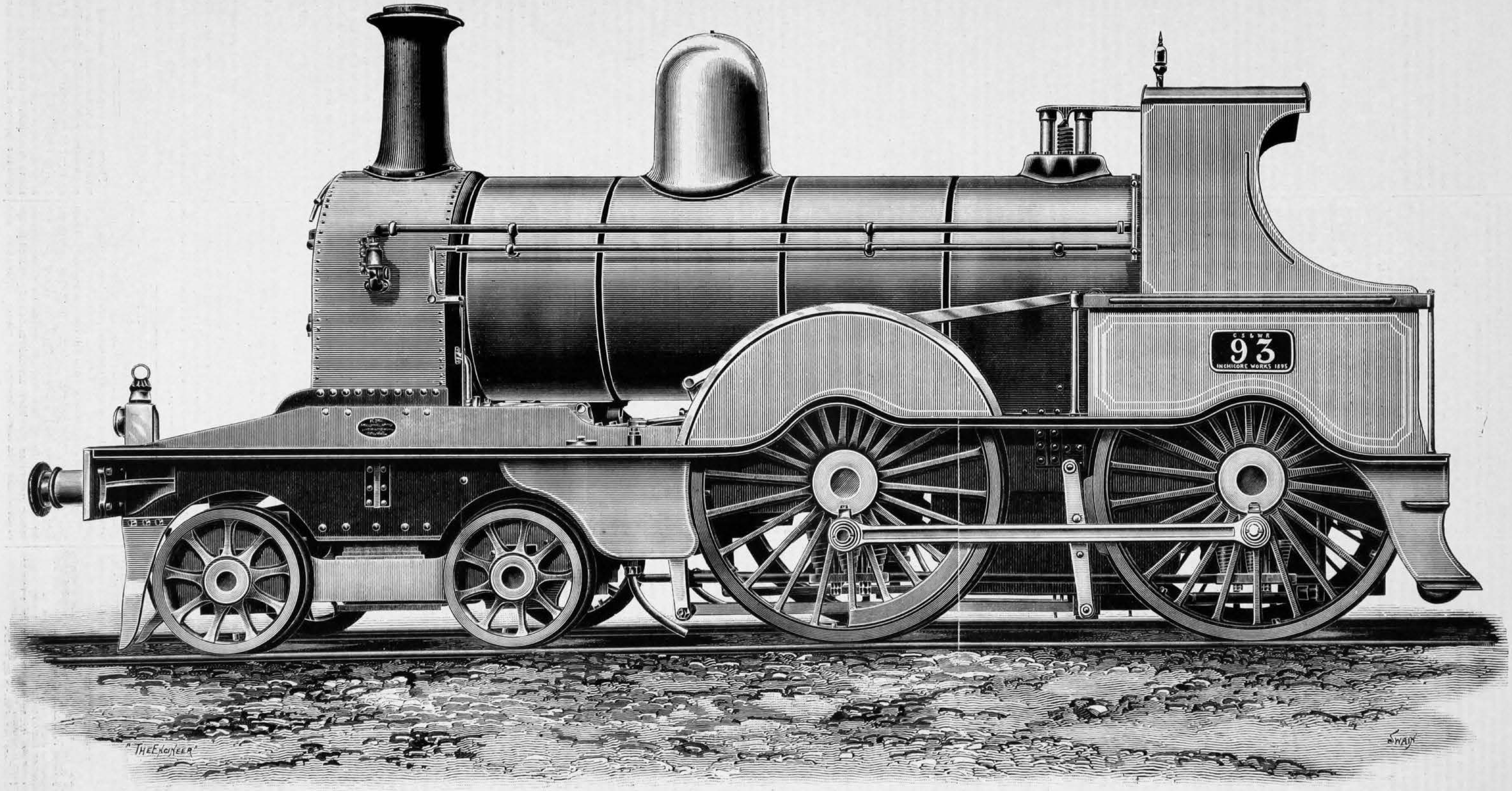
The Committee again adjourned until yesterday—Thursday.

Steps have recently been taken to increase the water supply of Slough, for which purpose the engineer, Mr. Secker, has had a series of three 11½in. artesian tube wells bored by Messrs. Le Grand and Sutcliff, of London, to an average depth of 150ft., the chalk formation being reached at from 61ft. to 72ft. below surface. The boring operations occupied ten weeks, or an average of twenty days each, including pumping trials. The three wells are to be coupled to one receiving main, and their united yield is equal to a supply of nearly two million gallons per diem.

COMPOUND EXPRESS LOCOMOTIVE, GREAT SOUTHERN AND WESTERN RAILWAY

MR. H. A. IVATT, M. INST. C.E., INCHICORE, ENGINEER

(*For description see page* 417)



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CONTENTS.

TO CORRESPONDENTS.

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C. W. R.—*We stated a fact concerning water-tight doors. We did not express an opinion. The Admiralty will not adopt doors of the kind you suggest because they would take up too much room. Drawings and models of doors of the kind were shown and explained at the last meeting of the Institution of Naval Architects, and they were absolutely ignored by everyone present. We hold that the air lock idea is excellent, but we can also say at the same time that there are many objections to it. If, however, you can send a drawing properly worked out to show how your doors would be fitted, we will publish it.*

BOOKS ON RAILWAY SIGNALS.

(*To the Editor of The Engineer.*)

SIR,—Would any reader be kind enough to inform me if there is any work or works published which would give me full information of the working of railway signals in all countries, also of fog signals; also where I could get these works? J. B. P.

London, April 15th.

REVERSING PROPELLERS.

(*To the Editor of The Engineer.*)

SIR,—Will any reader kindly let me know the name and address of the makers of reversible propellers? J. W. B.

April 21st.

DR. ANGUS SMITH'S COMPOSITION FOR COATING WATER PIPES.

(*To the Editor of The Engineer.*)

SIR,—Will any reader tell what are the materials used in this composition, or where I can find a description of it? C. H. B.

London, April 21st.

SUPERHEATING STEAM.

(*To the Editor of The Engineer.*)

SIR,—I have a horizontal brick flue, 2ft. by 2ft. by 27ft., through which urnace gases are continuously passing, temperature 700 deg. to 1000 deg. I wish to utilise a portion of this heat, to superheat steam for boiling down waste liquors, &c. Would any of your readers advise me how best to do this? SUBSCRIBER.

April 21st.

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MEETINGS NEXT WEEK.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, April 30th, at 8 p.m. Paper: "On Railway Telegraphs, with Special Reference to Recent Improvements," by W. Langdon, member.

GEOLOGISTS' ASSOCIATION.—Friday, May 1st, at 8 p.m. Papers: "On the Physical Geology of Purbeck," by A. Strahan, F.G.S., illustrated by the lantern. "Notes on Mollusca from the Skiddaw Slates," by J. Postlethwaite, F.G.S.

SOCIETY OF ARTS.—Monday, April 27th, at 8 p.m. Cantor Lectures: "Applied Electro Chemistry," by James Swinburne. Four Lectures. Lecture I.—Introductory—Phenomena of Electrolysis. Wednesday, April 29th, at 8 p.m. Paper: "Fruit Drying or Evaporation," by Edward W. Badger.

ROYAL INSTITUTION OF GREAT BRITAIN.—Tuesday, April 28th. Afternoon Lectures, at 3 p.m.: "Child Study and Education," by Professor James Sully, M.A., LL.D. (Lecture III.) Thursday, April 30th. "Recent Chemical Progress," by Professor Dewar, M.A., LL.D., F.R.S., M.R.I. (Lecture III.) Friday, May 1st, at 9 p.m. Paper: "Chronographs and their Application to Gun Ballistics," by Colonel H. Watkin, C.B., R.A., M.R.I.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Saturday, April 25th, at 6 p.m. Discussion on "Some Structural Details of Modern Ships," by Mr. M. C. James, will be resumed. Discussion on "The Determination of the Forces which produce Vibration with Three-crank Engines at High Speeds," by Mr. R. M. Ferrier, and "Balancing High Speed Engines," by Mr. A. E. Doxford, will be opened by Mr. James Patterson.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, April 25th, at 2 p.m. Papers for discussion: "Short History of the Jameson Coke Oven," by Mr. John Jameson. "Report of the Proceedings of the Flameless Explosives Committee," by Mr. A. C. Kayll, engineer. "Resistance of Air Currents in Mines," by Mr. T. L. Elwen. "Coal-cutting by Machinery," by Mr. William Blakemore. "A Compound Winding Engine," by Prof. W. Galloway. Paper: "Gas Producers and Gaseous Fuel Illuminants," by Mr. Robert Martin.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 28th, at 8 p.m. Papers to be discussed: "The Thirlmere Works for the Water Supply of Manchester," by Mr. G. H. Hill, M. Inst. C.E. "The Vyrnwy Works for the Water Supply of Liverpool," by Mr. G. F. Deacon, M. Inst. C.E. Papers to be read: "American and British Methods of Manufacturing Steel Plate," by Mr. Jeremiah Head, M. Inst. C.E. "Four American Rolling Mills, by Mr. Samuel T. Wellman. Friday, May 1st, at 8 p.m. Students' meeting—Paper: "Swing Bridge over the River Nene at Sutton Bridge," by Mr. Edward S. McDonald, Stud. Inst. C.E. Sir Douglas Fox, Vice-president, Inst. C.E., will preside.

THE ENGINEER.

APRIL 24, 1896.

HORSELESS CARRIAGES.

IT is absurd to doubt that a great and novel industry is springing up in this country. The self-propelled vehicle is with us, and its popularity will not be less than that of the bicycle. The history of the movement in favour of mechanical road carriages has yet to be written. History is being made daily. But our descendants will probably wonder not that the horseless carriage has caught the public fancy, satisfied an all but universal want, or gratified a ubiquitous desire, but that we, as a nation, consented for so many years to leave the finest highways in the world comparatively unutilised. No doubt the bicycle has done much to educate public opinion. We have learned that the roads of a country can be employed without the aid of horses and without walking on them. The fact was known to comparatively few until recently. Now it is understood by everyone. The step from the bicycle to the horseless carriage is as nothing to the leap between the horse drawn vehicle and the bicycle. It is impossible to forecast the results of the adoption of the new mode of locomotion with either certainty or profit. But it is not difficult to understand why the horseless carriage should be popular. The age is an age of movement. A little thought will serve to convince most men that the great difference between the world of to-day and the world at the beginning of the present century is that locomotion of every kind, and in all its endless forms, is infinitely more facile and more abundant now than then. Civilisation and locomotion go together. Not locomotion of the individual or the thing only, but locomotion of thought. It is because he has given the world roads and railways, and steamships and telegraphs, that the engineer has been the civiliser of the world. He has done more to promote material progress than the warrior, the statesman, or the philosopher. And the desire for locomotion has grown, and is growing. More people travel each day than travelled the day before. Our ships steam faster, our trains run more quickly, year after year. The horseless carriage will come to satisfy the wants of a humanity which finds the railway too unwieldy, the horse too expensive, and the cycle too trivial.

Very largely, no doubt, the advent of the oil engine has promoted the growth of the horseless carriage. Legislation has laid a heavy hand on steam, and has done infinite harm not only by prohibiting the use of steam-propelled pleasure carriages, but by stopping invention and the development of ideas. Inventors and engineers have been assured so strongly by legal enactments that a steam-propelled vehicle must be a nuisance that they have come to believe it. The petroleum motor has not yet earned or received a pestilent parliamentary reputation. The public are willing to believe in it, though they will not believe in steam, knowing the while not much, if anything, about either; and less in any case about steam than about petroleum. We are much mistaken, however, if it is not yet found that steam will hold its own against the petroleum motor. Its possibilities are far greater now than they ever have been hitherto. We can produce engines of a lightness undreamed of in the days of Hancock or Gurney, and boilers which, fired with petroleum, will realise the wildest dream of the inventor in the matter of small size and power. A copper coil which can be carried on a man's forearm will, as we have seen, make steam enough to propel a carriage carrying four persons on an indifferent road at a good pace. But it is indisputable, whatever steam may be or may do, that the notion of the petroleum motor has proved attractive; and our friends in France have not hesitated to push praise of the light oil engine to the extreme limits of veracity. The public has been promised a vehicle which will leave nothing to be desired, and the public has wondered how it has done without that vehicle so long. That is one reason why the present movement is so powerful, so widespread, and so rapid. But this is not all; the public needs to be educated, and we think we are justified in taking credit to ourselves for the part we have played in promoting the establishment of the new industry.

For years we have carefully placed before our readers particulars of every advance that was made in steam locomotion on common roads. We have persistently advocated the cause of the traction engine and the modification of legislative restriction. When in France, where the law of highways does not kill invention in the matter of locomotion, the new vehicle propelled by oil was brought before the public, we despatched a special commissioner to examine, investigate, and describe for the benefit of our readers; and we venture to say that THE ENGINEER was the first journal in England to tell the world what was being done in France. So impressed were we with the results of our investigation, that we decided to do all that lay in our power to promote the construction and use in Great Britain, and in British possessions, of the self-propelled vehicle. To that end we took two steps of prime importance. To stimulate invention we offered substantial money prizes, and we were successful in enlisting the warm co-operation of two eminent engineers and one equally eminent electrician. The names of Sir Frederick Bramwell, Mr. J. Audley Aspinall, and Dr. Hopkinson, are a sufficient guarantee, not only of the trustworthiness of the trials which will decide the awarding of our prizes, but of the real importance of the undertaking as a whole. We cannot but think that the possession of a first prize may be taken as a certificate of merit, possessing an unparalleled significance. The severe nature of the tests to which the competing vehicles will be submitted, and the absolute competence of the judges to estimate at their true value each phase of the performance of the vehicles, will impart maximum value to the awards, a value which we feel certain the public will not fail to appreciate.

But it was not enough to promote the construction or development of the horseless carriage. It was essential that our highways should be thrown open to its use. To this end we promoted a memorial to the Government, and the host of signatures we have obtained in every centre of industry in the kingdom could not fail to impress Government, and assist the good work. The mere demand for change in the law could effect little unless it was backed up by substantial evidence of the soundness of the demand and the extended range of the desire for a change. We have left nothing undone to supply this evidence, and our efforts have been, we are glad to say, completely successful. The passing of Lord Harris's Bill is, we venture to hope, now a mere question of time, and long before the date of our trials the highways will be thrown open to the use of the self-propelled carriage, under the same restrictions as those which now regulate the use of the horse-drawn vehicle. We ask for no more, and the country will be satisfied with no less. At every turn we hear of exhibitions, competitions, and prizes. They will all do good, no doubt. Far be it from us to say that they will not. But in the midst of the hurry and dust, and confusion of tongues, it is possible that the fact that to THE ENGINEER, the inception of the whole movement in this country is mainly, if not wholly, due may be forgotten; and we have been too much gratified by the success which has hitherto attended our efforts to suffer the truth to slip into oblivion. It is not every day that a journal can accomplish so much for the promotion of a new national industry as THE ENGINEER has done. That must be our sufficient excuse for insisting, as we do, on the fact.

ENGINEERS FOR THE ROYAL NAVY.

To state opinions as facts is a not unusual method of controversy. A notable example is supplied by a letter written by Mr. Albert Durston, Chief Engineer of the Navy, in reply to one addressed to him by Mr. Adamson, secretary of the Institute of Marine Engineers. In our last impression we referred at some length to a paper read by Mr. F. Cooper on "Engineers and the Royal Naval Reserve." We have not got a copy of Mr. Adamson's letter, which is of the less consequence that we can gather its tenour without difficulty from Mr. Durston's reply. That gentleman says:—"The paper on R. N. R. engineers is a most interesting one, and the matter is well put. Unfortunately, it is based on the erroneous statement published in THE ENGINEER, and it takes no account of our staff of chief engine-room artificers, and engine-room artificers who correspond to the junior engineer of the old navy or the mercantile marine. When these are taken into account our engine-room staffs compare favourably with the mercantile marine. As to points named in your letter (1) assistant-engineers for temporary service, as advertised for, the regulations will show we desire to get the pick of young mechanics whose parents have made some sacrifice for them. We do not, however, intend to increase them much more at present. (2) Engine-room artificers, as I have said, do junior engineers' duties, and I think their case well deserves consideration as to whether some of them could not have warrant officer's rank. (3) We should not, except in an emergency, draft engineers direct from the mercantile into the Royal Navy. (4) I think it would be a most desirable thing to put R. N. R. engineers on same footing as to training, &c., as the executive or deck officers."

The statement referred to as "erroneous" was published in our impression for March 7th last year. Whether it is erroneous or not is a matter of opinion, and not of fact, as Mr. Durston seems to think. Mr. Durston, it must be understood, speaks for the Admiralty, and what he has to say on the subject we may regard with strict propriety as an Admiralty utterance. We have stated, it will be remembered, that at least 1100 engineers and assistant-engineers are needed, and that a less number would not give the official complement to each warship that may be put in commission. We carefully eliminated all craft which no longer deserved the name of fighting ships; and we took for granted that if war on anything like a large scale broke out we should need all the ships we have. But the Admiralty, we have excellent reason to believe, do not contemplate the use of all our warships under any conceivable circumstances; and they have arrived at the conclusion that 850 engineer officers of all grades are sufficient to meet the needs of the Navy for the next twelve months. Now this may very well be true, and yet the statement which we have made, far from being erroneous, will remain strictly accurate. We assert, and we advance it as a fact, that there should be on the Admiralty lists a sufficient number of engineers to utilise every ship we possess, always and at all times. It appears to be useless to go on building more and more ships, while we cannot utilise what we have got. But it may very reasonably be argued, that this is a matter of opinion, and that none but experts can say how many ships of war we should need if war broke out. It happens that we have a very recent expression of opinion on this point from an expert, whose authority will scarcely be questioned. Lord Charles Beresford was the guest of the Sheffield and District Press Club on Saturday night, and among other interesting things he said :—"The First Lord of the Admiralty said we should not want all our ships. That he utterly denied. We were short of ships, and before we had been at sea a month we would wish we had more. *There ought to be a ship's company rating for every ship in the service, without touching the Reserves.* Between April, 1897, and 1899, we should have to get 22,000 men. Where was the First Lord going to get them? It was a very different matter getting men in these days, from what it was in former days. Now we require engine-room artificers, artificers, and stokers. These men were all skilled men. It took five years to make a seaman-gunner who could handle guns. In the Marlborough, the first ship in which he went to sea, 10 per cent. of those on board were non-combatants. In the Magnificent now there were 52 per cent. of non-combatants, so they could understand how the character of a ship's company had altered. The position of being short of actual requirements at the present moment, and not being ready for requirements three years ahead, was a dangerous position."

We direct attention to the words which we have italicised. As regards bluejackets, we do not express any opinion. We are content to take Lord Charles Beresford's word. But we do ourselves assert—and that as strongly as possible—that every ship in the service should have her full complement of engineers. Probably if Mr. Durston will look at the matter from this point of view he will see that far from The Engineer's statement being erroneous, it was perfectly accurate in the most minute particulars. The difference between ourselves and the Admiralty is not one concerning the number of engineers, but the number of ships. Provided all the ships in the Navy of the classes we particularised are to be available in war time, 1100 engineers must also be available to man them. Mr. Durston does not, we take it, dispute this. It cannot be disputed in the face of the Navy List. The contention of the Admiralty is that all the ships we possess would not be available in war time, whether we had engineers for them or not. This is a very remarkable and even startling proposition. We shall be surprised if we have heard the last of it.

It may be urged that this is not what the Admiralty really means. That they "back their luck" that there will be no war, and that, consequently, there are engineers in abundance. We fancy that very recent events must have excited some little doubt at Whitehall as to the prudence of this policy. It would in any case be interesting to know what percentage of our fleet our Admiralty contemplate putting in commission on emergency. We could then form some opinion as to whether there is or is not a delusion operating at Whitehall. But let us, for the sake of argument, conclude that only a percentage of our fleet would take part in a war, and go on to ask on what basis 850 officers are held to be sufficient. So far as we can gather, no provision whatever is made in this estimate for the "expenditure" of engineers. As we have already pointed out, they are, it appears, in Admiralty estimation endowed with charmed lives, which will carry them safe from violence, and with iron constitutions which will enable them to sustain the most tremendous bodily and mental exertions without breaking down. Our estimate of 1100 officers provides no reserve of any kind. There is nothing to draw on if a man is invalided; no one to take the place of a man killed or disabled. In a word, the error committed by The Engineer lies in under-estimating instead of over-estimating the number which should be available. We may knock off 30 per cent. of all the ships on our list, and then in war time 1100 would be all too few.

So much being said in defence of our accuracy, we may go on to consider the subject from another point of view. Lord Charles Beresford pointed out in the speech to which we have referred, that the Admiralty are going to add forty-six ships to our fleet within the next two years. We shall be under rather than over the mark if we say that 100 engineers of various grades will be needed for these vessels. It is true that many of them are torpedo catchers with but one engineer each, but others ought not to carry less than six engineers each. Where, we ask, do the Admiralty propose to get these men? And we may ask further, why it is that the Admiralty is so persistent in its policy of under-manning the engine-rooms of our fleet? The money saved is such a small sum by comparison with other items of expenditure, that we cannot believe that parsimony or a desire to save has anything to do with the matter. Is it not a fact that we have not more naval engineers because the Admiralty cannot get them? On this point a little enlightenment is most desirable. The official statement that all the men wanted are to be had must be discounted. Everything depends on how many the Admiralty say are necessary. Instead of 850 officers, they may hold that 50 would suffice. They may think that all the men they can get, however few, are enough. On this point we want something more reassuring than a mere expression of Admiralty opinion. If we had an engineer as First Lord we fancy that matters would assume a somewhat different aspect.

We gather from Mr. Durston's letter that the Admiralty regard engine-room artificers as competent to discharge engineers' duties. Is it too much to suppose that the Admiralty rely on the artificers to supply the deficiency in officers? Mr. Durston's letter would appear to suggest that it is not. If so, the inconsistency of the policy of Whitehall becomes more than ever manifest. We are told that the naval engineer must have an exceptionally excellent technical education, and in the same breath we are informed that artificers are competent to discharge the duties that highly trained gentlemen are expected to perform. It really is time, we think, that the Admiralty should make some specific statement of the nature of its policy as regards engineer affairs; there is nothing more likely to lead to confusion and misapprehension than reticence. The First Lord of the Admiralty virtually ignores the engineering branch of the service in his speeches. Others are not more open. No good purpose is served by silence, and much would be gained by a definite explanation of the system to be adopted in future in manning the engine-rooms and stokeholds of our ships of war, and the reason why two engineers and half-a-dozen artificers can do the work in a man-of-war that cannot be performed by less than a dozen engineers, with their greasers, &c., in an Atlantic liner, and of the part which the artificer is intended to play in future. Several other matters suggest themselves as needing elucidation; we should be satisfied, however, with definite information on the points we have stated.

THE INCANDESCENT GAS LIGHT CASE.

Public interest has been aroused in no common degree by the actions which have lately been brought by the Incandescent Gas Light Company, Limited, against the De Mare Incandescent Gas Light System, Limited, and the Sunlight Incandescent Gas Lamp Company, Limited, for infringement of the former corporation's patent. Many technical cases of the greatest commercial importance, and directly affecting the convenience and pockets of thousands of the general public, are fought out in comparative obscurity, and receive brief paragraphic notice in the daily press. The only difference in the present instance consists in the fact that the matter in dispute is one coming immediately and literally before the eyes of the community. Throughout the country, in every little town boasting a small gas works, one or more enterprising tradesmen are certain to have adopted the novel light to dazzle their customers and display their goods, and both users and onlookers feel that they have some personal knowledge of the nature and qualities of the mode of illumination known succinctly but inexactly as the incandescent gas light. The state of general opinion is accurately indicated by the appearance in the *Times* of Monday last, not only of an account of the judgments given on Saturday, but also of a leading article recapitulating and commenting upon those judgments. A judicial delivery on a patented process for the production of synthetic indigo at a cost lower than that of the natural material might occur and pass almost unregarded, although its effect upon one of the great industries of the greatest of our dependencies might prove to be colossal. That the obvious is always to be met with is more than an etymological truism. But apart from its popular side, the recent contest possesses interest of a technical character sufficient to warrant its consideration in these columns.

For months it has been a matter of common knowledge that the Welsbach system of lighting, owned and worked by the Incandescent Gas Light Company, has, after a long period of probation, advanced to an assured industrial position. Difficulties and defects in the earlier forms of the light have been gradually overcome by the persevering research of the company's technical advisers, and a light has been produced which for economy and efficiency takes a high rank. With the remembrance of lean years the company, being a trading organisation, no doubt sought to recoup itself with all possible speed. The prices charged for burners and mantles bore but a distant relationship to their cost of production, and the public, legitimately enough, was made to pay pretty stiffly for a valuable idea. The natural result followed. Others were anxious to reap part of the rich harvest which it was evident could be gathered from the not wholly intelligible anxiety of civilised man for a superfluity of artificial light. The principle underlying all varieties of incandescent gas lighting has been dealt with in this journal within the last few weeks, and needs no re-statement now. It is enough to say that inventors seeking a method to rival the Welsbach light must devise a different form for the refractory material to be heated, or must employ a different refractory material, or must prove the Welsbach patent invalid. Attempts in all these directions have been made, but with indifferent success. In the defence offered by the De Mare Incandescent Gas Light System it was contended that the patent was not novel, as the production of light by heating certain refractory substances has long been known and practised. This was emphatically negatived by Mr. Justice Wills, who, in a judgment showing a remarkable grasp of a subject not without complexity, stated that, in his opinion, the patent covered perfectly new ground and had shown the road to success in a region where before was failure unrelieved. Further, it was argued for the defence that the specification did not give instructions sufficiently precise to allow of the manufacture of mantles by the prescription included therein; this was also overruled. Thus for the validity of the Welsbach patent there has been issued a weighty pronouncement. Beaten on this point, the defence resorted to the denial that their method of lighting infringed the Welsbach patent. The structure used by the De Mare Company is a "plume," described in the judgment as consisting "of a number of threads tied on to a platinium wire, and arranged so as to form a sort of fringe, all the threads of which are brought very closely together where they are strung on to the wire, but allowed to separate as they leave it, so that the apparatus looks like a housemaid's small brush, the cross-sections of which would take the shape of a fan." The refractory oxides used in the formation of this plume are zirconia, erbia, and magnesia, and in the opinion of the Court fall within the scope of the Welsbach specification. Differences in the mode of manufacture and in the design of the finished plume from those of the Welsbach mantle were held not to constitute a departure sufficiently great to exonerate the defendants from the charge of infringement. Judgment was accordingly given against the De Mare Company, and, should the decision be upheld on appeal, the manufacture of plumes of the refractory rare earths must be discontinued until the lapse of the Welsbach patent.

The second case—that against the Sunlight Company—took a somewhat different course, and led to a wholly different conclusion. The refractory structure manufactured by the Sunlight Company is a hood or mantle scarcely distinguishable in form from that made by the Incandescent Gas Light Company. The material of which it consists, however, is composed of 50-60 per cent. of alumina, about 30 per cent. of zirconia, and a top-dressing of chromic oxide. The last named is applied by spraying a solution of a chromium salt on to a mantle made of alumina and zirconia and igniting the composite product. Mr. Justice Wills considered that the large difference in the oxides used from those employed in the Welsbach mantle removed this hood from the domain of the Welsbach patent which specifically embraces rare earths, whereas none of the oxides adopted by the Sunlight Company can properly be described as belonging to this chemical category. Some stress was also laid in the judgment on the homogeneity of the Welsbach mantle, and the heterogeneity of the Sunlight hood, the latter quality being presumably brought about by the process of spraying the chromium salt on to a skeleton previously rendered coherent. It is difficult to agree with this view, for seeing that the chromium is applied in a soluble state to a porous material it will penetrate the latter to a considerable extent and may even saturate it, forming ultimately a mixture almost as intimate as that produced by the simultaneous application of all the constituent oxides. We are, therefore, inclined to believe, that the essential ground for allowing, as was ultimately done, the claim of the Sunlight Company's patent to be considered no infringement of the Welsbach patent, consists in the nature of the oxides used rather than in the particular mode by which they are formed into a mantle. Thus the Sunlight Company is in the present position of affairs, free to make and sell a mantle of shape substantially identical with that of the Welsbach device. Disregarding the possible result of an appeal, the ultimate success of the mantle depends on its efficiency as compared with that of the Welsbach, and on its prime cost.

The result of the two actions at law, which we have sketched above, goes a long way to confirm what we have said on the occasion of previous patent cases of a similar kind. There is a strong disposition—and on the whole it is a healthy one—on the part of the Courts to uphold, if possible, a patent which is new and useful in a given field, even if foreshadowings of it can be adduced as anticipations. At the same time, although a fairly liberal interpretation of the specification of a patent of this class may be expected, it not infrequently happens either that the specification claims more than can be shown to be practicable, or it omits some method which is afterwards proved to be practicable in a way peculiarly poignant, viz., by its successful exploitation at the hands of a rival in trade. The protection of modifications of a process by separate patents, instead of by numerous claims or an omnibus claim in a single specification, appears to be advisable where the interests to be guarded are large, and opposition is probable. With regard to that aspect of the case which has to do with the evidence of experts on both sides, we should be silent were we not thoroughly convinced of the necessity of iteration. It is not insignificant that the *Times*, not usually over-mobile in its views, has adopted the opinion which we have oftentimes expressed, and declares that picked technical assessors aiding the Court in matters of scientific fact, even as a judge aids a jury on points of law, would much facilitate the hearing of cases lying outside the knowledge of the Court. The attainment of these desirable ends would be a reasonable compensation for the regrettable loss of many a racy story.

THE GROWTH OF STEAMSHIPS.

The return of the vessels in course of construction at the end of the first quarter of the year has some features that are of special interest. There is first shown the fact that out of all the steamships building, steel was the material used except in a trivial quantity; and that is due to the fact that iron and wood are only used in the construction of a few steamers which average 120 tons each, and are thus shown not to be for ocean purposes; whilst, on the other hand, the average of the steel steamships building was about 2250 tons each; and in only a slightly minor degree, similar remarks apply to the sailing vessels that were in course of construction in the same quarter. Out of some 400 vessels building in the United Kingdom, the largest proportion—more than a seventh– is of vessels between 3000 and 4000 tons; and the next largest is for vessels between 2000 and 3000 tons; whilst even in the numerical contrast, the comparison is in favour of the large steamers. In Belfast, the average size of the vessels building is very noticeable, it being over 5300 tons for both sail and steam together, an average which does not seem to be attained by any other of the British districts tabulated by Lloyd's returns. At the same time, it is noticeable that on the Continent there are many vessels of large dimensions in course of construction. At Lubeck, Rostock, and Stettin, out of the vessels building there, seven were of an average of 5900 tons each, but this is the average of the large vessels only—the smallest vessels not being included in the tables. Apart from Germany, there does not appear to be any very large average attained by the builders, though in one of the French districts, the large vessels in course of construction were over 3000 tons each, subject, however, to the remark already made as to the exclusion of small vessels from the returns. The fact, however, may be looked on as settled, that the tendency towards the building of large steamers continues, and that there is now a determination on the part of some of the foreign builders to participate in the orders for the construction of these vessels of greater tonnage. How far it will go remains to be seen, but the large steamships will increase the share of the work of the world over the seas they have been doing.

LITERATURE.

Polyphase Electric Currents and Alternate Current Motors. By SILVANUS P. THOMPSON, D.Sc., &c. London: E. and F. N. Spon. 1895.

THE author delivered a course of four lectures at the Technical College, Finsbury, on the subject of "Polyphase Currents," and has now published the matter with many additions, in the form of the present volume. Little has so far been done in this country with polyphase currents, and the author offers his thanks to German and Swiss firms for many particulars of which he has made use. The addition at the end of the volume of a full bibliography of the subject, and also of a list of British patents, will be found of great use. The book opens with a sketch of the construction of the ordinary alternator, and diagrams show how the current curve is caused to lead or to lag behind the volt curve. In our opinion the graphic method is decidedly the most useful for dealing with this subject; and the Zeuner type of diagram, so familiar to all mechanical engineers, is referred to in the first chapter, and is very useful for showing the momentary pressure on each of the three wires of a linked system. It seems strange to be reminded that the original Gramme machine, built about 1877, was in reality a polyphase generator, but the circuits were kept separate, and there is no reason to suppose that Gramme realised the possibility of linking up the different monophase currents. The author gives, in his usual lucid style, a description of the elementary form of polyphase generator, and this is followed by a description of the now historical machines used for the Lauffen transmission work. The second chapter deals with the combination of polyphase currents. The author makes use of the clock diagram to show how the pressure varies between the line wires of the three-phase system when the coils of the generator are joined up in star fashion, proving that the pressure between two of the leads outside the machine would be 173 virtual volts, while that generated by one coil was 100 virtual volts, and diagrams make this somewhat difficult subject clear.

Economy in copper is most assuredly obtained by the use of the polyphase system, and the author proceeds to point out that the pressure is determined by the lamps, which are not practicable for voltages over 100 to 110. This statement we think requires some correction, in view of the fact that in Bradford and elsewhere lamps have been used with the greatest success for 215 volts; and, in fact, there is little doubt that the three-wire system for direct current will be used very largely with 400 to 480 volts between the outside wires.

The author discusses the somewhat intricate question of the relative costs of copper, and finds that the three-phase system with the lamps joined in mesh, only 75 per cent. of the copper is used which would be required for the single-phase system. Taking the single phase and two wires as 100, the relative costs of the other systems have been put very clearly by Mr. Goerges. It appears that the single-phase three-wire system, with the middle wire half the section of the others, stands at 31·35; while three-phase with four wires has no advantage over the ordinary three-wire system, when the extra cost of fixing the fourth wire is taken into account.

The author uses steam-engine analogies to show how the two-phase and three-phase currents are used to produce the rotary field, and then takes up the history of Arago's experiments on rotating magnetic fields, followed by those of Babbage and Herschel. Walter Baily exhibited the first polyphase motor in 1879, before the Physical Society of London; and this fact will surprise many, who considered that the type had its origin in Germany. Three years later, Deprez laid down an important theorem; and in 1885 Professor Galileo Ferraris, of Turin, arrived independently at the same fundamental ideas as Baily and Deprez. A history is then given of Tesla's work, and also of the work of other electricians, the Frankfort Exhibition naturally supplying the best examples. The author then describes Mr. C. E. L. Brown's machines, and uses the dreadful words "rotor" and "stator" respectively for the moving and stationary parts of the machine. The most important part of the work is probably that which deals with the structure of the polyphase motor, and Chapter VI. deals with the theory of its structure. The volume closes with reference to the work carried out by various firms at the present time; and we may say that it sums up, in a very compact form, information hitherto scattered through the pages of the "Proceedings" of scientific societies and technical journals.

Die Berechnung der Centrifugalregulatoren. Von W. LYNEN. Berlin: Julius Springer. 1895. (The Calculation of Centrifugal Governors.)

THIS work is written by the governmental architect and private tutor of the Royal Technical High School of Charlottenburg, near Berlin, and is the first work we have seen devoted solely to the consideration of the design of the various forms of speed governors for prime movers. The author has evidently made the subject his special study, and although a considerable knowledge of the higher mathematics is required to enable the reader to follow him throughout, yet the various curves and formulas given should be of use to the practical designer. The method used is synthetic, and the action of each single force is considered separately. The general conditions of equilibrium are not discovered by analysis of the forces, that is to say, by static methods, but by the dynamic method. Results are given in the form of a series of curves, and with the aid of curves 1 and 2 the author considers that all weight governors with normal action can be calculated.

One result is a new calculation of the double ball governor, and the author hopes that the efficiency of the cosine governor will be better understood. The subject of axis governors is thoroughly treated, and it is pointed out that spherical or disc weights are to be preferred, for constructional reasons, to the usual club-shaped swinging weights. Numerous examples of calculation are given, in order that the new method of calculation may be clearly understood. The author concludes that the numerous governors in use do not essentially differ from one another, and that the type invented by Watt must be reckoned among the best. The curve of centrifugal force for the three governors at the end of the tables shows a turning point. This type is especially suitable for engines running with great uniformity, such as are used for electric light work, for it is almost astatic at the speed generally used, and has great power at the extreme speeds.

The author considers that, in spite of the importance of governors to engine builders, there is yet a great lack of knowledge on the part of engineers; the reason of this, he suggests, is that governors are built to a large extent by firms who make a speciality of the work. Personally, we think, however, that the latter statement is more applicable to continental than to British practice. Alluding to the analytical method of calculation, the author points out that the weight is considered in conjunction with the gear for moving the sliding piece, and there is a mass of values which only a maker with long practice can understand. He also gives a sketch of the usual figure drawn, and quotes the resulting formula for angular velocity in which there are eight arbitrarily chosen values. The value of ω is less decisive than the change of angular velocity with change of the value, but on this point neither formula nor diagram give any information. The author's method is first to consider the centrifugal force of a rotating mass, then the centrifugal force of a centrifugal pendulum suitable for the governor, and afterwards the forces other than centrifugal forces acting on it. The action of the latter is independent of the rotation of the governor, and depends only upon the nature of the movement. Examination must begin with the most normal motion, and with the simplest changes, and afterwards other and more complex changes can be dealt with. The superiority of the graphic method over the arithmetical is well shown for obtaining rapidly a clear view as to which particular part of the governor must be dealt with to obtain a desired result. The volume should certainly be of value to governor designers who can read German and follow the calculations. A great many different types of governors are dealt with, and the whole of the illustrations are merely line diagrams showing the links and joints.

A Laboratory Course of Experimental Physics. By W. J. LOUDON, B.A., Demonstrator in Physics in the University of Toronto; and J. C. MCLENNAN, B.A., Assistant Demonstrator. London: Macmillan and Co. 1895. Demy 8vo. Pp. 302. Net 8s. 6d. Uncut.

THIS somewhat cosmopolitan production—devised in Toronto, printed in Norwood, Massachusetts, and published in London and New York—is intended to overcome the difficulty experienced by the authors in providing during a limited time ample instruction in the matter of details and methods to large classes engaged in experimental physics in laboratories, and they signify that the book contains a series of elementary experiments arranged as far as possible in order of difficulty. These are intended for students who have but little acquaintance with higher mathematical methods, and they are followed by an advanced course of experimental work in acoustics, heat, and electricity and magnetism intended for those who have taken the elementary course, and who have a more extensive acquaintance with mathematical methods.

The elementary course is arranged under the following headings:—The vernier, the calipers, the cathetometer, the spherometer, micrometer, screw gauge, dividing engine, specific gravity bottle, hydrostatic balance, hydrometers, Mohr's balance, Boyle's law, the volumenometer, determination of capillary constants, the sextant, the goniometer, curvature of mirrors, focal length of lenses, indices of refraction, magnification with lenses, photographic lenses, photometers, specific heat of solids and liquids, latent heat of fusion, and level testing.

The advanced course is divided into three sections:—(1) Acoustics, dealing with the sonometer, equal temperament, transverse vibration of strings, pitch, Lissajou's method of tuning, harmonic motion, overtones, the chronograph, the clock fork, Melde's experiments with strings, Helmholtz's apparatus for combining simple tones, Kœnig's analyser, the manometric flame, velocity of sound and Dœppler's principle; (2) heat, dealing with thermometers, coefficients of expansion of dry air, Favre and Silberman's calorimeter, latent heat of steam, weight of dry air, hygrometry, density of vapour, Dumas' method, coefficient of expansion of metals, specific heat of dry air, pressure of vapours for low temperatures, and Regnault's apparatus for the determination of the pressure at high temperatures; and (3) electricity and magnetism, treating magnetic lines of force, magnetic moments, the declination and inclination compass, intensity of earth's magnetic field, magnetic field of a current, tangent and sine galvanometers, hydrogen and copper voltameters, calibration of galvanometers, galvanic batteries, resistance, temperature, coefficient of resistance, galvanometer resistance, resistance of batteries, E.M.F. determination and absolute determination of resistance by use of calorimeter. Then the determination of gravity by the pendulum and the torsion pendulum furnish matter for two short appendices, and twenty-one tables of various data terminate the book.

From the above synopsis the scope and the arrangement of the matter may be gathered, and as regards the latter it must be admitted that it is by no means happy, especially in the elementary course, as the dodging about from subject to subject it necessitates could not but confuse the student; whilst as regards the former, when considered as a course of practical physics, it is inadequate and incomplete. It is true, on this point, the authors state that the important subject of "Physical Optics" has been omitted because they have not yet mapped out a suitable course of experiments. Then, as regards the treatment, in many instances it is concise and clear, in all it is brief, but in some it is unsatisfactory and cursory; for example, the student is suddenly introduced to the vernier, which is described but not defined; its construction is detailed, but the principles on which it is based are not clearly set forth; examples of its application are given, but the manner of applying it is not explained. Regnault's apparatus for the determination of the pressure of vapours at high temperatures is illustrated by an unworkable diagram with unexplained conventions, and the whole of the directions for working are, "compress the air in the large reservoir, determine pressure by means of the manometer and barometer, and finally take the temperature at the boiler." The object being essentially practical and instructive, the extreme brevity indulged in does not contribute to the utility of the articles. There are more or less copious tables of contents, distributed at irregular intervals, preceding each section in fact, which are far from readily accessible, and as there is neither a general table of contents nor an index, ready reference is impossible, a by no means useful feature in a book for students. The book, however, is well printed and well illustrated, and may serve a useful purpose as a notebook for the particular matters dealt with, and more especially as an adjunct to a more comprehensive course of lectures on practical work.

SHORT NOTICES.

The Volunteers and the National Defence. By Spencer Wilkinson. Westminster, London: Archibald Constable and Co. 1896. Price 2s. 6d.—This is an essay written with the object of giving a comprehensive account of the chief processes of modern war, and to show how the volunteer force may be fitted to do the work of defence with conditions of war what they are to-day. After an introduction and chapter on the scope and method of inquiry into the subject, the author deals with his subject in two main parts, and under the subheads mobilisation, transport, march, quarters, security and exploration, battle, actual conditions of volunteer service, attendances, ranges, principles of modern methods, discipline, and finance.

Lean's Royal Navy List, Containing Special Points of Interest. By Lieut-Colonel Francis Lean—Retired full pay—Royal Marine Light Infantry. No. 74. April, 1896. Published quarterly. London: Witherby and Co. Price 7s. 6d.—This excellent publication is now in its nineteenth year. It was started in January, 1878, and every year of its life has seen improvement in it. It is not too much to say that for fulness of information and careful editing it has no equal. As a book of reference it is invaluable.

The South-Eastern Railway: Its Passenger Services, Rolling Stock, Locomotives, Gradients, and Express Speeds. By the author of "British Railways." With three plates. London: Cassell and Co., Limited, 1895. Price 2s. 6d.—A very convenient little handbook of thirty-two pages, containing much information of interest and value to all who wish to know something of the working of railways. The South-Eastern has a somewhat bad reputation for unpunctuality and slowness. We gather from our author that this is not due to want of locomotive power—indeed it is not easily to find anything better than Mr. Stirling's latest engines—but to the severity of the gradients, the weight of the trains, and the crowded condition of the road. There are diagrams of speed and gradients, and very full particulars of the train service.

The London, Brighton, and South Coast Railway: Its passenger Services, Rolling Stock, Locomotives, Gradients, and Express Speeds. By the author of "British Railways." With two plates. London: Cassell and Co., Ld. 1896. Price 3s. 6d.—A capital little book of 56 pages. The author has more to say about the Brighton than about the South-Eastern Railway. The method of treatment is, however, the same. The particulars of locomotive work are very complete and interesting.

BOOKS RECEIVED.

The Cheque Bank Handbook, 1896. Second edition. List of principal banks and agents.

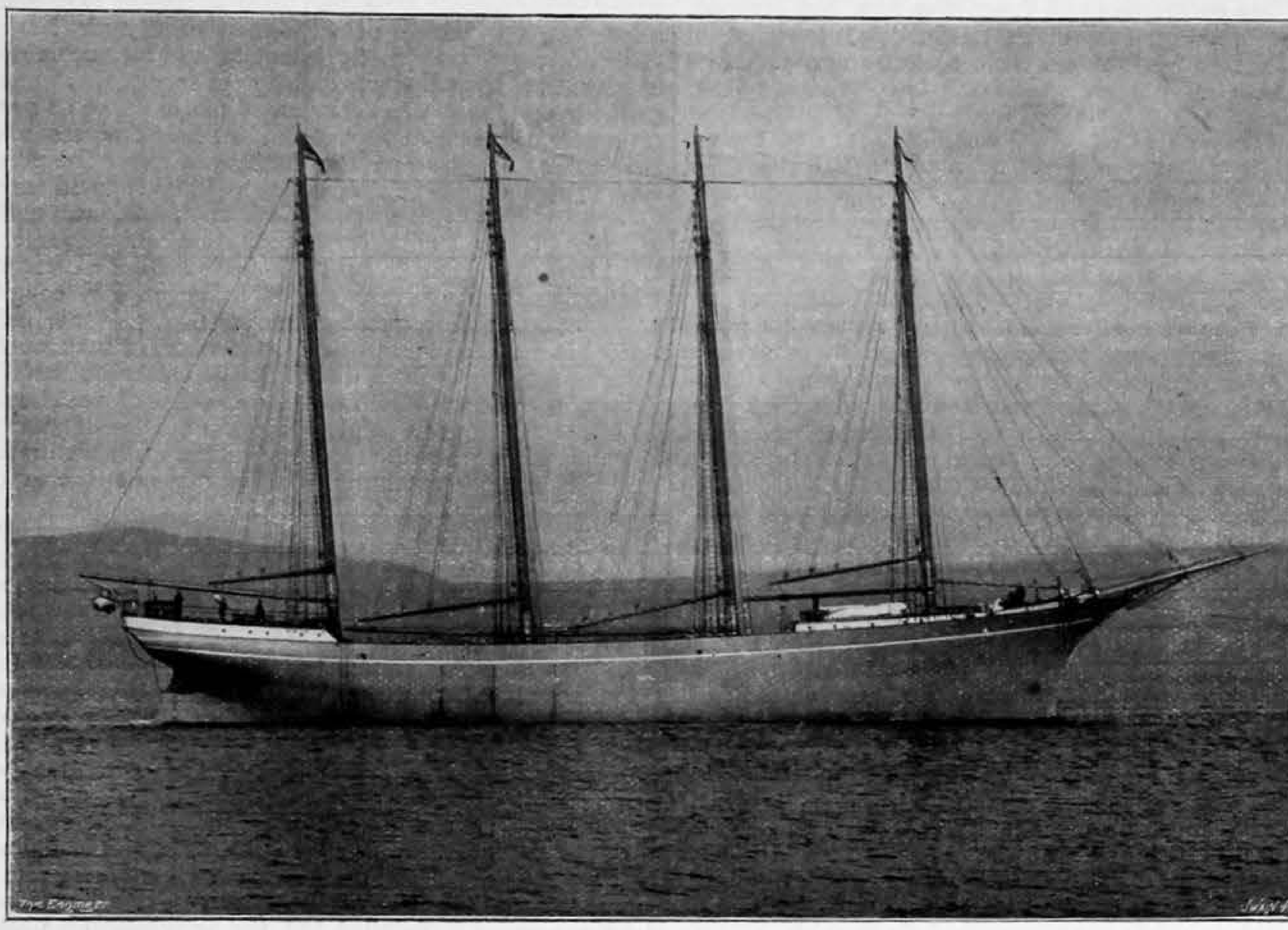
The Progress of Artillery. Naval Guns. By James Atkinson Longridge, M. Inst. C.E. London: E. and F. N. Spon. 1896.

An Elementary Treatise on the Calculus, for Engineering Students. With numerous Examples and Problems worked out. By John Graham, B.A., B.E. London: E. and F. N. Spon. 1896.

Les Rayons X et la Photographie à travers les Corps Opaques. Par Ch. Ed. Guillaume, Adjoint au Bureau International des Poids e. Mesures, D.Sc. Paris: Gauthier-Villars et Fils. 1896. Paper 127 pp.

A REUTER telegram from Simla says heavy floods in the Panjkora Valley have damaged the bridges at Chutiatan, and have destroyed all the bridges on the river above Dir. It is hoped, however, that the forwarding of reliefs to Chitral will suffer no delay.

THE FOUR-MASTED SCHOONER HONOLULU



A NOTABLE CLYDE-BUILT SCHOONER.

THE attention now being directed to the subject of the manning of ships, coupled with the constant aim of shipowners to avail themselves of any economy possible in that direction, while at the same time securing the needful efficiency, are considerations which should render some details of the new steel fore-and-aft schooner Honolulu of interest. This vessel—of which we give an illustration reproduced from a photograph kindly furnished to us by her builders, Messrs. Robert Duncan and Co., Port Glasgow—besides being the largest steel fore-and-aft schooner ever built in this country, is of a type very rarely met with in British waters, and altogether a novelty as emanating from the stocks of a Clyde shipyard. She has been built for the timber-carrying trade to the order of Mr. John Ena, merchant and shipowner, Honolulu, for whom Messrs. Duncan and Co. have before built sailing vessels of the ordinary kind. As will be seen from our illustration, the Honolulu, both in the matter of hull and of rig, has features distinguishing her from the ordinary sailing ships of modern times, at least so far as British practice is concerned. This was conspicuously made evident in the course of last month, when the Honolulu, while loading a general cargo prior to departing on her maiden voyage, lay alongside some of these full-rigged vessels in the Queen's Dock, Glasgow. Vessels of the type of the Honolulu, however, are no novelty on the Pacific, and along the west coast of America; many of these being double her tonnage, which is about 1000 tons gross.

Our illustration conveys a fair idea of the peculiarities of rig, of the vessel, and perhaps also of her hull. Features which at once attract notice are the great sheer, graceful clipper bow and bowsprit, the four lofty pole-masts of equal length, and the simplicity, not to say meagreness, of the rigging gear. The vessel's general proportions are somewhat extreme as compared with the proportions ordinarily adopted in modern sailing vessels, while the hull form is quite yacht-like in its fineness of lines. The vessel's dimensions are 225ft. length over all, or 210ft. between perpendiculars; 42ft. beam, and only five beams to the length; and 18ft. 6in. depth of hold. The rise of floor is of the unusual height of 6ft., giving a relatively small midship area, and, combined with the fineness of water-lines, giving a coefficient of form resembling that pertaining to those renowned tea clippers built in our midst in the "fifties," which made such marvellous passages to and from the Far East. The Honolulu has four huge steel pole-masts, each of them about 140ft. in height from keel to truck, and with an immense fore-and-aft sail, hooped to the mast and laced to gaff and boom. These four sails, and three jib sails which are carried forward, give a total spread of canvas considerably greater in proportion to displacement than the total sail area of any square-rigged vessel afloat.

The structure of the vessel is of the strongest description for the safe carrying of heavy timber cargoes, somewhere about 1¼ millions superficial feet of lumber being her complement. Save the collision bulkhead forward, the interior of the vessel is unobstructed from end to end, and there is no 'tween decks. The main deck from stem to stern is entirely of steel, with strong bulwarks supported by heavy bulb web stanchions every 4ft. apart, in order to secure safety in carrying the immense deck-loads common in the particular trade for which the vessel is intended. The forecastle deck is also of steel, while the poop deck is laid with specially selected Oregon pine. Besides having unusually large hatchways forward of each mast for timber cargoes, there are fitted in the bow and stern large ports capable of taking in the heaviest timber of almost any length, the timber being put on board by an ingenious arrangement of leads and pulley blocks worked from a special steam winch of extra power, situated in the large deckhouse abaft the forecastle. This steam winch, combined with a large multitubular boiler, is specially designed with warping drums, both horizontal and vertical, and every appliance and gearing, not only for loading and discharging deckloads of heavy timber, but for rapidly hoisting and working the vessel's immense fore-and-aft sails. This combination of boiler, winch, and gear has been supplied by Messrs. Murray Brothers, of San Francisco, who are familiar with the requirements in this installation of special machinery on board ships of this type. In case of need, steam can be raised in this boiler in about ten minutes to a pressure of 200 lb. per square inch—an immense advantage where all the spars, sails, and gear are of the heaviest description. Manual labour is saved to a very considerable extent, and a smaller number, or less experienced seamen, is capable of managing the sails, ropes, &c. The style of rig adopted, in fact, and the equipment of the vessel generally, admit of her being efficiently worked by about half the number of seamen which would be required under ordinary British regulations.

Steam from the boiler above-mentioned also drives a powerful capstan windlass of Emmerson and Walker's make, and also actuates one of Tangye's patent duplex steam pumps capable of throwing 2000 gallons of water per hour. This appliance will be invaluable in the event of fire or other accident to the vessel or cargo. A set of Mills' patent pumps is fitted amidships, which can also be worked from the steam winch through the medium of messenger chains. The entire outfit of blocks for the vessel is of a special and very expensive description made by Messrs. Laird and Sons, Irvine, from patterns and particulars supplied by its owner and adapted for the excessively hard work they have to accomplish. The rudder is of a design also furnished by the owner, and which is seldom seen in large sailing vessels in home waters, being abnormally broad at the bottom, tapering to nothing at the load water-line, for the purpose of manœuvring the ship quickly when going through narrow channels amongst the Sandwich Islands. The vessel, which is classed "British standard" with the British Corporation of Shipping, Glasgow, was built and equipped under the superintendence of Captain William Thonagel, of San Francisco, who has had great experience, and is well known in the Pacific trade.

THE RAILWAY ZONE TARIFF SYSTEM IN RUSSIA.

SINCE the introduction in February, 1879, of the special Government tax on railway passenger tickets, 25 per cent. on first and second-class, and 15 per cent. on third-class tickets, the passenger rate on Russian railways per mile has been 2·15d. per mile first-class, 1·61d. second-class, and 0·827d. third-class. From time to time attempts were made to reduce these rates, but all that was accomplished was a reduction in the three classes of 3 per cent. per mile in 1880, and 6·8 per cent. in 1891. The comparatively small use of the Russian railways showed conclusively that the rate was too high. While in 1891 the number of railway passengers in Great Britain was 817,000,000, in Germany over 315,000,000, in France 208,000,000, and in Belgium about 57,000,000, the number conveyed in Russia was only 43,500,000. Notwithstanding the enormous distances in Russia, more than one half of the passengers conveyed did not travel over 33·15 miles, and only 6 per cent. of the total travelled 199 miles. The number of coaches used is, therefore, very small. On the average for each first-class passenger five places were available, for each second-class passenger not less than four places, and on some lines twenty places, and for each third-class passenger more than two places.

The good results which followed the adoption of the zone tariff in Hungary led the Russian Government to pursue a similar course, and the new passenger tariff was introduced on 1st December, 1894. The zone tariff begins at 199·56 miles, between that point and 1011·3 miles there are 36 zones, viz., 199·56—331·5 miles, eight zones; 332·16—470·73 miles, seven zones; 471·39—656·37 miles, eight zones; 657·03—1011·3 miles, thirteen zones. After this distance every 33·15 miles is counted as a zone.

The cost of a third-class railway ticket for a distance of from 0·663 to 199·56 miles is: up to 106·08 miles, 0·824d.* per mile; from 106·74 to 198·9 miles, 0·516d. per mile. The charge for a second-class ticket is one-half, and for a first-class ticket two and a-half times higher than for a third-class. Children from five to ten years pay in each class half a full fare. Baggage to the amount of 36·112 lb. is allowed for each full ticket. The rate for transportation for each hundredweight of passenger's baggage is up to 215·48 miles, 0·369d. per mile; beyond that distance 9·64d. per zone is added. The new passenger tariff makes long-distance travelling by rail very much cheaper than under the former system. The following shows the comparative cost of a third-class ticket for distance up to 198 miles under the old and new systems:—

Distance.	Old tariff. £ s. d.	New tariff. £ s. d.
106·08 miles	0 7 3½	0 7 3½
132·60 ,,	0 9 1¼	0 8 5
198·90 ,,	0 13 7¾	0 11 3¼
265·20 ,,	0 18 2¼	0 13 9¾
331·50 ,,	1 2 9¼	0 16 4
397·80 ,,	1 7 4	0 18 6¾
464·10 ,,	1 11 10¼	1 0 9¼
530·40 ,,	1 16 5	1 2 8
596·70 ,,	2 0 11¾	1 4 6¾
663·00 ,,	2 5 6½	1 6 5¾
994·50 ,,	3 8 3¼	1 14 6¾
1326·00 ,,	4 11 0½	2 0 10¼
1657·50 ,,	5 13 11¼	2 7 2¾
1989·00 ,,	6 16 7	2 13 6¾

The reductions vary from 7·76 per cent. at 132·6 miles to 60·8 per cent. at 1989 miles, and average 46·81 per cent. The reduction between certain known places is still more marked, viz.:—St. Petersburg to Moscow, old fare £1 7s. 5¾d., new fare 19s.; Riga, old fare £1 7s. 10½d., new fare 19s.; Verballen, old fare £1 18s. 2¼d., new fare £1 3s. 5¼d.; Nishni-Novgorod, old fare £2 6s. 2½d., new fare £1 6s. 7¼d.; Warsaw, old fare £2 7s. 9¾d., new fare £1 7s. 3¼d.; Kharkov, old fare £3 0s. 8d., new fare £1 11s. 8d.; Kiev, old fare £3 7s., new fare, £1 14s. 2½d.; Odessa, old fare £4 3s. 0½d., new fare £2 0s. 6½d.; Piatigorsk, old fare £5 2s. 3d., new fare £2 3s. 8½d.; Vladikavkaz, old fare £5 9s. 6¾d., new fare £2 5s. 7¼d.; Cheliabinsk, old fare £5 17s. 3½d., new fare £2 8s. 1½d.

The difference in the rates of second-class travelling is still greater, the fare from St. Petersburg to Verballen having been reduced from £3 14s. 8¾d. to £1 15s. 1¾d.; that to Warsaw from £4 13s. 6½d. to £2 0s. 10¼d.; and that to Odessa from £8 2s. 5½d. to £2 17s. 11½d. The result is that people of small means, who had to travel long distances by third-class, can now go second-class for less money. How little the first and second-class have been used is shown by the following figures:—

Proportions of Passengers carried.

Years.	First-class. Per cent.	Second-class. Per cent.	Third-class. Per cent.	Fourth-class. Per cent.
1883	2·02	9·62	86·05	2·31
1889	1·49	7·54	88·80	2·17
1891	1·36	6·86	88·81	2·97

The following shows the difference between the old and new tariffs for every hundredweight of baggage:—Distances of 198·90 miles, old tariff, 6s. 7¾d.; new tariff, 6s. 2¼d. 397·80 miles, old tariff, 13s. 3½d.; new tariff, 11s. 10½d. 596·70 miles, old tariff, 19s. 11¼d.; new tariff, 16s. 8d.; 994·50 miles, old tariff, £1 13s. 2¾d.; new tariff, £1 4s. 7¾d. These reductions, ranging from 8 per cent. at 198·90 miles to 25·12 per cent. at 994·50 miles, and averaging 16·1 per cent., are much less for long distances than those for passengers.

It was expected that the Russian railways, through the introduction of the new tariff, would lose yearly £1,894,202, provided traffic remained the same. According to the former tariff the railways earned £8,061,754 from the passenger traffic, and according to the new tariff they could only expect to earn £6,665,885; but it is hardly possible that such a loss could occur, experience thus far showing the contrary. For instance, when in 1881-82, on the Warsaw-Vienna Railway, a lower rate was introduced on fourth-class tickets, the number of passengers increased from 1,600,000 to 2,000,000; but as soon as the rate advanced again the number of passengers returned to the former figures. The Griaze-Tsaritzine Railway had the same experience. It made a reduction of 0·43d. per mile, and not only did the number of passengers become greater, but the number of miles travelled also increased. In 1891, when the rates were reduced to the people of the needy districts, it was shown that, in comparison with 1890, the number of persons who used the lower rates increased by 44·3 per cent., and the number of miles travelled by 80 per cent. If the passenger traffic should increase on account of the great reductions under the new tariff in proportion to that mentioned in the foregoing cases, the prospects for the Russian railways are bright, and other countries may follow the Russian example. Later advices state that instead of the expected deficiency of £1,894,202, the receipts last year rose to £9,183,333, an increase of £1,121,579, or 13·92 per cent.

According to the United States Consul-General at St. Petersburg, it seems from the number of railway projects on foot as if Russia were about to enter upon a period of unusual railway activity. Last year, when the zone tariff had been working for some time, a syndicate of Berlin and Paris financiers was formed at Warsaw for the purpose of proposing to the Russian Government an extensive scheme of railway construction, comprising the construction of a railway from St. Petersburg to Kiev, the renting of the existing lines joining Kiev, Kazatin, and the Uman-Elisabetgrod branch, and the construction of a line from Uman through Volnesensk to Odessa, without a Government guarantee.

* As the value of the rouble has fluctuated from 3s. 2¼d. in 1874 to 1s. 5½d. in 1895, all rates in this paper are based on its gold value 3s. 2d.

NEW WALRAND-LEGENISEL PLANTS.—Walrand and Legenisel, of Paris, have just completed and put in operation two of their special types of plant at the works of the Société Franco-Russe, and the Baltic Works, in St. Petersburg. At the first-named works there is only one 300 kilog. converter, while at the latter there are two of 800 kilog. As a result of the success attained at the last-named works, the authorities of the Obouchov State Foundry have decided to put down a plant of the same type.—*American Manufacturer.*

GAINSBOROUGH WATERWORKS.—At their meeting on the 13th inst. the Gainsborough Urban District Council, after passing a vote of condolence with the widow and family of their late engineer, Mr. Jabez Church, unanimously appointed Mr. Church's partner, Mr. Percy Griffith, as engineer to continue and complete the waterworks extensions now in progress. Since our last reference to these works, the first portion of the large boring has been successfully completed. This is 320ft. deep and 36in. diameter, and is lined with 30in. wrought iron tubes, the annular space around the tubes being filled with 3 parts fine sharp sand and iron borings to 1 part of Portland cement. The last lengths of the tubes were lowered on March 10th, and after carefully testing them for verticality, the cement was filled in behind them till it finished off level with the top of the last tube. As the boring was so much larger than the tubes, the whole weight of the 290ft. of tubes—upwards of 18 tons—had to be suspended on the overhead gear. Ample precautions were, however, taken by the contractors, Messrs. E. Timmins and Sons, and the whole of the operations were conducted without mishap or accident of any kind. The next section of the boring is now in progress, and is being bored 24in. in diameter. If it is found possible to continue this to the total depth required to be tubed—another 440ft.—without any difficulty from infall, &c., the whole of this section will have 18in. tubes lowered into it, and filled in with cement as in the first section. It will be remembered that this boring is to be carried down to a total depth of 1450ft., and is to finish not less than 18in. diameter at the bottom, so that the endeavour to avoid any driving of the tubes by the system described will be fully appreciated by anyone experienced in boring operations.

FORMULÆ FOR CALCULATING THE PERFORATION OF ARMOUR.

CAPTAIN TRESIDDER, the well-known member of Brown's Armour Plate and Steel Works, last year suggested a formula for perforation which might, he urged, be adopted with advantage internationally, on the following grounds: (1) Close agreement with actual results obtained at various velocities; (2) theoretical soundness; (3) simplicity. There is considerable support for the claims thus advanced —that is to say, this formula gives results for high velocities which are much more nearly correct, so far as we have evidence, than do the recognised British formulæ of Maitland or Fairbairn. For low velocities, we believe the last named formulæ, which are practically identical, give good results—better, we are inclined to think, than Tresidder's; but in the present day high velocities are much more important than low ones, because the former are more likely to be employed. Then, again, without question, Tresidder's formula is more simple than others. He has also embodied it in a slide rule which is an actual luxury for those who have to calculate perforations. With regard to theoretical soundness, authorities do not appear willing to admit that Captain Tresidder's claim is proved. He has not had much opportunity of advocating his views, and mathematicians are slow to be convinced on a question like this, so that at present the formula stands on its working merits, and the working merits of any formula now are difficult to determine fully, because firing ordinarily takes place against steel plates treated and hardened in such a variety of ways as to make comparison very difficult.

So far as we can speak with confidence, the whole question stands as follows:—We have in past years fired at comparatively low velocities at wrought iron until experience enabled us to arrive at a trustworthy formula for these conditions. Such a formula was obtained by a combination of such elements as are theoretically sound, with such empirical terms and corrections as caused a fairly correct result to be obtained over a certain range of conditions. As armour developed, difficulties increased. Steel, chilled iron, and steel-faced armour replaced wrought iron. If these always yielded in the same way as wrought iron, that is, by perforation, it would be easy to arrive at a relation between the resistance of any particular steel plate and that of wrought iron of the same thickness, but when plates yield by fracture the conditions are greatly changed. For example, in perforation, the smaller the diameter of a shot, the smaller is the hole it needs to make in order to pass through, and the less is the work required to make such a hole. If, on the other hand, the plate yields in preference by fracture, it is a question if the diameter of the shot enters into the calculation. It appears probable that the action is the splitting action of a pointed wedge struck with the plate, and both plate and shot generally break without a hole the size of the shot's transverse section being made at all. Chilled iron and wrought iron offer the extreme examples of what were then termed "hard" and "soft" armour, the former yielding wholly by fracture, the latter wholly by perforation. Probably the former action depends mainly on the total striking energy of the shot, affected, no doubt, also by its tenacity, on which depends the amount of work delivered before the shot breaks. The latter depends directly on the striking energy, and inversely on the diameter of the hole to be made, that is, the smaller the hole the greater the penetration. How widely the powers of perforation and of fracture differ may be seen from the fact that for many years there were on board the Nettle two guns available for testing plates, an old-fashioned 10in. gun and a new type 6in. piece. The perforation of the two was about equal, the smaller gun attaining to an equality with the heavy old-fashioned one, by having less work to do in making a 6in. hole than the heavy shot had to perform in making one of 10in.

For the work of fracture the small projectile had no such advantage, and it is probable that efficiency of the two shots might be nearly in proportion to their respective striking energies, and these were nearly in the proportion of two to one; so that while the 10in. and 6in. shot were able to perforate about the same thickness of soft armour, the former delivered about double the shock of the latter on hard armour. As armour developed further, it generally took an intermediate form, yielding partly by perforation and partly by fracture, and this may be said to be the case at the present time. Calculation also becomes more difficult from the liability of the shot to break against the hard face. As we have asked before now, who can calculate what a tool may do in the act of breaking? We may certainly understand how the effect may be greater under some conditions than others. For example, at a high velocity a shot may perform work before the line of least resistance is found, and thus cause surprise by behaving much better than at a lower velocity. On the other hand, at a still lower velocity, the shot may not break at all, and thus a worse result may be obtained at an intermediate velocity than at either a very low or very high one. These effects have been seen in experiments; we may conjecture why, but any approach to calculation is difficult. A question of this kind can only be dealt with systematically. The elements must be separated and investigated one by one. The first step needed is to ascertain the laws relating to perforation of wrought iron at the high velocities which have now come in. At present formulæ which have been empirically adjusted, so as to give good results over a certain range of velocities, are employed for those much higher with very little guidance as to their suitability. The little evidence we have is to the effect that the English official formulæ give perforations which are far too small; indeed, at Shoeburyness on one occasion a 6in. shot, fired even at the moderately high velocity of 2378 foot-seconds, passed clean through plates 17in. thick, and went on about 1600 yards, when by the old English formulæ it should have only perforated a 16in. plate, and should not have entered nearly 16in. into a 17in. plate. Krupp's formula, and that of De Marre, appear to be much more correct for high velocities; but we have very scanty data to support them. The relation borne by the respective formulæ to each other is best seen by tracing the curves showing the results they give. The diagram herewith exhibits the perforations given for the 6in. gun firing a 100 lb. projectile by the formulæ of Fairbairn, De Marre, Krupp, Tresidder, and a Gâvre formula.

The ordinates give the perforation in inches of wrought iron due to the velocity in feet-seconds registered along the abscissa. The figures and points of registry are those taken and worked out by Captain Tresidder in his pamphlet "Notes on Formulæ for Armour Piercing." These are as follows:—

Projectile.	Striking velocity f.s.	Fairbairn.	De Marre.	Krupp.	Tresidder.	Gâvre.
		Perforation in inches by				
6in. shot of 100 lb. ...	600	... 3·2	... 2·30	... 2·30	... 2·28	... 2·00
	1000	... 5·9	... 4·98	... 4·95	... 4·90	... 4·17
	1780	...11·2	...12·15	...11·80	...11·64	... 9·45
	1950	...12·4	...13·93	...13·48	...13·35	...10·78
	2380	...15·3	...19·00	...18·22	...18·00	...14·38
	3000	...19·5	...27·05	...25·80	...25·47	...19·98

On the diagram the curves pass through the points calculated and plotted at the different velocities, these points lying on or between A a, B b and C c.

Fairbairn's, it will be seen, gives the highest result at low velocities, but soon falls below most of the others, the curve crossing that of De Marre at X about 1350 foot-seconds, Krupp at Y at about 1460 foot-seconds, and Tresidder at Z at about 1600 foot-seconds.

From about 1200 to 1750 all the variations in the results fall within an inch, but at 3000 foot-seconds Fairbairn gives 6¼in. less than De Marre, which, as has been repeatedly pointed out, is a monstrous discrepancy. The Gâvre formula gives also strangely low results throughout. We think, however, that this formula has been abandoned generally in favour of that of De Marre. Those then with which we are most concerned are the formulæ of Fairbairn or Maitland, De Marre, Krupp and Tresidder. The first has been long used officially, and is not yet actually discarded. Krupp appears to agree with our Shoebury trial better than De Marre's, and Tresidder gives practically very nearly the same results, the difference mainly being that in Krupp's the element of weight tells more, so that with a long projectile with great weight in proportion to its calibre, Krupp would give greater perforation. Tresidder's formula is commonly written thus, for working by logarithms:

$$t^2 = \frac{W v^3}{d} \times \frac{1}{\log^{-1} 8{\cdot}8410},$$

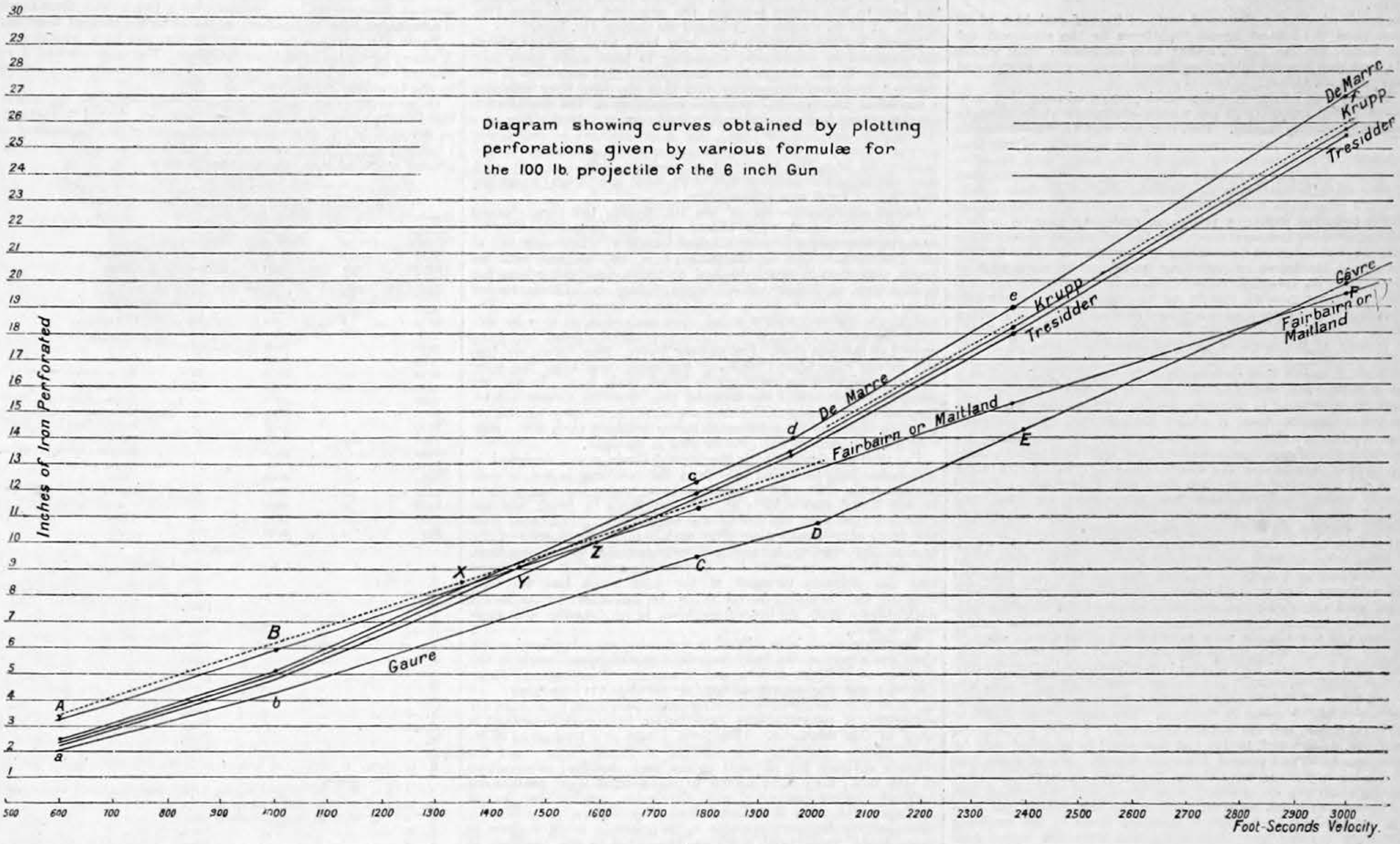
where t = the thickness in wrought iron in inches, w the shot's weight in pounds, v the striking velocity in foot-seconds, and d the diameter of shot or calibre of the gun in inches. Krupp's formula, using the same notation, is—

$$t^{\frac{4}{3}} = \frac{W v^2}{d^{\frac{5}{3}}} \times \frac{1}{\log^{-1} 5{\cdot}7776},$$

Raising all Krupp's terms to a power of $\frac{3}{2}$, we get

$$t^2 = \frac{W^{\frac{3}{2}} v^3}{d^{\frac{5}{2}}} \times \frac{1}{\log^{-1} 8{\cdot}6664}$$

This obviously approximates nearly to Tresidder's formula.



It is very desirable that the subject of perforation of wrought iron at high velocities should be investigated, not by firing on a large scale, when only a few rounds can be allowed on the score of economy, but with some small piece, when, at comparatively trifling expense, whole series might be obtained. A well planned series would, at all events, give sound data for the scale on which it was carried out, and furnish a formula which would be gradually tested by every round fired on a large scale, and those who have most experience in these matters believe that it would be found to hold good. It might be possible after that to devise something to teach laws of fracture, although this is difficult and far less important than perforation.

In the meantime, we can only act on what data we have before us. It is not to be expected that we should give up using formulæ for the low velocities for which they have been proved good. For high velocities, unfortunately, there is evidence that their use causes gross mistakes. The most natural course to take then would be to keep to our old Maitland or Fairbairn formula up to 1450 or 1600 foot-seconds, at which points it agrees with Krupp and Tresidder respectively. Here we might "shunt," as it were, on to one of these curves, and use the Krupp or Tresidder formula for the higher velocities.

There is, however, an objection to such a course—namely, that service tables exist which it is undesirable to alter unless we know that we are right in doing so. Now, in the present state of our knowledge, we have no certainty that we are correcting for the better until the difference becomes a large one, when it is necessary to act. On the whole, then, the best present course is to let our tables stand unaltered up to 2000 foot-seconds velocity. This covers all but the newest guns. For velocities over 2000 foot-seconds we may be confident that Krupp's or Tresidder's formula is much nearer the truth than the old ones, and we are inserting new velocities for new guns rather than making corrections in our existing tables. There remains the evil that a projectile striking at a velocity just below 2000 and one just above 2000 foot-seconds are calculated on different systems, and a wide gap exists between them. This is shown on the diagram by the dotted line which takes the course we suggest, and abruptly leaves the Fairbairn curve for that of Tresidder at 2000 foot-seconds; but perhaps it is a good thing that we should have an inconsistency made apparent like this, to remind us of our unsatisfactory condition of ignorance. At all events, we can suggest nothing better at the present time.

THE MOBILITY OF MOLECULES OF CAST IRON.*

By A. E. Outerbridge, jun., Philadelphia, Pa.

It has been generally accepted as a fact that cast iron, under the influence of repeated shocks, becomes brittle, and will finally break under a blow which otherwise it would have withstood. It will probably surprise metallurgists, therefore, to learn that experiment disproves the supposed fact, and establishes exactly its opposite.

The result of about a thousand tests of bars of cast iron of all grades, from the softest foundry mixtures to the strongest car wheel metal, enables me to assert with confidence that, within limits, cast iron is materially strengthened by subjection to repeated shocks or blows.

It is very well known that the usual process of annealing castings—such, for example, as car wheels—increases their strength by relieving cooling strains. But, it is not well known—if known at all prior to this announcement—that the molecules of cast iron are capable of movement—for they do not touch each other†—without the necessity of heating the casting, and that they can thus rearrange themselves in comfortable relation to their neighbours, and relieve the overcrowding near the surface of the casting. In more technical words, a molecular annealing may be accomplished at ordinary temperatures which will release the strains in the castings, precisely as does annealing by slow cooling in heated pits or ovens. A statement so surprising should not be made without sufficient data to establish its correctness beyond cavil, since it is contrary to former belief, certain to be questioned, and properly so. Before proceeding to give a record of the experiments which have been made, and which can be readily repeated by any one, a brief history of the origin of the first observation leading thereto may be interesting.

In 1883—being at that time engaged in metallurgical work at a large car wheel establishment—I noticed that chilled cast iron car wheels rarely cracked in ordinary service after having been used for any considerable time; if wheels did not crack when comparatively new, they usually lasted until worn out or condemned for other causes. No application was made of this observation at that time, further than to institute a careful investigation of the condition of the annealing ovens when some new wheels were returned cracked, under the supposition that the wheels were not well annealed, and an equally careful revision of the iron mixture to ascertain whether the fault lay therein.

In 1894, a large number of "transverse test bars," 1in. square and 15in. long, accumulated in the foundry of Wm. Sellers and Co., Incorporated; and, to expedite the cleaning of sand from their surfaces, they were all thrown into an ordinary "tumbling barrel" with other castings, and knocked about for several hours. When these test bars were broken upon the transverse testing machine, and the records were tabulated, I noticed with surprise that the average strength of the entire series was considerably higher than was usual with similar iron mixtures. This difference was fortunately so marked as to cause a careful inquiry—first, into the condition of the testing machine; then as to the chemical composition of the metal in the bars. The machine was found to be in good order, and the metal was normal. A card pattern was then made, upon which twelve test bars could be moulded side by side in one flask, and poured from one runner. Six of these bars were placed in the tumbling barrel, the other six were cleaned of adhering sand with an ordinary wire brush, and the twelve bars were broken upon the machine. All of the bars which had been subjected for about four hours to incessant blows in the tumbling barrel were stronger than their companion bars—the actual gain varying from 10 to 15 per cent. This metal was soft foundry iron.

These tests were repeated on several consecutive days with similar results, while various theories were suggested, and clues were followed, to detect the hidden cause of this strange fact.

One plausible explanation offered was, that the rubbing of the bars together in the tumbling machine slightly rounded the corners, and thus prevented a starting-point for a "check" or break of the bar under the strain in the testing machine.

This theory was soon overthrown by tests. The corners of six bars were rounded by filing—the companion bars not being filed; all of the bars were then cleaned with a wire brush and broken upon the transverse testing machine, and there was no apparent gain in strength in the bars with rounded edges. Round test bars —1¼in. in diameter, 15in. long—were then poured from one ladle of iron. Some of these were cleaned in the tumbling barrel, and all that were so treated proved to be much stronger than the companion bars which had been merely cleaned with a wire brush.

This process of eliminating false theories was continued, until finally a new explanation occurred to me, and simultaneously a convincing test of its accuracy suggested itself. The explanation, as indicated in the title of this paper, is the mobility of the molecules of cast iron, at ordinary temperature, when subjected to repeated shocks.

The crucial test referred to consisted in subjecting six bars to 3000 taps each with a hand hammer upon one end only of the bar. All the bars so treated showed a gain in strength equivalent to the gain exhibited by bars which had been subjected to blows over the entire surface for several hours in the tumbling barrel. Here was a new revelation, of scientific interest to the metallurgist, and suggesting to the founder the possibility of annealing castings at ordinary temperatures by availing himself of this molecular mobility. It proves also that we have for many years been unconsciously accomplishing this beneficial result, at least partially and irregularly, by tumbling small castings in a revolving barrel, merely for the purpose of conveniently cleaning them from adhering sand.

* Read at the Pittsburgh Meeting of the American Institute of Mining Engineers, February, 1896.

† In order to comprehend the modern idea of the nature of matter, we should try to realise that the molecules composing even the most dense solid substances with which we are familiar—such as gold, platinum, &c.—are not in contact, and are free to move within certain well defined limits. Lecture on "Matter," by the writer, *Journal Franklin Institute*, September, 1885, vol. xc., p. 184.

Another interesting fact was incidentally brought out in this investigation, namely, that the strain caused by cooling, and the consequent weakening, exists even in the smallest castings, where we would naturally expect that the cooling would be practically uniform throughout the section; moreover, that even in bars of uniform section, such as 1in. test bars, the weakening by cooling strains sometimes amounts to more than 10 per cent. of the ultimate stress. Repeated tests show that ½in. bars, in which the fracture is comparatively uniform to the eye throughout the section, are subject to the same law. Other tests show that the comparative difference in transverse strength between bars which have been hammered on their ends, or otherwise subjected to the process of molecular annealing by vibration when cold, and companion bars cast in the same flask, not so improved, depends to a certain extent upon the number and force of the blows, and to a still greater degree upon the grade of cast iron tested. For example:—

(1) Greater relative difference is found in hard mixtures, or strong iron, than in soft mixtures, or weak iron.

(2) Greater relative difference is found in 1in. bars than in ½in. bars, and somewhat greater difference in 2in. bars than in 1in. bars.

Impact tests.—The foregoing experiments having been repeated sufficiently often to satisfy me of their absolute reliability—and really remarkable uniformity—a new series of tests was commenced for the purpose of ascertaining how many blows were required, and approximately what force was needed to accomplish the desired object of relieving cooling strains. A new machine was constructed for this purpose, and light was soon thrown upon these questions, while still other important questions were suggested and answered by the use of the same machine.

The impact machine first used was an old one, and consisted of a weight fastened to an arm swinging in a graduated arc. The friction of the pivot and the crude construction of the machine precluded even an approximately accurate measurement of the force of the blow delivered.

The new machine consisted of a frame or yoke, marked in inches, and a wedge-shaped weight, adapted to the size of the bars to be tested, which was raised vertically to any desired number of inches, and when released, fell by gravity in free space, striking the bars in the centre between the supports, which were 12in. apart. A 14 lb. weight was adopted for testing 1in. bars.

Impact testing machines have long been used, and car wheels are accepted or condemned according to tests made upon such machines. It has always been maintained that each blow of the "drop" weakened the casting, and that the final blow was only a record of the residual cohesion remaining in the metal after previous blows had proportionately weakened it. In the case of a thoroughly annealed car wheel, this reasoning may be sufficiently correct; but as applied to impact testing machines used for testing unannealed bars, the argument is absolutely fallacious. In such cases the impact machine is itself a means of molecularly annealing test bars, as I will now demonstrate.

Impact experiments.—Six of the 1in. square test bars, cleaned with the wire brush, were broken upon the impact machine by dropping the weight from a sufficient height to break each bar at the first blow. The six companion bars, also cleaned with the brush, were then in turn subjected to blows, numbering from ten to fifty each, of the same drop weight, falling one-half the former distance, these blows being insufficient to break the bars. The weight was then permitted to fall upon each of these bars in turn from the height at which the six bars previously tested had been broken at the first blow. Not one bar broke. Two, three, six, ten, and in one case fifteen blows of the same drop from the same extreme height were required to break these bars. In another similar case the weight was dropped once from the former height, then raised by inches until four more blows, each being 1in. higher than the last, had been delivered before breaking the piece. Subsequent tests showed still greater gain in strength.

The next experiment with the impact machine was designed to test molecularly-annealed bars from the tumbling-barrel, in comparison with untreated companion bars, under one heavy blow. It was found that a blow of sufficient force to break the unannealed bars with one fall of the weight must be repeated from five to twenty times—depending mainly upon the nature of the iron mixture—to break the molecularly-annealed companion bars. By careful experiment in the manner described, it was shown that the ultimate strength of the bars which had not been through the tumbling-barrel could be increased, by successive slight blows upon the impact machine, to an equality with their companions.

The experiments here related in a running conversational narrative form a part of the daily records of metallurgical work at the foundry of William Sellers and Company, Incorporated, Philadelphia; and the aggregate number tabulated is very large. All the tests corroborate fully the statements here made; and they are susceptible of repetition and confirmation by anyone interested in work of this character. They form a part of a long series of investigations—extending over a period of fifteen years—upon the relation between the physical nature and chemical composition of cast iron; they have served to throw light upon phenomena hitherto obscure connected with the design, construction, &c., of castings; and, as it is believed that they contain the germ of a new scientific discovery valuable in its principle to all workers in these fields, these brief notes are presented to the Institute in response to the invitation of its secretary, and through the courtesy of the firm of William Sellers and Company, Incorporated, for whose benefit and at whose cost they were primarily made.

In conclusion, it should, perhaps, be observed, to avoid the possibility of misunderstanding, that the molecular annealing of cold cast iron by successive slight shocks differs from annealing by heat in that it has no power to change the condition of carbon in the casting or to alter the chemical constitution in any way. All that is claimed is that every iron casting when first made is under a condition of strain due to difference in the rate of the cooling of the metal near the surface, as compared with that nearer the centre, and also to the difference of section; and, further, that it is practicable to relieve these strains by repeatedly tapping the casting, thus permitting the individual metallic particles to rearrange themselves and assume a new condition of molecular equilibrium. The large number of tests made and the remarkable uniformity of the results obtained warrant me in making these statements with full confidence that the repetition of such experiments, even under less favourable conditions for accurate observation than I have enjoyed, will convince others of the correctness of my conclusions, and will perhaps establish a new law of the physics of cast iron.

A few practical deductions of universal application may be drawn from these observations. (1) Castings, such as hammer frames, housings for rolls, cast iron mortars or guns, which are to be subjected to severe blows or strains in actual use, should never be suddenly tested to anything approaching the severity of intended service. Quantitative tests made upon the impact machine prove that the molecules of cast iron rearrange themselves under reasonably few shocks, so that it is perfectly practicable to molecularly anneal such castings when cold. Pulleys, and indeed all castings, are subjected in every-day service to this process of molecular annealing; and old castings are therefore more reliable than new ones, unless they have been misused. It is not impossible that the same law applies to steel castings and perhaps to all metal castings, and that in testing new guns, each preliminary small charge of explosive material, subjecting the casting to comparatively moderate shocks, enables the gun to relieve itself of internal strains, and eventually to withstand with safety shocks which would have destroyed it without this precautionary measure. This, however, is mere theory, and must not carry the weight of the arguments regarding cast iron, which are clinched by a thousand actual tests. (2) Strong iron castings, and castings of irregular section, have greater initial strains than soft iron castings or castings of comparatively uniform section; and it is, therefore, more important to subject the former to gradually increasing shocks until the strains are relieved by the movement and re-arrangement of the molecules.

Tables.—The tables here given show the results of tests for transverse strength of test bars, of different section and widely different grades of iron, which have been subjected to this process of molecular annealing, and also tests made upon the impact machine with test bars cast in the same moulds. To avoid the unnecessary duplication of figures, a few individual tests only are here tabulated, but they represent the average of probably a thousand records. The largest apparent gain shown in Table I. in the transverse strength of companion bars of 1in. section, is 525 lb.—see last line of the table—or very nearly 19 per cent. It is evident, even without plotting all the tests, that they would show a gradually ascending curve having direct relation, first, to the character of the alloy of iron; and second, to the number of blows given, up to the point when strain is relieved—beyond which an increased number of blows does not increase the strength of the bar. Furthermore, it may be noted that these tests with the impact machine indicate the existence of a similar law with relation to the ability of the metal to resist sudden and severe shocks. Similar observations apply to the tests recorded of ½in. and 2in. bars. All the 2in. bars were broken upon the testing machine of Messrs. A. Whitney and Sons, by their operator, who was at first ignorant of the object of the tests. Subsequently, similar tests were made by that firm with their car-wheel iron, and identical results were obtained by them. The tabulated tests have been selected from the daily records of experiments made at the machine tool works of William Sellers and Co., Incorporated, Philadelphia.

In Table I., the left-hand columns show the breaking strain and deflection of test bars of different kinds of cast iron, cleaned in the ordinary manner with a wire brush. The right-hand columns show the tests of companion bars, cast from the same runner, molecularly annealed by being subjected to shocks in the tumbling barrel, or by tapping on one end with a light hammer, as noted under "Remarks;" also a few tests made with round bars 1¼in. in diameter, cast on end.

Table II. gives a few of the tests with 1in. bars, made upon the new impact testing machine, using a 14 lb. weight. The tests marked A represent bars cleaned with a brush, and those marked B companion bars, molecularly annealed in the manner described.

Table III. gives a few records of 2in. test bars, broken by A. Whitney and Sons upon their machine. The tests marked A were cleaned with the brush; those marked B were molecularly annealed in the tumbling barrel.

Other experiments have suggested themselves in the course of this investigation; and my paper, therefore, is not presented as an exhaustive, but as a tentative treatment of this interesting and, I believe, novel line of research, which is not incapable, even in its present stage, of some practical application.

Table I.

Unannealed. Breaking strain. Pounds.	Unannealed. Deflection. Inches.	Molecularly annealed. Breaking strain. Pounds.	Molecularly annealed. Deflection. Inches.	Remarks.
2350	·13	2850	14	Close grain.
2025	·12	2300	·14	Open ,,
2125	·13	2275	·14	,, ,,
2275	·13	2400	·14	,, ,,
2525	·14	2850	·15	Close ,,
2175	·13	2500	·15	Open ,,
2100	·13	2375	·14	,, ,,
2025	·12	2300	·14	,, ,,
2775	·14	2900	·15	Close ,,
2150	·13	2250	·13	Hammered on end of bar.
2550	·14	2925	·15	,, ,, ,, ,,
3000	—	3200	—	Round bars 1¼in. diam.
3000	—	3150	—	Hammered on end of bar.
2150	—	2450	—	Bound bars 1¼in. diam.
2100	·13	2425	·15	Open grain
2100	—	2400	—	Round bars 1¼in. diam
2050	·12	:400	·14	Open grain.
2875	·14	3100	·15	Close ,,
2175	·13	2500	·15	Open ,,
2150	·13	2350	·13	,, ,,
2675	·13	3000	·14	Close ,,
2775	·14	3300	·15	,, ,,

Table II.

A.	1 blow of 14 lb. weight falling	13in.	broke the bar.	Open grain.
B.	8 blows ,, ,,	13in.	,,	,,
A.	2 ,, ,, ,,	14in.	,,	,,
B.	9 ,, ,, ,,	14in.	,,	,,
A.	2 ,, ,, ,,	14in.	,,	,,
B.	14 ,, ,, ,,	14in.	,,	,,
A.	2 ,, ,, ,,	15in.	,,	,,
B.	15 ,, ,, ,,	15in.	,,	,,
A.	3 ,, ,, ,,	15in.	,,	,,
B.	8 ,, ,, ,,	15in.	,,	,,
A.	2 ,, ,, ,,	15in.	,,	,,
B.	7 ,, ,, ,,	15in.	,,	,,
A.	3 ,, ,, ,,	13in.	,,	Close grain
B.	4 ,, ,, ,,	15in.	,,	,,
A.	2 ,, ,, ,,	13in.	,,	,,
B.	10 blows at 13in., 5 at 15in., 5 at 17in., 3 at 18in., broke the bar. Close grain.			
A.	1 blow of 14 lb. weight falling	14in.	broke the bar.	Open grain.
B.	20 blows at 13in. and 3 blows at	14in.	,,	,,
A.	3 ,, of 14 lb. weight falling	13in.	,,	,,
B.	15 ,, ,, ,,	14in.	,,	,,
A.	8 ,, ,, ,,	12in.	,,	,,
B.	50 ,, at 12in. and 10 blows at 15in. failed to break the bar.			

Note.—The last bar, after withstanding these blows, was broken upon the transverse testing machine at a strain of 2975 lb.

Table III.

	Breaking strain in pounds.	Grade of iron.
A	20,400	Close grain.
B	21,600	,,
A	13,600	Open grain.
B	15,800	,,
A	14,000	,,
B	14,800	,,

I have suggested, and adopted throughout this paper, the hypothesis of the mobility of the molecules of cast iron, resulting in an effect similar or analogous to the effect of annealing by heat, because it seems to be warranted by the facts developed by the experiments described; it is of course possible, in our *à priori* ignorance of the laws governing atoms and molecules, that the theory may not be correct, but the tentative propounding of a probable hypothesis, by inciting to a more extended course of experiment, along different related lines of investigation, often leads to establishing or disproving the theory, and thus adds to our stock of positive knowledge.

Guatemala: Central American Exhibition, 1897.—The Department of Science and Art has received, through the Foreign-office, a copy of a despatch from her Majesty's Acting Consul-General at Guatemala, respecting a "Central American Exhibition" of Science, Art, and Industry, which it is proposed to hold in that city next year, commencing on the 15th March, and closing on 15th July. Although primarily a Central American Exhibition, the Government of Guatemala are desirous that foreign nations should take part in it; a department will be assigned to them, and they will enjoy all the privileges possible, with the right of competing for the prizes.

Naval Engineer Appointments.—The following appointments have been made at the Admiralty:—Chief engineers: Mark Blakeman, to the Daphne, to date February 2nd; William J. Anderson, to the Skipjack, to date March 7th; and Henry Percival Vining, to the Vernon for the Seagull, to date March 13th, all reappointed on promotion; George Ramsay, to the Blanche, to date May 5th. Engineers: Harry R. Batchelor to the Magpie, additional, for recommission; and Richard Bryan to the Wildfire, additional, for the Sans Pareil, to date April 17th; W. J. Duffell, to the Repulse, to date May 5th. Assistant engineer: Arthur F. White, to the Blanche, to date May 5th.

HODGES' COMPOUND BLOWER.

The accompanying illustration—Fig. 1—shows, by a transverse section, a compound blower manufactured by Messrs. Hodges and Co., of Cazenove-road, Stoke Newington, the special feature of which is that the air is subjected to several successive compressions during its passage through the machine, the number of which in the one under notice is three. A blower of this type is most generally used for giving a working pressure of $1\frac{1}{2}$ lb. per square inch, but they are

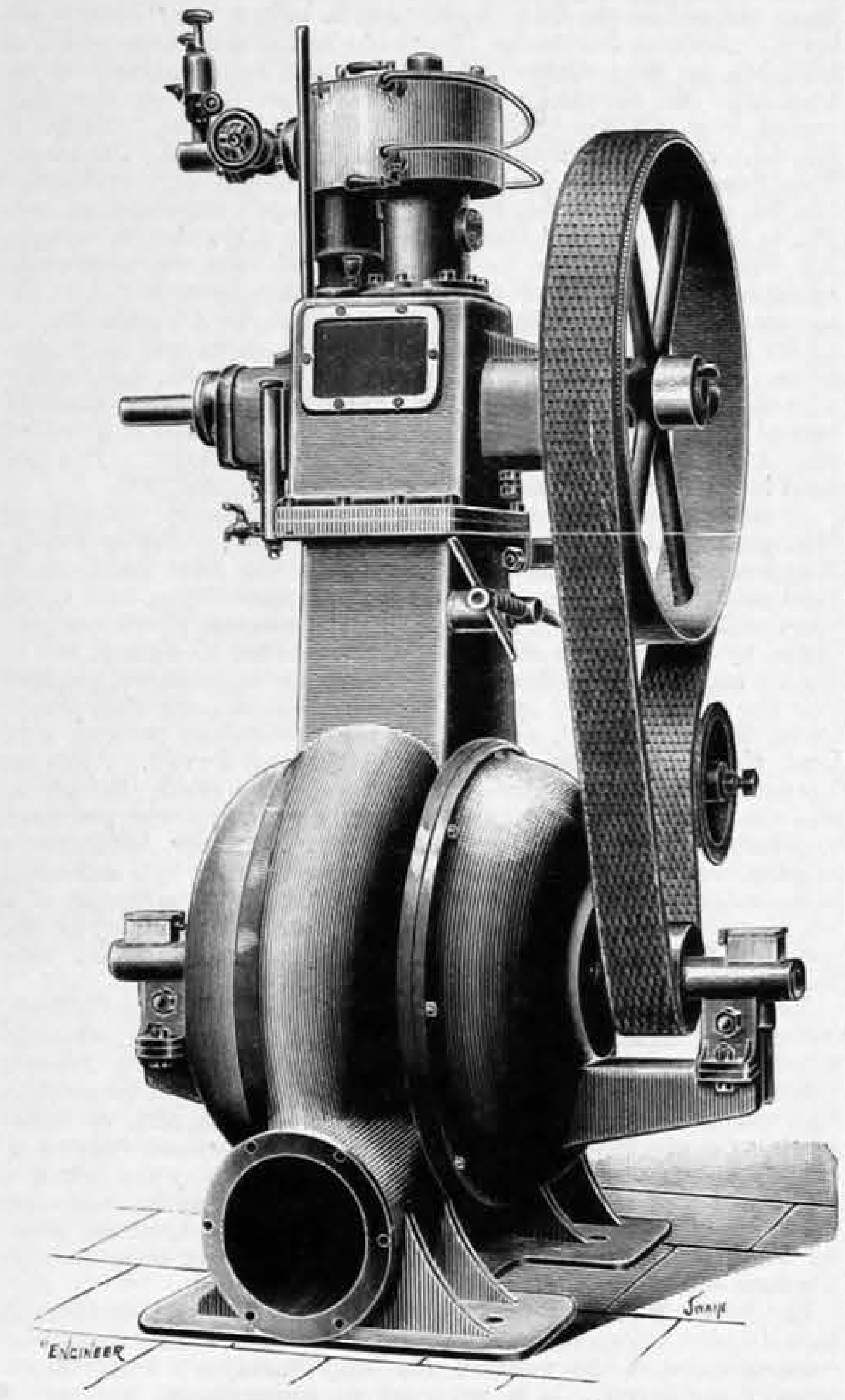


Fig. 3—HODGES' COMBINED ENGINE AND BLOWER

also made to give as high an air pressure as 4 lb., involving the necessity of six compressions. It will be seen from the sectional view that the blower is constructed with five separate blast wheels mounted on a common shaft, and enclosed by suitable casings, so formed as to allow each wheel to work in its own chamber. The shaft revolves in bearings carried by the brackets shown, and is driven by the pulley situated between the bearings. A A are the two outer blast-wheels, made of steel discs, with blades of the same material fixed on one side only; B B are two intermediate wheels of similar construction, but with narrower blades and consequently smaller capacity than A A; C C, the centre blast-wheel, has blades fitted on both sides of the disc, forming a double blast wheel, having still smaller blades with a consequent further diminished capacity. In the spaces D D D D, between the backs of the wheels and the adjacent casing, are provided a number of fixed radial scoops E, the peculiar shape of which, it is claimed, constitutes an important factor in the efficiency of the machine.

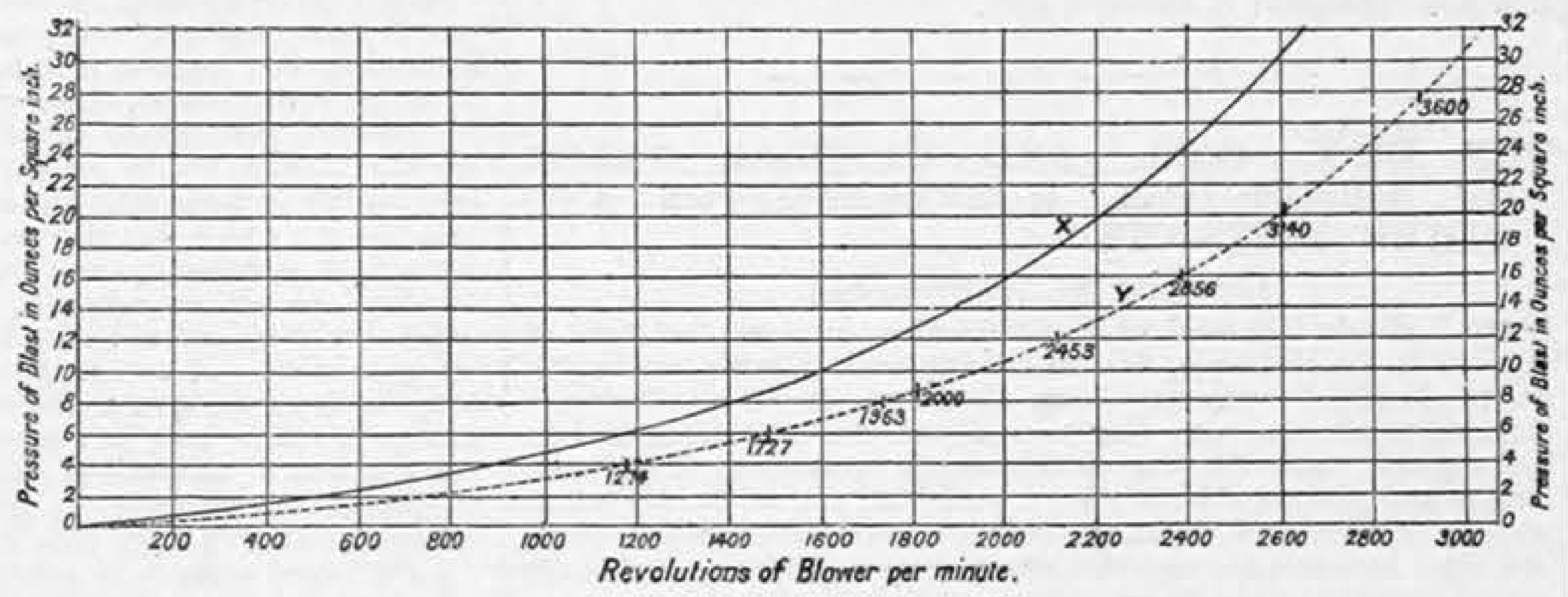


Fig. 2—DIAGRAM OF REVOLUTIONS AND AIR PRESSURE—HODGES' FAN

In operation, air entering the blower at either side, as shown by the arrows, is caused to rotate by the outer wheels A A, from the peripheries of which it is thrown off in a state of rapid rotary motion, the energy of which is utilised by

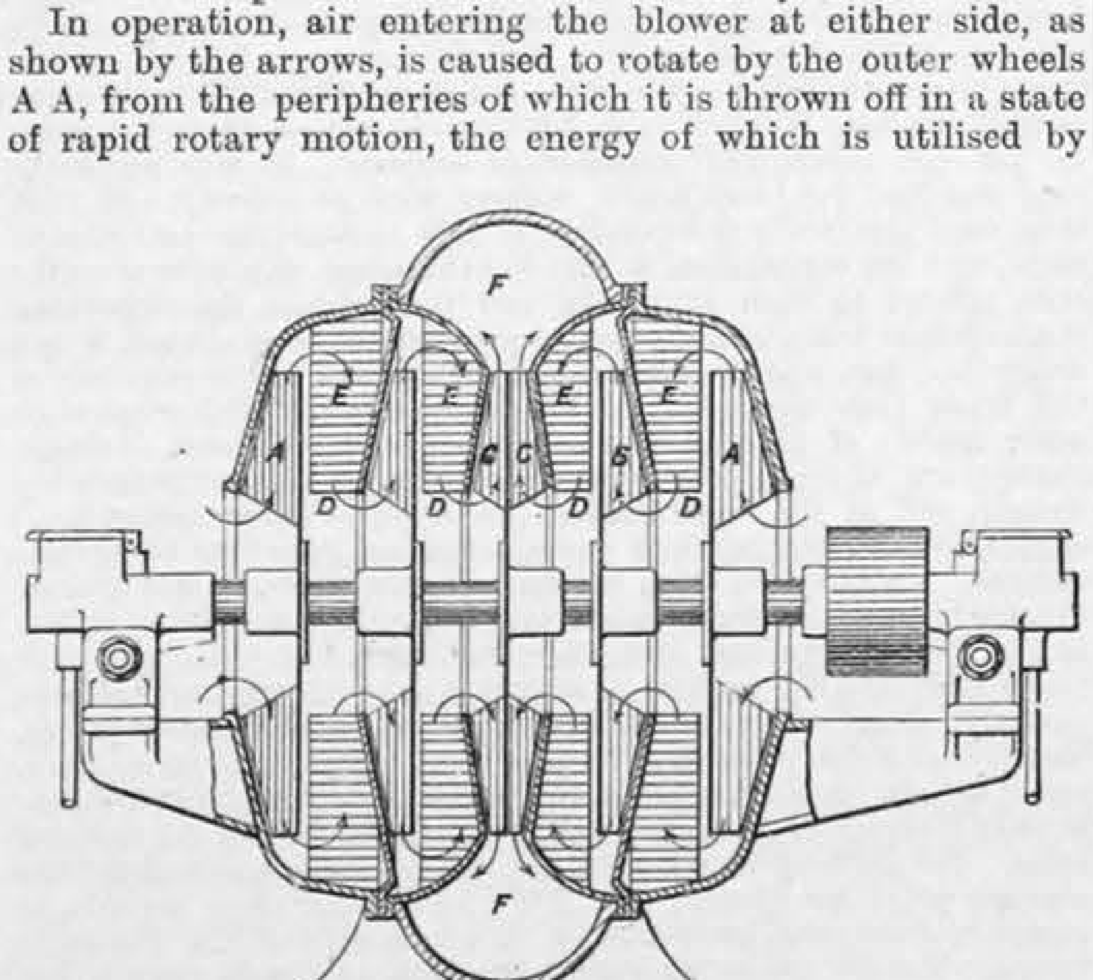


Fig. 1—HODGES' COMPOUND BLOWER—SECTION

impact upon the radial scoops E. This impact is said to transform the rotary movement of the air into a series of centripetal jets of high velocity, which, converging centrally, produces a blast at the inlets of the intermediate wheels of greater pressure than at the peripheries of the outer wheels, the increase in pressure being obtained without further expenditure of driving power. Upon the air leaving the outer wheels new conditions obtain, consequent upon its increased density and weight, and it may here be pointed out that a superabundance of air is always maintained under pressure at the inlets of the intermediate wheels, owing to the diminished area of the latter. A second compression now takes place by the agency of the wheels B, upon leaving which the air comes in contact with the second series of scoops and is finally compressed by the centre wheel and delivered into the annular receiving chamber F. Fig. 2 is a diagram giving the results of experiments made by Messrs. Hodges on the speeds and pressures of a compound blower of size No. 25, and shows clearly the pressure and volume of air delivered at any given speed. Referring to the diagram, each of the horizontal lines above O represents 2 oz. pressure per square inch, while each of the vertical lines from O to the right represents 200 revolutions per minute. The upper line X represents the curve of maximum pressures at the speeds given; thus at 1400 revolutions per minute the No. 25 size blower gives a maximum pressure of 8 oz. per inch, at 2600 revolutions $30\frac{1}{2}$ oz. pressure. The most efficient working pressure is found to be about two-thirds the maximum, which is represented by the dotted line Y. On this line, at the pressures of 4 oz., 6 oz., 8 oz., 12 oz., 16 oz., 20 oz., and 28 oz., the figures under the intersections represent the cubic feet of air discharged per minute at the stated pressures.

We also illustrate in Fig. 3 one of these blowers combined with a high speed engine, the whole forming a compact and serviceable arrangement, obviating the use of counter-shafts and the loss of power incidental thereto. Being self-contained, the only fixing this machine requires is the bolting down and provision of steam and exhaust pipes for the engine. As the floor space required is limited, it can be placed in any suitable position, such as the corner of a smithy, close to the cupola, where the pressure of blast can be varied as required by the furnace attendant. When once the engine is started it requires little or no attention beyond the filling of the sight-feed lubricator, and a little oil being added to the crank chamber at weekly intervals. The connection between the blower and engine is made with an endless belt, a tightening drum or pulley being provided for keeping the belt taut. The engine, which is double-acting, is very carefully constructed, all the running parts being of steel, working in extra large phosphor bronze bearings. The crank chamber, it will be seen, together with the bearing brackets, is one solid casting, thus insuring perfect rigidity and alignment. The main bearings are adjustable upwards, by which means the shaft is retained square with the crosshead guide. The slide valve is of the balanced piston type, and the steam ports very short and straight. The cylinder, which is $8\frac{1}{4}$in. in diameter, is fitted with relief valves and drain cocks, with pipes led into the exhaust and sight-feed lubricator. By extending the crank shaft, as shown, to receive a separate pulley, the engine can be used independently of the blower for driving any extraneous appliance or a line of shafting.

Although the engine is elevated it is remarkably free from vibration, even at very high speeds, a feature which is due to the careful method employed by the makers in balancing the moving parts. We have seen this engine running at a speed of over 500 revolutions per minute, driving the blower, and the engine running separately over 1200 revolutions without any holding-down bolts whatever, and with no perceptible vibration.

TESTING STEEL BOILER PLATES IN THE UNITED STATES.

When the Board of Inspectors of Steam Vessels met at Washington, in annual session in January, the representatives of all the steel plate manufacturers in the country appeared, and urged a large number of changes in the regulations to ascertain the tensile strength. The Board, after considering the matter, acquiesced in some of the points urged, and adopted the following rule, which was made public at the Treasury Department on the 3rd inst.:—

"To ascertain the tensile strength and other qualities of steel plate, there shall be taken from each sheet to be used in shell or other parts of boiler which are subject to tensile strain, a test piece prepared in form according to a specified diagram. The straight part in the centre shall be 9in. in length and 1in. in width, marked with light prick punch marks at distances of 1in. apart, as shown, spaced so as to give 8in. in length. The sample must show, when tested, an elongation of at least 25 per cent. in a length of 2in., for thickness up to $\frac{1}{4}$in. inclusive; and in a length of 4in. for over $\frac{1}{4}$in. to 7-16in. inclusive; in a length of 8in. for 7-16in. to 1in. inclusive, and in a length of 6in. for all thickness over 1in. The reduction of area shall be the same as called for by the rule of the Board. No plate shall contain more than ·06 per cent. of phosphorus, and ·04 per cent. of sulphur, to be determined by analysis by the manufacturers, verified by them, and copy furnished the inspector for each order tested; which analysis shall, if deemed expedient by the supervising inspector-general, be verified by an outside test at the expense of the manufacturer of the plate.

"It being further provided that said manufacturer shall also furnish a certificate with each order of steel to be tested, stating the technical process by which said steel was manufactured. It being further provided, that steel manufactured by what is known as the Bessemer process shall not be allowed to be used in the construction of marine boilers. Plates over 1in. in thickness may be reduced to 1in. in the straight part for testing, in cases where the testing apparatus is not of sufficient capacity to test the full thickness of plate. The reduction of area and elongation must be equal to the requirement of full thickness of metal. Provided, however, that contracts for boilers for ocean-going steamers require a test of material in compliance with the British Board of Trade, British Lloyd's, or Bureau of Veritas rules for testing, the inspectors shall make the tests in compliance with the above rules. The samples shall also be capable of being bent to a curve of which the inner radius is not greater the $1\frac{1}{2}$ times the thickness of the plates after having been heated uniformly to a low cherry red, and quenched in water of 82 deg. Fah."

RAILWAY CARRIAGE LAVATORIES.

The modern luxuries of railway travelling, and the extensive introduction during recent years of sumptuously equipped saloons on most of the leading lines, have necessitated special attention to matters of detail connected with the general fittings and accessories of these carriages. With regard to the sanitary fittings, Messrs. Morrison and Ingram, of Manchester, have recently designed several specially arranged lavatories and closets for railway carriages, of one of which we give an illustration showing a closing-up lavatory, which, whilst being commodious and replete with convenient accessories, is compressed into a remarkably small space, the lavatory, when closed, not projecting more than $9\frac{7}{8}$in. from the wall, whilst the width is only $19\frac{1}{2}$in., and the height 6ft., including the over-mirror. The lavatory, every working part of which is readily accessible, is fitted with a hot and codl water supply to the basin, and a convenient arrangement is provided for hanging towels, whilst there is also a small cup-

board suitable for various toilet requirements. The folding urinal in connection with the combined arrangement is automatically flushed, whilst the door is kept open.

WEAR OF TIRES ON PASSENGER ENGINES OF THE NEW YORK CENTRAL RAILWAY FOR THE PAST TWENTY YEARS.

By P. H. Dudley.

Comparing the weights upon the drivers a few years ago with those in present use shows an increase in the static or dead load of some 65 per cent., while the increased speed of the trains now produces dynamic effects more than double the static loads, yet by increasing the width of the head of the rails as they were renewed and the higher standard of track maintained, the rate of the wear of tires for the heavier locomotives has not increased, but, on the contrary, decreased. In 1883, on the 65 lb. rails, deep and narrow type of heads, drivers carrying 13,360 lb. ran an average of 19,400 miles for a loss of $\frac{1}{16}$in. in thickness of the tires. This was the second type of 65 lb. rails, the first one having been rolled in England and had a wider head.

In 1884 the 5in. pioneer 80 lb. rail was put in service, the head being $2\frac{11}{16}$in. wide. Its use was yearly extended, and by 1889 locomotives on the Hudson division made nearly one-half their mileage on the 80 lb. rails. Engines then carrying 17,600 lb. per driver ran an average of 19,300 miles per loss of $\frac{1}{16}$in. in thickness of tire. In 1891 passenger engines on the Hudson division made their entire mileage on the 80 lb. rails, while those on the Mohawk and Western divisions made about three-quarters of theirs on the same class of rails; drivers carrying 20,000 lb. ran an average of 19,400 miles per loss of $\frac{1}{16}$in. in thickness of the tire. This refers to the loss by wear and returning for future service. In 1892 the 100 lb. rail, head 3in. wide, was laid on the Harlem line, which carries the combined passenger traffic of the three railroads entering and leaving Grand Central Station, New York City. The renewing of the entire line of the New York Central and Hudson River Railroad from Mott Haven Junction to Buffalo and return with 80 lb. rail was completed in 1892. In 1894 the 100 lb. rail was laid from Spuyten Duyvil to Peekskill, making about one-quarter of the Hudson division laid with 100 lb. rails.

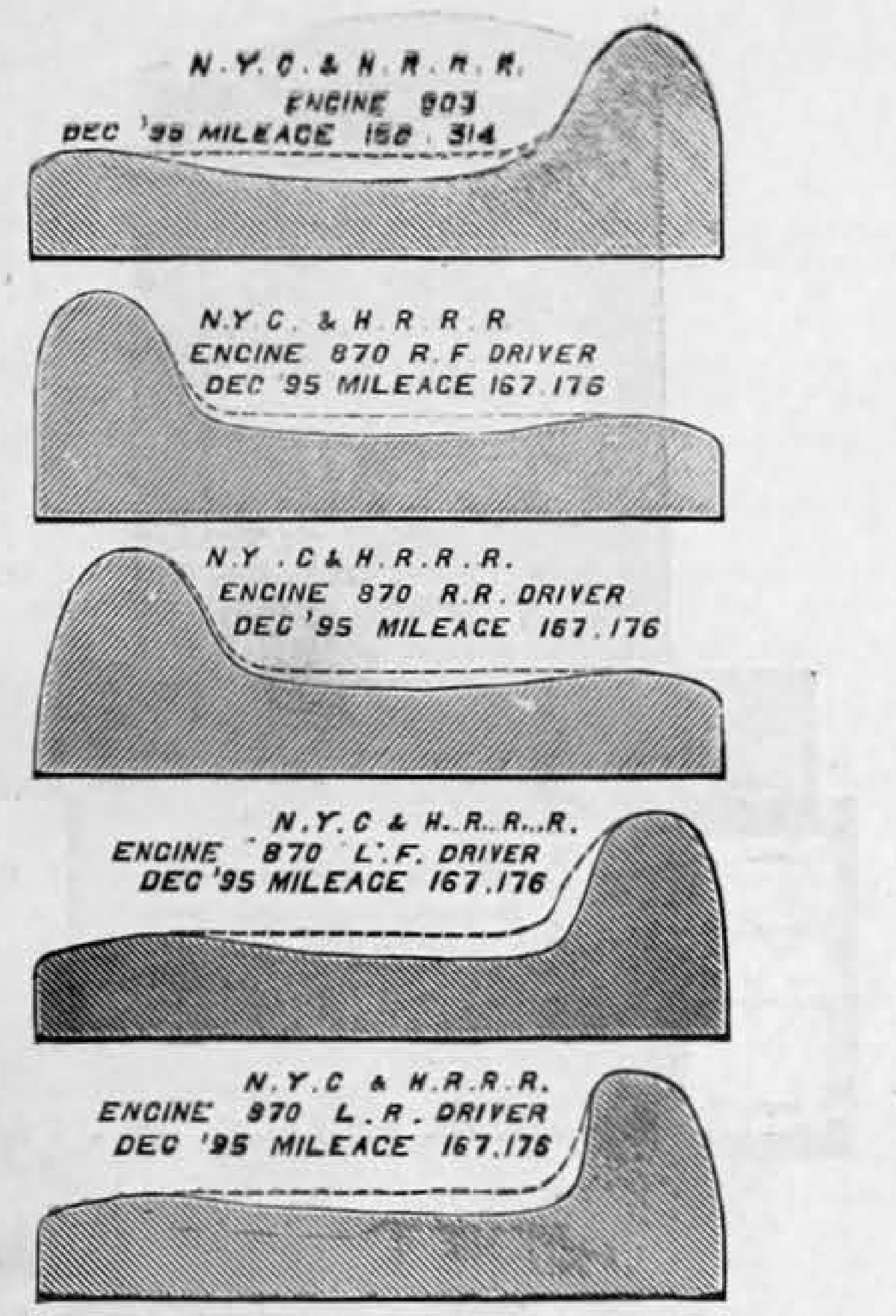
In June, 1895, I asked Mr. William Buchanan, general superintendent of motive power and rolling stock, for the mileage of some of the class "I" engines running over the 80 lb. and 100 lb. rails. When the class "I" engine was designed in 1889, the weight on each driver was 20,000 lb., but as the 80 lb. rails were put into the track the weights have been increased to 22,000 lb. The total weight of the locomotives in running service is 200,000 lb., or over 40,000 lb. being upon the truck. The mileage of the tires only includes one turning since October, 1892, and ends March, 1895.

Some of the engines, of which there were 43 in all, did not enter service until 1893, and others in 1894.

The list is so large, covering such a wide range of service, that it must show conclusively whether or not a broad flat-topped rail increases or decreases the rate of wear of tires running over them. The 43 engines ran 3,706,567 miles, and the total loss in thickness of tires in sixteenths of an inch was 160, or an average of 23,166 miles for a loss of each $\frac{1}{16}$in. of tire. Twenty-three of the engines which ran in part over the 100 lb. rails show an average mileage of 29,046 miles for each $\frac{1}{16}$in. loss in thickness of the tire. The mileage of 19,400 miles per loss of $\frac{1}{16}$in. in thickness shown by the light engines on the 65 lb. rails is now much exceeded by the heavier engines on the 80 lb. rails, the average mileage being 23,166 miles, and on the 100 lb. rails it will exceed the 29,046 miles, which over one-half the present engines now show by only making a part of their mileage on the wide rails.

The comparison between the wear of tires on the engines running the Empire State Express over the Hudson division, making one-fourth of the mileage on the 100 lb. rails, and the one running over the Western division exclusively on 80 lb. rails is very interesting.

The engravings show the approximate wear as obtained by plaster casts after the mileage indicated on them had been made by the engines.



Diagrams Showing Wear of Tires on Engines No. 903 and No. 870.

Engine 870 commenced the service for which the wear of the tires is shown May 25th, 1894, and completed it December 21st, 1895. The engines are double crewed, as is customary with all, and the mileage made per month fluctuated between 8576 and 9200. Out of the 575 days the engine was worked 571 days, the four idle days being occupied in boiler washing. The total mileage in that period was 167,176 miles. During all this time the fires were not drawn except on the four idle days.

The following table shows the wear of tires with different weights on them and running on various rail sections:—

No. of engine.	No. of miles run.	Circumference of drivers in feet.	Pounds of metal lost per 1000 miles, four-drivers.	Rail section on which engines ran.	Weight on each driver.
					lb.
870	167,176	20·41	0·801	80 lb. and 100 lb.	20,000 to 22,000.
903	152,314	22·00	1·332	80 lb. rails.	20,000 to 22,000.
84	56,219	18·06	1·234	English 65 lb. rail.	15,000 to 18,000.
86	73,647	18·06	1·387	" " "	15,000 to 18,000.
4	78,864	17·28	1·379	" " "	15,000 to 18,000.

NOTE.—The 100 lb. rail has a head 3in. wide, the 80 lb. rail a head $2\frac{11}{16}$in. wide, and the English 65 lb. rail had a head $2\frac{5}{8}$in. wide.

The loss per yard in circumference of tire, per 1,000,000 tons rolling contact on the rails was as follows:—

	lb.
No. 870	0·042
No. 903	0·070
No. 84	0·121
No. 86	0·136
No. 4	0·132

The general dimensions of the class "I" engines are given in the following table:—

Cylinder, diameter and stroke	19in. × 24in.
Steam port	18in. × $1\frac{1}{4}$in.
Exhaust port	18in. × $2\frac{3}{4}$in.
Bridges	$1\frac{1}{8}$in. wide
Valves:—	
Travel	$5\frac{1}{2}$in.
Outside lap	1in.
Inside lap	None
Boiler:—	
Diameter, smallest ring	58in.
Pressure per square inch	170 lb.
Fire-box:—	
Length, outside	$105\frac{1}{2}$in.
Width	$40\frac{3}{4}$in.
Area	27·3 square feet
Heating surface	150·8 square feet
Flues:—	
Number	268
Outside diameter	2in.
Length between sheets	11ft. 11in.
Heating surface	1670·7 square feet
Total heating surface	1821·5 " "
Weight of engine in working order	120,000 lb.
Weight on drivers	80,000 lb.
Weight on trucks	40,000 lb.
Weight, maximum tender loaded	80,000 lb.
Tractive force per pound M. E. P.	111 07
Adhesion to tractive force	0·20
Diameter of drivers	78in.
Driving wheel base	8ft. 6in.
Total wheel base of engine	22ft. 9in.

Engine No. 903 hauled the "Empire State Express" on the western division from April 3rd, 1894, to December 3rd, 1895, total mileage 152,314. Of the four tires of engine No. 870, the left front one was physically the softest and shows the most wear, as seen in the accompanying illustrations. Both front drivers show increased wear over the rear ones from crushing the sand when first applied to the rails, and is more noticeable than on the crucible steel tires of the lighter engines, of which I took plaster casts many years since. Ross Meehan shoes were applied to the drivers covering the full tread and flange of all drivers for both engines. On No. 870 considerable wear was produced on the outside of the flanges of the left side drivers, which is not included, as it was not produced by the rails.

The wear of tires per 1,000,000 tons rolling contact on the rails for the amount of metal lost, as shown by plaster casts, would be influenced by many conditions which need not be considered here; yet the results point to the same general fact that by widening the top of the rail, and giving it a larger top radius, the rate is decreased, notwithstanding an increased weight is carried upon the drivers. The top radius of the pioneer 80 lb. rail is 12in., with $\frac{5}{16}$in. corner radii, and for the 80 lb. and 100 lb. rails, laid in 1892 and since, it is 14in., and corner radii of $\frac{5}{16}$in. The important point is to secure as large an area of contact between the drivers and the rails as practicable, for the larger the area is the less are the wheel pressures per square inch of contact, and the greater width of metal of both rails and wheels to resist and distribute the tractive force exerted. The tractive force of both 870 and 903 on the rails drawing the same train would be practically alike, and the difference in wear of tires mainly due to the greater average area of contact of 870, running part of its distance on the 100 lb. rails, while 903 ran entirely on 80 lb. rails. The mileage of either engine is very large, nearly double what is obtained on the narrow-headed rails, as will be seen by a comparison with engines Nos. 84, 86, and 4, which ran on the 65 lb. rails. The practical results of introducing the broad-topped stiff rails show a decreased wear of tires, frogs, rails, ties, and expense of minimum maintenance, while the speed and train loads have been largely increased. The standard freight train load of the New York Central and Hudson River Railroad, on the 80 lb. rails, is 50 loaded 60,000 lb. capacity cars, making a gross load of 2250 tons, forming a train 2000ft. long, which runs 150 miles in six to eight hours. The train load has more than doubled from the old 65 lb. rails.

The broad thin type of head is making rapid progress abroad. Dr. Haarman, at his Osnabruck works, Germany, has introduced several sections, while many are being rolled in England for India and Australia. My 80 lb. section has recently been rolled in England for two Canadian lines. While the thin wide head and stiff type of rails is now generally recognised as the most economical form, the pioneer 5in. 80 lb. rail met with decided opposition, as being heavier and stiffer than was needed. Its introduction was largely due to the persistent efforts of Mr. J. M. Toucey, then general superintendent, but now general manager, of the New York Central and Hudson River Railroad. The rail once in the track made friends and had strong advocates, for the value of stiffness in a section was recognised, the principle being utilised by many railroads. It is not weight alone, but stiffness as well, which gives value to a section. It marked an epoch in railway progress, and while the advantages of a broad head and stiff 5in. rail have exceeded expectations, there are still greater values to be obtained by the use of the broader head and stiffer 100 lb. rail.—*American Engineer Car Builder.*

THE NEWPORT HARBOUR COMMISSIONERS' WEEKLY TRADE REPORT.

GOOD attendance on 'Change. Steam coal shipments are good, with fair inquiries for the future. Prices steady. The house coal trade continues good for the advancing season, and prices are without change. Tin-plates in better demand. The steel and iron works continue well employed.

Prices:—Coal: Best steam, 8s. 3d. to 8s. 6d.; seconds, 7s. 9d. to 8s.; house coal, best, 10s. to 10s. 3d.; dock screenings, 5s.; colliery small, 4s. 3d. to 4s. 6d.; smiths' coal, 6s. 6d.; patent fuel, 10s. 3d. Pig iron: Scotch warrants, 46s.; hematite warrants, 47s. 9d., f.o.b. Cumberland; Middlesbrough No. 3, 37s. 10d. prompt; Middlesbrough hematite, 45s. 4d. Iron ore: Rubio, 11s. 9d. to 12s.; Tafna, 11s. 3d. Steel rails, heavy sections, £4 12s. 6d.; light ditto, £5 to £5 5s., f.o.b.; Bessemer steel tin-plate bars, £4; Siemens tin-plate bars, best, £4 2s. 6d., all delivered in the district, cash less $2\frac{1}{2}$ per cent. Tin-plates: Bessemer steel coke, 9s.; Siemens coke finish, 9s. 3d.; ternes, per double box, 28 by 20 C., 18s. 6d. to 20s. Pitwood, 15s. 3d. to 15s. 6d. London Exchange telegram: Copper, £44 17s. 6d.; Straits tin, £59 10s. Freights: Homeward, firm.

THE IRON, COAL, AND GENERAL TRADE OF BIRMINGHAM, WOLVERHAMPTON AND OTHER DISTRICTS.

(From our own Correspondent.)

STEEL is steady this week at £5 for Siemens marked steel slabs at stations in the Midlands, £4 15s. for Bessemer blooms and billets, £6 to £6 10s. for Siemens bars, £5 7s. 6d. to £6 for Bessemer bars, £7 to £8 10s., according to tests and sizes, for Siemens best boiler-plates, and £5 15s. delivered for Bessemer ship-plates. Angles and girders of basic steel are £5 10s., and £6 5s. for boiler-plates. All the steel works are active, and the finished iron works and blast furnaces are also well engaged upon orders booked at the commencement of the new quarter.

Common bars are £5 5s. to £5 10s.; merchant bars, £6 to £6 5s.; and marked iron £7, with £7 12s. 6d. for the L.W.R.O. brand of the Earl of Dudley's make. Black sheets are £6 12s. 6d. to £7 for singles, £7 to £7 7s. 6d. for doubles, and £7 15s. for lattens. Angles are £5 15s., stamping sheets are £9 10s. and best thin sheets £11. Nail rod is £6 10s. Hoop and thin strip £6 7s. 6d. Tube strip for bedstead tube making is £6 5s., and for gas tube making £5 10s.

Staffordshire cinder pig is 36s. to 37s. for forge, with 2s. more for foundry; part mine, 39s. to 45s., according to quality; and all mine 55s. to 57s. 6d. Cold blast pig is 90s. Lincolnshire forge pig is 44s. 7d. net at stations. North Staffordshire and Derbyshire, 42s. to 43s., and Northamptonshire 41s.

The Tame and Rea District Drainage Board, at their quarterly meeting on Tuesday, had before them the estimates for the ensuing year, totalling £60,170. The Board approved a scheme submitted by their engineer, Mr. Till, for a large extension of the sewage farm. This scheme of extension will in all probability ultimately involve a capital expenditure of £244,500. When the Board was formed in 1877 the population in the drainage area was but 481,944. In 1884 the constituency had increased to a population of 605,594, and, without any extension of the area, it is estimated that by the year 1912 its population will amount to 900,000 persons, nearly the whole of whom will be resident on land draining to the sewage farm. A considerable extension of land and works is therefore absolutely necessary in the course of the next few years, in order to deal with the continually increasing quantity of sewage. Parliamentary powers will be necessary. The engineer of the Board is Mr. Till, and the services of Mr. Charles Hawksley have also been retained on a commission of 5 per cent. on the cost of construction, Mr. Hawksley undertaking to design the works, prepare all needful working drawings, and supervise the works during construction, as well as to give advice in relation to Local Government Boards and Parliamentary inquiries, and attend thereat. The new land which is to be acquired will raise the total area of the farm to be used for sewage disposal to 2320 acres, of which over 2000 acres will be available for irrigation. Mr. Till estimates the costs of the works only, including main conduit, outfalls, and stream diversions, new improvement, pipes and main drainage, laying out, machinery, and raising mains, extension of existing buildings, &c. &c., and stocking the land, at £124,500, exclusive of easements, compensation, or purchase of mill or water rights. He estimates, approximately, the cost of pumping expenses for lifting 5,000,000 gallons of sewage per day to the high level lands, exclusive of interest, sinking fund, or capital, at about £900 per annum.

Cycle engineers seem to be enjoying a good time. Easter week was one of the most remarkable in the history of the cycle engineering trade, and orders continue to pour into the Midland towns for machines from all parts of England and abroad, and factory accommodation at Coventry is extending in all directions. This remarkable activity in the cycle and cycle fittings trades is responsible for some extraordinary advances in the cycle share market of the Midlands, in which securities of this description have lately been sought after, to the neglect of nearly all other kinds of industrial shares. The extent of the upward movement may be best gauged, perhaps, by a comparison of the prices of a week ago with those realised on the first of the month, before the "boom" had set in. Beeston Pneumatic Tire at the earlier date were selling at from 18s. to 20s.; within the past ten days the price realised has been £6. W. Bown, Pref. 7 per cent., has risen in the same period from £3 15s. to £4 10s.; Cycle Components, from 20s. to 44s. 6d.; Humber and Co., from 26s. 3d. to 29s. 3d.; Pneumatic Tire, from £9 to £12 15s., ex dividend; Rudge-Whitworth, from 13s. 9d. sellers to 19s. 6d. buyers; St. George's Engineering, from 21s. to 35s.; Allday and Onions, from $£4\frac{1}{4}$ to $£5\frac{1}{4}$; and Self-sealing Air Chamber, from 15s. to 21s. The steel tube concerns which minister to the wants of cycle manufacturers have shared in the advance, Star Tube rising from £3 premium to £4 premium, or £5 for the £1 shares, and Rose Tube from about par to £1 premium; and during the week, in some of these cases, still further advances have been made. The newly-formed Cycle Manufacturers' Tube Company have arranged for the erection of a factory upon land purchased from the Coventry Corporation. The contract for the first portion of the work amounts to £21,000.

A conference of representatives from the County Councils of Montgomeryshire, Breconshire, Radnorshire, Cardiganshire, Merionethshire, and Carnarvonshire, with the local members of Parliament and gentlemen interested in agriculture, has taken place at Machynlleth. The object of the meeting, which was promoted by the directors of the Cambrian Railway Company, was to discuss methods for facilitating the carriage of agricultural produce over the district served by the Cambrian Railway. Sir Humphreys Owen, M.P., presided, and among other directors present were Lord Henry Vane Tempest and Mr. Edward Davies. After an interesting discussion of the conveyance of live stock, the chairman announced, amidst applause, that the company was prepared to revert to the rates of 1892 locally. Mr. Forrester Addie advocated the opening of a market in the Black Country by a reduction in the rates for produce, and the publication by the company of a list of customers and producers. Professor Parry, Aberystwith, spoke of unfavourable rates for home produce compared with foreign goods.

Three fatalities have unfortunately occurred at Himley Colliery, causing the death of William Marson (20), Gornalwood, who was killed whilst following his employment at No. 8 pit, Himley Colliery; and the death also of a man named Joseph Shaw (51), who resided at Pensnett; and of Wallace Kennell (22), of Wallheath, who was killed on the Earl of Dudley's private railway at Himley Colliery. The first two cases were caused by the fall of a roof whilst they were fixing up an iron girder across the roof. In the last-named case the deceased was engaged in shunting, when he was crushed against a truck and died almost immediately. Verdicts of accidental death have been returned.

The Public Works Committee of the Birmingham City Council have decided to report to the Council in favour of the scheme of reorganisation of the work of the City Surveyor's Department recently mentioned. It is proposed to continue the services of Mr. Till in connection with the City Council, but not in connection with the Drainage Board, and to pay him a reduced salary of £600 a year; while a deputy or assistant colleague shall receive £400 from the Corporation and £400 from the Drainage Board. This arrangement will involve no increase of costs, Mr. Till's salary hitherto having been £1000 from the City Council, and £400 from the Drainage Board.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

Manchester.—Although there is perhaps not quite so confident a tone in some quarters, owing to the persistent slackening off in the demand during the last month, with a consequent weakening of prices for raw material, there would seem to be nothing actually in the present position to occasion any real uneasiness as to the future. It was not to be expected that the heavy buying that went on two or three months back could be continued; and apart from the lull which was only natural to follow, trade, taking it all through, is satisfactory, and the principal iron-using branches of industry are not only kept fully employed, but in most departments new work comes forward rather in increasing than decreasing quantities. Of course there are nervous or needy holders of iron who are always, in a condition of the market like the present, anxious to realise even at a sacrifice in price. Generally, however, a strong tone is maintained; and apart from second-hand parcels or speculative transactions, prices have not, under the circumstances, given way more than might have been looked for.

A continued absence of animation is the report throughout the iron market here, and although there was an average attendance on Tuesday's Exchange, business all through was extremely slow. In pig iron especially there is a complete pause as regards further buying for the present. This absence of new business coming forward has, however, not hitherto been regarded as appreciably affecting the position of makers, and the report on 'Change of the altogether unexpected action of the associated Lincolnshire smelters at their meeting last Friday in deciding to reduce their list rates 1s. per ton occasioned considerable surprise. It was generally supposed that the Lincolnshire makers were so heavily sold that they were practically independent of new business for some time to come, and the explanation is that Northampton pigs have recently been offered at such extremely low figures that the important Staffordshire trade in Lincolnshire pig iron has been almost, if not altogether, lost, and that it is solely with a view to the recovery of this trade that the reduction has been made. With regard to other brands of pig iron, makers' prices remain without quotable change, but the position, taking it all through, is unquestionably weaker, and in the open market prices were very irregular, merchants, in fact, making their own quotations, according to circumstances. Lincolnshire iron, at the reduced rates, is now quoted 41s. for forge to 43s. for foundry, with Derbyshire remaining at 46s. to 47s. for foundry, net cash, delivered here, but with regard to Derbyshire iron the position of makers is not so strong as it has been recently. Local makers have made no change in their quoted prices, foundry qualities remaining at 46s. 6d., less $2\frac{1}{2}$d., delivered here, and it is only where they come into competition with forge Lincolnshire at Warrington that they will be at all affected by the reduced rates. For delivery Warrington, 41s. 8d. net cash is now about the average price for Lincolnshire forge, and Lancashire makers, to secure business, will have to come in at something like the same figure. Makers' prices for outside brands are somewhat easier, but without quotable alteration. They are still quoting 47s. net cash for good foundry Middlesbrough, delivered by rail Manchester, but orders could be placed at 6d. to 9d. less, and delivered Dock Quays, Manchester, at about 44s. 9d. net cash. For Glengarnock makers' official quotations are 48s. 6d. delivered Lancashire ports, and 50s. 6d. delivered Manchester Docks, but sellers could be found at 6d. to 9d. under these figures, and Eglinton could be bought without difficulty at 47s. net prompt cash, delivered Lancashire ports, and 49s. 3d. delivered Dock Quays, Manchester.

New business comes forward steadily in the manufactured iron trade, and forges are kept fully going. For bars prices are firm at last week's quotations, £5 10s. to £5 12s. 6d. being the minimum for Lancashire, and £5 12s. 6d. to £5 15s. for North Staffordshire qualities, delivered here. Sheets, however, are weak and irregular, owing chiefly to the collapse of prices in Staffordshire; and £7 5s. to £7 10s. may perhaps be taken as about the average figures for delivery here. The Association list rates for hoops are steady at £6 2s. 6d. for random, to £6 7s. 6d. for special cut lengths, delivered Manchester district, and 2s. 6d. less for shipment.

In the steel trade a moderate business is reported, with a steady tone in prices at late quotations, makers being very firm at 58s. to 58s. 6d, less 2½, for good foundry hematites; with £4 7s. 6d. to £4 10s. net cash the average figures for steel billets; £6 to £6 2s. 6d. for local made steel bars; £6 7s. 6d. for boiler plates; and £5 10s. to £5 12s. 6d. for steel girders, delivered Manchester district.

A brisk tone prevails in the metal market, with prices well maintained at full list rates.

In the engineering trade general activity continues to be reported, and in some quarters a considerable amount of new work has been booked during the last few weeks. This remark applies particularly to machine tool makers, who have secured some large orders for delivery well into next year, whilst at many of the local establishments there is quite a pressure to get through the work already in hand. Stationary engine builders also continue fully engaged, both in the light and heavy departments; boiler makers are also kept extremely busy, having a larger weight of orders in hand than they have had for a considerable time past, and amongst locomotive builders a fair amount of new work has also been secured.

Messrs. Henry Wallwork and Co. have just completed for Messrs. A. C. Wells and Co., of Manchester and London, a specially designed painting machine to be used on the Liverpool Overhead Railway. This consists of a modification of their "Lightning" painter, which was some time back described and illustrated in The Engineer, but in the present instance it is to be driven by an electric motor. The whole of the machinery, consisting of the electrically-driven air compressor, by which the paint is forced up to the painting nozzles, and then discharged in fine spray, the paint receptacle, and the electric motor, are fixed, in compact form, upon a travelling car constructed to run upon the tram rails below the overhead railway, and the machine can be operated at any point along the line by an electric current supplied from the company's own installation. Another improvement and modification of their painting machinery is also being introduced in the form of a portable self-contained painting machine weighing less than 1 cwt., and complete in itself, with air-pumps, paint receivers, and all the requisite apparatus carried on one small base-plate, fitted with wheels and a couple of handles, arranged in truck form, so that it can be readily wheeled from point to point. The mixing arrangement, which is automatic, is operated by the rotation of the crank actuating the air pump, which is worked by hand, and supplies the compressed air for forcing the paint to the nozzles. I may add that the method of painting by machinery, introduced by Messrs. A. C. Wells and Co., is making considerable headway, the machines they have already supplied having, I understand, given great satisfaction, and I hope, for a later issue, to be in possession of more complete details, with illustrations, of the newly designed and improved machines they are now introducing.

Throughout the coal trade the position remains unsatisfactory, with comparatively few collieries working above four days per week, and all descriptions of round coal hanging upon the market. With the present mild spring weather, requirements for house fire qualities are necessarily falling off, and although there is no actually quotable change in list rates, surplus supplies are pushed for sale, and in the open market prices are weaker. The lower descriptions do not move off any better for iron making, steam, and general manufacturing purposes, and the complaint generally is that they are extremely difficult to sell, with only excessively low prices obtainable, ordinary steam and forge coals not averaging above 5s. 9d. to 6s. 3d. at the pit mouth. For engine classes of fuel there is a fair demand, and with collieries in many cases rather short of supplies, the tendency as regards prices is, here and there, decidedly in an upward direction. The general average prices, however, remain unchanged at about 3s. and 3s. 6d. for common, to 4s. and 4s. 6d. for better qualities, and 5s. for special sorts, at the pit mouth, and although in a few cases advances of 3d. per ton are being got, these are altogether exceptional.

In the shipping trade business shows no improvement, and owing to the excessively low figures at which orders recently have only been obtainable, some of the collieries are declining to compete at all for business, preferring rather to leave this branch of trade alone than to accept orders at altogether unremunerative prices. Common steam coals, delivered Garston Docks or High Level, Liverpool, average about 7s. to 7s. 3d., and for delivery Partington tips, Manchester Ship Canal, about the same figures would be taken.

Some feeling of anxiety with regard to the possibility of another wages dispute in the coal trade is beginning to manifest itself as the period approaches when the present Conciliation Board agreement comes to an end. It is evident that the miners are as determined as ever upon the question of a minimum wage, and this part of their policy they have all along kept to the front with unshaken persistency. The coalowners, on the other hand, are as strongly adverse to binding themselves down to a fixed minimum rate of wages—at any rate on the basis proposed by the miners—and if the question is to be fought out on this issue, it is difficult to see how a renewal of the struggle can be avoided. By the agreement which comes to an end in July, the miners have already succeeded in getting in the thin end of the wedge with regard to the principle of a minimum wage, and it is probable they may endeavour to drive it still further home by suggesting that the existing arrangement — that is, that the present rate of wages remain undisturbed for a period of eighteen months, after which the colliers, if the state of trade warrants it, are to be in a position to ask for an advance—shall be carried over for another similar period. The contention of the coalowners, however, is that the present state of trade and the lower wages paid in other competing colliery districts does not warrant the rate of pay already received by the federated miners, and that the Board of Conciliation shall have power to regulate the rate of wages, which, of course, means that there must be some reduction. I scarcely think, however, that either the miners or the coalowners will care to enter upon another protracted contest, and in well-informed quarters it is thought probable that some means will be found to bridge over the difficulty by an arrangement which, whilst not actually binding the coalowners to a minimum wage, may for the time being satisfy the miners, who will no doubt be advised by their leaders that it is not their policy just at present to push the matter to the extremity of forcing on another struggle. It would seem, however, to be almost inevitable that the minimum wage question, which has taken so strong a hold upon the minds of the colliers, must sooner or later be fought out, but in all probability the miners' leaders will prefer to wait until the condition of the coal trade is more favourable than it is at present for carrying the struggle to a successful issue.

Barrow.—The demand for hematite qualities of pig iron is still brisk, and orders are offering freely to makers, who are already well sold forward. Business in Bessemer qualities of metal is not only strong by reason of the immediate large consumption on the part of steel makers, but because there is an all-round good demand for forward deliveries generally. The production of the 39 furnaces in blast is all going into consumption, and during the week 1102 tons have been cleared out of warrant stock, leaving 302,816 tons still in hand, or 13,641 tons increase since the beginning of the year. Makers quote their old rates of 50s. per ton for parcels of mixed Bessemer numbers, net f.o.b., and warrant iron is selling at 47s. 11d. net cash, while buyers are offering at 47s. 10½d.

There is still a good business in the iron ore trade, and smelters are using large supplies as well of native as of Spanish qualities. Last week's quotations are still maintained.

The steel trade is brisk, and the mills are busy in every department, including rails and plates, as well as billets, hoops, castings, and merchant steel. Orders are still numerous all round, and prices are firm, heavy rails being at £4 12s. 6d. per ton.

Shipbuilders are looking forward to some new orders, and during the week the Naval Construction and Armaments Company has booked an order from the Admiralty for two more torpedo boat destroyers. It has already in hand two of this class of boat, and it is quite on the cards that boats of a higher rate of speed will be ordered.

The coal and coke trades are very firm.

In shipping things are much brisker. During the week the exports from West Coast ports reached 9189 tons of pig iron and 14,694 tons of steel, as compared with 4098 tons of pig iron and 4559 tons of steel in the corresponding week of last year, an increase of 5091 tons of pig iron and 10,135 tons of steel. Since the beginning of the year the shipments have totalled up to 94,771 tons of pig iron and 131,222 tons of steel, as compared with 78,888 tons of pig iron and 110,169 tons of steel in the corresponding period of last year, an increase of 15,883 tons of pig iron and 21,053 tons of steel.

THE SHEFFIELD DISTRICT.

(*From our own Correspondent.*)

Better time has been worked in most of the collieries in the South Yorkshire district. The week's output has been an average one. Very little change has taken place in the condition of trade. Values remain low, although the prices of steam and small fuel have an upward tendency. Slack and smudge are in increased request, owing mainly to the extra demand for coke-making purposes. Establishments making their own coke find it to their advantage to use their own slack and smudge. The supply of slack is very restricted owing to the short time worked at the pits. A limited tonnage of both Silkstone and Barnsley house coal is being forwarded to London, owing to the mild weather, and the large quantity of seaborne coal at present in the market. A similar remark applies to the eastern and other markets.

In house fuel the quotations, owing to the plentiful supplies, are low. Silkstone coal is at 8s. to 9s. for best hand-picked, while ordinary samples are obtainable at 7s. to 7s. 6d. per ton at the pits. Best qualities of Barnsley "softs" make from 7s. 3d. to 7s. 6d. per ton, inferior qualities 6d. to 9d. per ton less. Owing to the low prices asked for secondary sorts of thick seam coal, the thin seam pits are worked with considerable difficulty. The best qualities of this class will not fetch more than 5s. 9d. to 6s. per ton. There is an abundant supply of fuel in the market, and low values only can be obtained. It is expected in many quarters that the Baltic ports will shortly be opened. A large tonnage is being forwarded in connection with railway and other contracts. Steam coal prices range from 6s. 9d. to 7s. per ton. Good screened slack is obtainable at from 3s. 6d. to 4s.; ordinary pit slack, 2s. 6d. to 2s.; while smudge is as low as 1s. 6d. per ton at the pits. An improvement has taken place in the coke trade, and the majority of the district ovens are now well employed. North Lincolnshire has been taking a much larger tonnage of late, owing to more furnaces being put into blast. Derbyshire is requiring an average amount, and a similar remark applies to several of the other iron smelting districts. Values of best coke range from 9s. 6d. to 10s. per ton in owner's wagons at the works.

The heavy departments of the city continue in the same regular condition. The railway material branchs are well off for work. Some very good orders for springs, buffers, axles, tires, and similar goods, have recently been booked. These have been mainly for the Midland, and the Manchester, Sheffield, and Lincolnshire, for its London extension, as well as for other of the leading home railway companies. Several foreign railways, including South American, have also placed some large contracts. The increased activity in these branches has had a stimulating effect on the demand for steel, and three of the Bessemer works are working night and day. The Queensland Government have placed an order for half-a-dozen engines with the Yorkshire Engine Company. This company is also well employed on work in other departments. The armour-plate mills and forging presses are busily engaged on Government orders, and it is satisfactory to note that during the last week or two some further orders for shells of various patterns have been received by the Sheffield firms who make this class of work a speciality.

In the lighter industries a remarkable improvement has taken place since the quarter ended. A very brisk business is being done in files, the men working full time. Competition is still very keen, and it is stated that in some cases manufacturers are disposing of the files at cost prices, relying on the steel used for their profit. The skate business has been very poor this year, owing to the absence of any prolonged winter, and heavy stocks laid in last year have remained untouched. The mild weather has had the effect of stimulating the demand for building tools, and heavy tools for the engineering trades have been in good request. The saw business is only quiet. Since Easter an improvement has taken place in the cutlery trade. Some excellent orders have been received for cutlery. These have been mainly for the pen and pocket qualities. A very good business is also doing in the table knife branch. Manufacturers of the cheaper qualities of cutlery are well off for work, finding full employment for their men.

Lord Charles Beresford, who has been the guest of the Master Cutler—Mr. H. Herbert Andrew—during his visit to the Sheffield Press Club, visited the Toledo Steel Works, the Master Cutler's establishment, and the Cyclops Works, Messrs. Charles Cammell and Co., on Monday. At the first place he witnessed the process of manufacturing tool steel, cotton spindle steel, and steel for mining purposes; as well as the production of special steel for safes, the preparation of metal for projectiles, the Siemens-Martin process, the drawing of telegraph wire, &c. The Master Cutler and Mr. J. L. Potts, the manager, conducted Lord Charles Beresford and the party accompanying him over the departments. At the Cyclops Works, Mr. Alexander Wilson, J.P., the managing director, and Mr. T. W. Jeffcock, J.P., one of the directors, received the visitors, who were shown the rolling of a 25-ton armour plate for H.M.S. Illustrious, now being built at Chatham. Another plate for the Victorious was Harveyised, and his lordship was also able to see the machining of the plates to be used in one of the new warships, as well as several of the minor processes. At the Press Club, Lord Charles vigorously criticised the naval system at the Admiralty as theoretically excellent but practically rotten. He particularly objected to no provision being made for manning the new war vessels, pointing out that the First Lord of the Admiralty admitted that in April next he would be 11,000 men short, and that he intended to take them from the First Naval Reserve. His lordship contended that we had no Naval Reserve, and that 22,000 more men will be required a year hence. He wants to know where the First Lord is going to get them.

THE NORTH OF ENGLAND.

(*From our own Correspondent.*)

Though the local iron market is very quiet, and both buyers and sellers show a disinclination to operate at present, yet the tone cannot by any means be described as depressed. On the contrary, business men are decidedly hopeful, for their belief is that this lull is simply one of those unaccountable pauses which occur from time to time in every upward movement, when buyers, after a brisk period of buying, take a rest. Makers have certainly well filled order books, and are quite indifferent about selling further at present, while buyers have ordered enough to satisfy their requirements for some little time to come, and they hold off just now. But there is nothing in the position and prospects of trade to favour an opinion that trade is falling off.

The activity in the pig iron industry is unprecedented, the production is the largest on record for the North of England, and it is regarded as certain that it is not now in excess of the requirements, though it has been so for the last half-year. But now the exports are very heavy, and local consumption has never been larger, for finished iron and steel works are in full swing—indeed, the present rate of production has never been surpassed. It is calculated that at the end of the month a decrease of 3000 tons in the stocks of Cleveland pig iron will be reported. Some apprehension is felt that the output of pig iron will be increased, and that too many furnaces will be put in blast. This has been partly caused by the report of the sale of the Coultham Ironworks, but it is not likely that they will enter upon the competition for at least six months, as the furnaces need to be relined. It is not probable that the new owners will restart them unless they can see their way to making a fair profit. At present the profit must be small, where a producer has to buy his materials in the open market, and has to give anything like the present prices for them.

The exports of pig iron from the Cleveland district have this month amounted to 76,982 tons, as compared with 68,858 tons last month, and 84,344 tons in April last year to 22nd. The exports have kept up very well indeed when it is taken into consideration that the navigation season commenced so early this year. Local consumption also is good, and a large quantity of hematite pig iron is being forwarded to the Sheffield district.

Makers generally maintain their quotations fairly well, as they are for the present independent of the market, but second hands have reduced their prices 3d. per ton for all kinds of pig iron; they, however, have only been selling small lots for delivery before the end of the month. Of No. 3 Cleveland pig iron sales have been made at 37s. 9d.; while No. 1 was 39s.; No. 4 foundry, 37s. 3d.; and grey forge, 36s. 9d. Cleveland white iron is practically unprocurable. In the absence of business and the desire to do it, reliable prices for forward delivery can hardly be given. Cleveland warrants have this week touched a lower price than has been known since January 14th, 37s. 8d. cash being all that the buyers would give on Monday. There has since been a slight recovery, and on Wednesday afternoon 37s. 10d. cash would be given, there being sellers at 37s. 11d. The stock of Cleveland pig iron in Connal's stores on Wednesday night was 190,256 tons, an increase for the month of 2782 tons. It might have been expected that with such excellent shipments and inland deliveries iron would rather be drawn out of than put into the public stores.

Finished iron and steel manufacturers have booked very few orders since before Easter, but they are well supplied with contracts, and can keep their establishments in full operation. There is, therefore, no easing of prices. The managing director of one of the leading bar-making establishments in the North of England states that never since their works were founded has business been so brisk as it is at present; indeed, orders have been coming in so rapidly that they were unable to keep pace with them, and there seems to be every prospect of a still more active trade. The question of a restart at the Darlington Steel Works, which have been idle since October, 1894, is much discussed. The directors had a meeting last Saturday, when the subject was considered, and a further meeting is to be held, so as to settle upon the proposal to be made to the shareholders at the forthcoming annual meeting. It is true that the selling prices of steel rails have gone up, but the cost of production has increased likewise, and the directors seem to be doubtful about the present activity being maintained. The inland situation of the works tells against them in their competition with the manufactories near the seaboard. Deliveries of rails and railway material, as well as bridge work, are very heavy from the Tees, and it is a long time since Middlesbrough Dock has been so crowded with large steamers as it is at present, most of them bound for India and Japan. Heavy steel rails are obtainable at £4 12s. 6d. per ton net at works.

The steel ship-plate trade is very brisk, as shipbuilders in the North of England and Scotland are so actively employed. On the Tyne especially is this the case, a considerable proportion of it being work for the British Government. This week orders have been placed with Palmers' Shipbuilding and Iron Company for two thirty-knot torpedo boat destroyers, and other two are to be built by Messrs. Hawthorn, Leslie, and Co. Palmers have now on hand for the British Government eight torpedo boat destroyers, and two third-class cruisers. Owing to the improved prospects, the value of Palmers' shares has considerably increased. A short time ago their £15 A shares could have been bought at 7½, now they are 9½. On the Tyne there are at present ordered eighteen war ships, including torpedo boat destroyers, and of these thirteen are for the British Government. The Tyne Iron Shipbuilding Co. will build a steel steamer of 3400 tons gross for the Stag Steamship Co., and Messrs. Ropner and Sons, Stockton, will build a steel steamer of 5400 tons deadweight, for a Cardiff firm, the price, it is stated, being £30,000. Owing to the activity in shipbuilding the price of steel plates is strongly upheld at £5 2s. 6d. per ton, and some firms will not sell under £5 3s., both less 2½ per cent. and f.o.t.

Wages questions continue to come to the front, the improvement in trade having led the men to endeavour to secure a larger share of the realised prices. At the foundries the men have commenced an agitation for increased wages, and those at the Anderston Foundry, Port Clarence, are the first to hand in a definite claim, which is for no less than 15 per cent. advance. The Northern United Enginemen's Association, which includes cranemen and firemen, have accepted the offer of the employers, an advance of 1s. per week in wages for those receiving 25s. per week and upwards, and 6d. for those under 25s. The pattern makers have agreed to accept an advance of 1s. per week. The joiners of the Tees, Hartlepools and the Tyne yards claimed 3s. per week advance, and the employers offer 1s. from May 6th; the men have this offer under consideration.

The death is announced of Mr. Thomas Walker, of Saltburn, a partner, since its formation in 1872, of the firm of Walker Maynard and Co., Redcar Ironworks.

The employés of the Cleveland Bridge and Engineering Co., Darlington, on Monday presented an illuminated address, a gold pendant, and a silver kettle to Mr. Edward Westby Jacob, who is retiring from the managership of the works, which he has held for the last ten years, during which time the works had been considerably extended.

A testimonial from the working men and others in South-East Durham was on Saturday presented to Alderman Joseph Richardson, D.L. Mr. Richardson is senior partner in the firm of Richardson, Duck and Co., shipbuilders, Thornaby-on-Tees. The University of Durham have conferred the honorary degree of D.C.L. upon Sir David Dale, Bart., who has for so many years been a leading member of the iron and coal trades in this district, and has done so much to popularise the principles of arbitration and conciliation in disputes between employers and their men. He took a prominent part in establishing the Board of Conciliation and Arbitration for the North of England Manufactured Iron Trade, which has successfully adjusted industrial difficulties in that industry since 1869.

The traders of Middlesbrough and district have commenced to agitate for an enlargement of and a new entrance to the Dock, which is the property of the North-Eastern Railway Company, as there is not accommodation for the very large vessels that are now employed in the trade between this country and India and the East, a trade in which Middlesbrough is very largely engaged, as so much railway material and bridgework is manufactured in the district for that part of the world. The trade up till within the last few years has been carried on with steamers of from 2000 to 4000 tons, and the dock and entrance were capacious enough for these. But of late the tendency has been to greatly enlarge the capacity of the vessels employed, as it is found that steamers of from 7000 tons upwards can be worked much more economically, and lower freights can be accepted without loss. But there is not adequate accommodation at Middlesbrough Dock for such vessels, and the consequence has been that they have frequently to take only a part of their cargo on board in the dock and fill up elsewhere. Some vessels are too wide to get into the dock at all, and some of the leading shipowners decline to risk sending their vessels. Not only is the entrance too small, but there is not room enough to swing the vessels if they were in. It has been decided to send a deputation to the directors of the North-Eastern Railway Company, to represent to them the necessity of making adequate provision for dealing with these large vessels. The dock at Middlesbrough was opened in 1842; in 1852 it passed into the hands of the railway company; in 1872 it had to construct a new entrance; and in 1883 it had to make a still larger entrance and to enlarge the dock considerably. If the trade is not to be hampered it will be necessary without delay to still further increase the accommodation. Some traders are of opinion that it would be well if the example of Antwerp could be followed, and quays erected with deep water berths in the lower reaches of the river. That would make the port a less expensive one. The suggestion that a new dock independent of the railway company should be constructed lower down the river does not find favour with the traders.

The steam coal trade is exhibiting improvement, and the collieries north of the Tyne are doing better than for six months past, while the price of best steam coal has been this week raised 3d. per ton, viz., to 8s. f.o.b. Blast furnace coke is scarce; the supply was not in excess of the requirements before the Brancepeth explosion, and now consumers cannot get all they need. Brancepeth Colliery was probably the largest coke making establishment in the country, and the stoppage of the business there could not but seriously affect the supply. This week fancy prices have had to be paid by those needing coke at once, but contracts over three or six months can be placed at 14s. delivered at the Tees-side furnaces.

NOTES FROM SCOTLAND.

(*From our own Correspondent.*)

The pig iron market has been comparatively quiet this week. Scotch warrants are only in moderate request, hematite being slow of sale, while Cleveland iron is much neglected. There is scarcely any speculative interest in Glasgow market at present. Prices are already such that an early rise could hardly be expected; and, on the other hand, the "bears" do not appear assured that the time has yet arrived for a very decided fall. Business has been done in Scotch warrants from 46s. 1½d. to 45s. 11d. cash, and 46s. 3½d. to 46s. 1d. one month. Cumberland hematite has sold from 48s. 1d. to 47s. 9d. cash. Cleveland warrants have changed hands at 37s. 10½d. one month.

There are 43 furnaces producing ordinary, 35 hematite, and 3 basic iron, the total of 81 comparing with 75 at this time last year. Only a small quantity of iron has been added to the stock in Connal and Co.'s Glasgow stores.

Prices of G.M.B. iron are 3d. to 6d. per ton lower, and the special brands are not quite so steady as of late. Govan and Monkland, f.o.b. at Glasgow, Nos. 1, are quoted at 47s. 3d.; Nos. 3, 45s. 9d.; Carnbroe, No. 1, 47s. 6d.; No. 3, 46s.; Gartsherrie, Calder, and Summerlee, Nos. 1, 50s. 6d.; No. 3, 48s.; Coltness, No. 1, 53s.; No. 3, 48s. 3d.; Glengarnock, at Ardrossan, No. 1, 50s. 6d.; No. 3, 46s.; Eglinton, No. 1, 47s. 6d.; No. 3, 45s. 6d.; Dalmellington, at Ayr, No. 1, 47s. 6d.; No. 3, 45s. 6d.; Shotts, at Leith, No. 1, 52s.; No. 3, 48s. 6d.; Carron, at Grangemouth, No. 1, 52s. 6d.; No. 3, 49s.

Good shipments of Scotch pig iron are being made to Italy, but in other directions the export trade does not show any improvement. The past week's shipments have amounted to 7937 tons, compared with 8695 in the corresponding week of last year, and of the total there was sent to Italy, 2800 tons; Germany, 810; India, 145; United States, 25; Russia, 170; Australia, 245; France, 30; Holland, 394; Belgium, 35; China and Japan, 160; other countries, 86; the coastwise shipments being 3037, against 6032 in the same week of 1895.

The finished iron industry is fairly active, but competition is keen, and prices are thereby kept down. The steel works are very busy, with good prospects as to the future, orders coming in freely, both for shipbuilding and general engineering work. It is reported that the tender of a Clyde firm recently sent to the United States, for 3000 tons of railway bridge material, has been found to be the lowest—cost, freight, &c.—but it is considered doubtful whether the order will be sent here. Be this as it may, the incident is instructive as to the ability of our steel makers to cope with competition abroad, at least in this particular kind of material.

There are one or two somewhat more hopeful features in connection with the coal trade, which on the whole stands much in need of improvement. A brisk demand is experienced for small coal and dross for manufacturing purposes, and the shipments abroad are this week considerably larger, the quantities despatched from the East Coast to continental ports being heavier than for some time. The prices f.o.b. at Glasgow are: For main coal, 5s. 9d.; splint, 6s. 3d. to 6s. 6d.; ell, 6s. 3d. to 6s. 9d.; and steam, 7s. 6d. per ton. The tone of business in Ayrshire is steadier, although there does not appear to be any considerable increase in its volume.

WALES AND ADJOINING COUNTIES.

(*From our own Correspondent.*)

The coal trade is slightly brisker, and holiday influences are steadily wearing off. The coal shipments from the port of Cardiff for the past week were 305,000 tons. This is very satisfactory, and indications are that it was not a sudden boom but the prelude to a large export during the month. "Big steamers" have been again in evidence, the Pindari for Colombo with 7700 tons, the Samoa for Bombay with 8000 tons, and Oriscalli for the same port with 6000 tons. Swansea coal shipments last week were encouraging, 31,000 tons, though it was reported that the San Francisco trade is quiet. Newport has exported 47,270 tons foreign, and 21,919 tons coastwise.

The anthracite trade between Swansea and Germany is improving, and coal totals for that destination take second rank in importance with those for France. It is hoped that, as the season advances, and business with San Francisco improves, the weekly total of anthracite exports from Swansea will begin to take good distinctive form.

There has been some little trace of discontent noticed amongst the Plymouth colliers with regard to the settlement of the "test case," but I am glad to state that at a meeting of colliers on Monday the matter was satisfactorily explained, and a vote of confidence in Mr. David Morgan, the miners' agent, passed unanimously.

The impartial notice of the "discharged note" question in The Engineer of last week reminds me that a short time ago I had an interview with an old miners' agent, and a long discussion of the subject took place, and though I knew that a good deal of feeling had been imported into the matter, it was a subject of surprise that so much intense excitement had been aroused. The men were stubbornly bent at all hazards, if refused, to throw down their tools, and the prompt action of the coalowners and of the Sliding Scale Committee, in frankly and even genially abandoning the situation, has done a good deal towards bringing about a better understanding. "Mabon's" action in the affair has been warmly commended, and there is but one opinion, and that a warm one, about the good services of Sir W. T. Lewis, Bart.

Colliers, like those "who go down to the deep in ships," seem to be perversely reckless. Two men from the Dowlais Collieries were fined this week for having tobacco pipes in their possession in Bedlinog colliery last week.

On 'Change mid-week, Cardiff, the mustering of members was gratifying, and business was regarded as healthy in coal, coke, and fuel. Best steam coal was in demand at 10s. 3d. to 10s. 6d.; seconds ranged from 9s. 9d. to 10s.; ordinary seconds, 9s. 3d. to 9s. 6d.; drys, 8s. 9d. to 9s. 3d.; best Monmouthshire, 8s. to 8s. 3d.; seconds, 7s. 9d. to 8s.; very best small, 4s. 9d. to 5s.; best, 4s. 3d. to 4s. 6d.; drys and inferior generally, 3s. 6d. to 3s. 9d. The house coal trade is now unmistakeably upon the down grade. The green winter has been followed by an early spring, and all hopes of a good house coal demand appear to have been abandoned. Quotations remain much about the same, but prices vary a good deal with the conditions. Best, 10s. to 10s. 3d.; No. 3 Rhondda, 9s. 6d.; brush, 7s. 9d. to 8s.; small, 6s. to 6s. 3d.; No. 2 Rhondda, 7s. to 7s. 6d.; through, 6s. to 6s. 3d.; small, 4s. to 4s. 3d. Pitwood continues weak.

Good trench on Saturday was offered in Cardiff from 14s. 9d. to 15s. Iron ore imports are becoming more noticeable, and prices are quoted in Cardiff firmly as follows:—Rubio, 11s. 9d.; Tafna, 11s. to 11s. 3d.; Garucha, 10s. 9d. to 11s. Large consignments came in this week. Cyfarthfa had several cargoes, Blaenavon three, Dowlais three; Mr. Howard, Ebbw Vale, and Briton Ferry, one each. I was pleased to see an abundant supply in all sorts of places around the Cyfarthfa furnaces this week, and a much better despatch of tin bar from the same quarter. Preparations are going on at Cyfarthfa for resuming the steel rail trade, which has been partially abandoned on account of the demand for steel bar for tin-plate destinations. It was reported on 'Change, Cardiff, this week, that the demand for steel bars is getting less, and that the highest price obtainable for Bessemer quality is £3 17s. 6d., while Siemens is quoted at £3 18s. Heavy steel rails are down from £4 10s. to £4 12s. 6d., light sections are at £4 17s. 6d. to £5 5s. The prices of ship plates are well maintained, and steel scrap, rail and bar ends, &c., are caught up.

A more varied list of quotations, iron and steel, was given this week at the Swansea Exchange, as follows:—Pig iron, Glasgow warrants slightly lower, 46s. cash buyers; Middlesbrough, No. 3, 37s. 9½d.; hematite, 45s. 6d.; Welsh bars, £5 10s. to £5 12s. 6d.; sheet iron, £6 15s. to £6 17s. 6d.; steel, £6 10s. to £6 12s. 6d.; steel rails, heavy, £4 10s. to £4 12s. 6d.; light, £4 17s. 6d. to £5 7s. 6d.; Bessemer steel, bars, £3 17s. 6d.; Siemens best, £3 18s.; tin-plates, Bessemer coke, 9s. to 9s. 1½d.; Siemens, 9s. 1½d. to 9s. 3d.; ternes, 16s. 6d. to 22s. 6d.; best charcoal, 12s. 6d. to 12s. 9d.; block tin, £59 12s. 6d. to £60 2s. 6d.; lead, £11 to £11 2s. 6d.; Spanish, £10 17s. 6d. to £11; copper, advancing £45 6s. 3d. to £45 8s. 9d.

Other Swansea quotations are:—Anthracite, best, 11s. to 11s. 6d.; seconds, 9s. to 10s.; ordinary, 8s. to 8s. 9d.; steam, 9s. to 10s.; bituminous, No. 3 Rhondda, 9s. 6d. to 10s.; No. 2, 8s. 6d. to 9s. 6d.

Coke continues to advance, implying increased activity in the iron trade. Last prices Cardiff, were, 12s. 9d. to 15s., furnace; foundry, 15s. 6d. to 19s. 6d., according to brand.

Patent fuel in fair demand, Cardiff and Swansea.

There is still not much movement to record at the iron and steel works; Cyfarthfa is to have its resident London agent, though of course, from time immemorial, Cyfarthfa has had its representative in the city. All that can be stated about the trade is that prospects are more hopeful. Better news reaches me from the tin-plate districts. Last week there was a larger shipment than make, reducing stocks, and gratifying news is to hand that several works are going to restart. One notable case I am glad to announce is that of the Beaufort Works, Morristown, by concession of the men.

I regret to announce that the tin-plate trade is very depressed at Briton Ferry. The mills at the Vernon, Gwalia, and Villiers are still idle, and there is no prospect of a restart unless the men see the wisdom of following the steps of others, and make a reduction. This is what I have on various occasions pointed out as an imperative necessity, to take a leaf out of iron and steelworkers' books. If these had stubbornly contended for old wages, furnaces would now be as deplorably hard off as mills. The mills at Baglan Bay and Earlswood are fully occupied.

Production of tin bar at Albion and Briton Ferry is a fair average.

I note that Wales is importing freely pig from Ulverstone, and iron bars from Workington.

I referred lately to the possibility of a new industry at Swansea, and the likelihood that the waste sulphate of soda in the district would be utilised for the treatment of sulphide ores from Australia. This is now made tolerably sure by the arrival of the steamer Buluwayo from Port Pirie, South Australia, with a cargo of 3006 tons, and new works are planned to be adopted for the process forthwith.

Opponents of the movement in London for obtaining Welsh water, and who think that it has collapsed, may be interested to learn that a steady survey is still going on in certain localities, tending to indicate that if carried out Langorse Lake will figure conspicuously.

It is stated at Milford Haven that a subsidy has been granted to the Milford Dock Company by the Admiralty for the use of their large graving dock at Milford when required by them. This dock is 600ft. in length, and considered to be one of the finest dry docks in the kingdom.

It has been decided, adverse reports notwithstanding, to proceed with the Llanelly Harbour Bill. The Docks Committee have held several meetings of late, when all matters in reference were well discussed, and they now report that they expect the Bill will come before the House of Lords Committee next week, when all matters *pro* and *con.* will be dealt with in evidence.

I share with many a good deal of interest in the fate of our Welsh Bills, which, as I close my dispatch, are coming to the front. The first is the Great Western Additional Powers Bill for lines in Roath, and improvements in connection with the Bute Docks. Then comes the great struggle, the proposal to amalgamate the Bute Docks and Rhymney. Next, the proposal to form the Windsor Docks on the mud flats between the Taff and Ely rivers. This is expected to be strongly opposed. Then we have the proposal of the Barry Company to get into the Monmouthshire coalfield, and some minor Bills of less significance. These I have mentioned are certain to bring out the best powers of promoters and counsel.

NOTES FROM GERMANY.

(*From our own Correspondent.*)

The trade in iron and steel is improving steadily all round; material changes, either in prices or demand have, however, not taken place, and there is, consequently, not much of interest to be related this week.

Business on the Silesian iron market continues strong. The favourable influence of the Russian commercial treaty is now being felt, especially in the steel and hardware trade, where a steady and altogether satisfactory employment prevails.

Exports in machines to Russia have also been pretty large for some weeks past, the prices realised being, as a rule, fairly remunerative.

Though heavy contracts are not being booked just at present, the activity on the Austro-Hungarian iron market continues, on the whole, satisfactory, owing to the numerous orders that were secured some weeks ago. During the first three months of the present year, the convention of the rolling mills sold about 75,000,000 kilos., which shows a plus of about 23,000,000 kilos. against the same period last year. There is an exceedingly brisk business done in girders and structural iron, and the railway and engineering department is also in fair employment.

On the French iron market raw as well as finished iron finds good markets, and prices are tolerably firm, but have not perceptibly changed since last week, merchant bars being offered at 150f. p.t., girders 160f. p.t., while steel rails were sold at 115f. p.t. free at works.

A lively tone prevails on the Belgian iron market, and prices have been rather more paying of late. Pig iron is in quiet but regular demand, while the various sorts of malleable iron continue to be very actively inquired for. Quotations are, as a rule, tending upwards. Luxemburg foundry pig is quoted 53f. p.t.; common forge, 52f. to 53f. p.t.; merchant bars, No. 2, f.o.b. Antwerp, 122·50f.; No. 3, 127f. p.t.; the same Belgian station, 132·50f. and 137·50f. p.t. Girders, f.o.b. Antwerp, 122·50f. p.t.; the same Belgian station, 130f. p.t. Heavy plates for export, No. 2, 138f. to 140f. p.t.; No. 3, 148f. p.t.; sheets, free Belgian station, 162f.; in some instances, 165ft. p.t.; steel plates, 143f. to 145f. p.t. Steel rails, 113f. to 115f. p.t.

During the first quarter of 1896 201,770 t. pig iron were produced in Belgium, against 222,800 t. for the same period the year before; 75,795 t. being forge pig, against 109,809 t. last year; 21,325 t. foundry pig, against 26,100 t.; and 104,650 t. basic, against 86,900 t. for the corresponding period the year before. On April 1st of present year there were 28 blast furnaces in blow in Belgium, out of 44 built.

On the Rhenish-Westphalian iron market a good number of orders have been coming in upon the week, and prospects for spring demand are most encouraging. Export trade has also perceptibly improved of late. The week's business in pig iron has been on rather a large scale, and quotations are beginning to be more remunerative. The same may be told of the manufactured iron department. In bars and girders quite an animated business is doing; hoops are, likewise, in good request, and as for plates and sheets, the mills have not been so well employed for months. The number of orders that come in at the foundries and machine factories increases from week to week. The situation of the tube foundries, on the other hand, appears to be but slowly improving; prices are fluctuating, and have, in a few instances, even been moving in a downward direction. This may chiefly be accounted for by the exceptionally large stocks, which have been increasing all through last winter, and now concessions have naturally to be made to clear the stocks. The occupation of the wagon factories continues a good one.

Total output of coal in the Saar district was, for the first quarter of 1896, 1,470,070 t. against 1,283,090 t. for the same period last year; output in Silesia amounted to 3,491,470 t., against 3,117,010 t.; in the Ruhr district 9,218,130 t., against 8,344,120 t.; and in the three districts together, 14,179,670 t., against 12,744,320 t. for the same period last year. This shows an increase of 14·6 per cent. for the Saar district, 12·0 per cent. for the Silesian districts, 10·5 per cent. for the Ruhr districts, and 11·2 per cent. for the three districts together, when compared to the production for the same period the year before.

Negotiations are reported to be carried on between the Russian Government and German locomotive factories concerning the supply of about 300 locomotives worth M. 19,000,000. One-third of this order is to be carried out before the end of present year, while the remaining two-thirds will be delivered in 1897.

In 1895 output of gold in Russia is stated to have been considerably lower than in previous years; while in 1893 no less than 2664 pud were washed, output in 1894 decreased on 2483 pud, and last year amounted to 2406 pud only. This decrease may partly be accounted for by the exceedingly dry summer in East Siberia, which, for a time, prevented the gold washing in the rivers, and partly because there was much difficulty in securing labourers, a great number of them being employed in the less fatiguing and much more remunerative work for the Siberian Railway.

The following shows foreign trade of the Low Countries in iron and metals for 1895. In import, the largest figures fall to Great Britain, Germany, and Belgium. There were imported, iron manufactured goods as well as raw iron, worth 90·4 million florins; copper and copper articles, worth 49·1 million florins; steel and steel manufactured goods, worth 49·7 million florins; lead and lead articles, 16 million florins; zinc, for 12·5 million florins; tin, worth 20·2 million florins. With regard to export in iron and iron manufactured goods, which was worth 75·4 million florins, England, Germany, and the Dutch Colonies in East India are the chief consumers. Copper and copper articles (48·4 milllion florins) chiefly go to Germany; steel and steel manufactured goods (17·4 million florins) are exported to different countries. In plates and bars export to Germany is most important. Rails (11·2 million florins) are chiefly sent to the East Coast of Africa and to the Dutch Colonies in East India, while for steel wire (5·6 million florins) Great Britain is the chief consumer.

AMERICAN NOTES.

(*From our own Correspondent.*)

New York, April 16th.

Weakening prices for iron and steel are among the probabilities of the next thirty days, unless something unusual happens. The reason is current requirements are not heavy. Pig iron production is 750,000 tons ahead in stocks. Current weekly production is close on to 200,000 tons. Consumption is 180,000 tons, or perhaps under. A break in the billet pool is a possibility, and besides we have always to reckon with the sudden and unexpected. Buyers have suddenly turned their backs on the market. They never recognised 2·00 dols. coke and 4·00 dols. Bessemer ore as fair, and with the hanging-back demand they now say they will wait and see. Political questions are pressing, and politicians are at sea. The semi-centenary of the Pennsylvania Railroad was celebrated this week. The capital stock is 129,301,600 dols.; lines owned and controlled, 9077; investment, 857,000,000 dols.; gross receipts last year, 132,720,000 dols.; operating expenses, 92,859,286 dols. for 1895; net earnings, 39,861,525 dols.; passengers carried, 75,052,479; tons of freight carried, 160,410,144. The recent rumours of enlarged railway construction are encouraging the iron trade. Much mileage is projected, and in several localities there is urgent need of construction of short lines. The gold craze is now on; large parties are going to Alaska. The inquiries and orders for machinery are increasing steadily. In the smaller industries conditions are improving. Projected enterprises in railway and manufacturing plant and mining developments involve enormous outlays, and if the general conditions warrant such expenditures, iron and steel capacity could be fully engaged.

Testing Armour for Russia.—Last week the first test of armour plate was made by the Carnegie Company for the Russian Government, by the courtesy of the United States officials, at the Indian Head proving grounds. The plates submitted represented a group of 350 tons of armour now ready for shipment to Russia. It was a 5in. double-forged plate, the first thin armour to be subjected to that process. The test was conducted under Russian requirements, which were that the plates should repel the projectiles. Two shots were fired, one of a 4in. and the other of a 5in. shell, with a velocity of 1700ft. a second. Both shells failed to penetrate the plate, and as the test was satisfactory, the group will be accepted. The value of the armour represented in the test was between 125,000 dols. and 150,000 dols.—*American Manufacturer.*

The Incorporated Association of Municipal and County Engineers.—The twenty-first voluntary pass examination of candidates for the offices of municipal engineers and surveyors to District Councils carried out by this Association was held at the Institution of Civil Engineers on Friday and Saturday, the 10th and 11th inst. Twenty-seven candidates entered, and twenty-three presented themselves for examination, the written portion of which was taken on the first day. The greater portion of the second day was occupied with the *vivâ voce* portion of the examination. The examiners were:—I. For Engineering, as applied to Municipal Work, W. Santo Crimp, M. Inst. C.E. II. Building Construction, J. Senior, M. Inst. C.E., past-president, superintending examiner. III. Sanitary Science, J. Lobley, M. Inst. C.E., past-president. IV. Public Health Law Work, J. T. Eayrs, M. Inst. C.E., past-president. The next examination will be held at Liverpool in October next.

LAUNCHES AND TRIAL TRIPS.

On the 14th there was launched from the shipbuilding yard of Messrs. Joseph L. Thompson and Sons, North Sands, Sunderland, a steel screw steamer built to the order of Messrs. Joseph Brown and Son, of Old Castle Buildings, Liverpool. The vessel is of about 4850 tons deadweight capacity, and is constructed in accordance with Lloyd's rules for highest classification. The engines are of the triple-expansion type, by Messrs. John Dickinson and Sons. On leaving the ways the vessel was named Netherfield by Miss Amina Brown, of Liverpool, daughter of Mr. Joseph Brown.

On Saturday, the 18th inst., the s.s. Clarence, which has been built to the order of Mr. F. le Boulanger, of Swansea, by Messrs. Craig, Taylor and Co., of Thornaby-on-Tees, proceeded to sea on her trial trip, which proved highly satisfactory. The engines, which have been constructed by Messrs. Westgarth, English and Co., Middlesbrough, worked without a hitch, and a speed of about 11 knots was maintained during a run of over three hours. The dimensions of the boat are as follows:—254ft. by 37ft. by 18ft., the engines being 19in., 31in., 51in., by 33in. stroke, with two large boilers working at 160 lb. pressure. The owner was represented by Mr. George Eldridge, of London, and Captain F. Dinan, the atter of whom will take command of the vessel.

During the current month Earle's Shipbuilding and Engineering Company, of Hull, have delivered to Messrs. Thos. Wilson, Sons, and Company, of the same town, a fine steel screw steamer named the Dido, 400ft. long, built for the Bombay trade, and capable of carrying 7200 tons deadweight; they have completed and handed over to the representatives of the Haytian Government, after successfully carrying through her speed and gun trials, a 16-knot steel gunboat, named the Crête-à-Pierrot, of 950 tons displacement, constructed under the superintendence of Sir E. J. Reed, K.C.B.; also the steam trawler Argo, owned by the Ocean Steam Fishing Company, of Grimsby; and they have in addition engined the trawler Prince, which has been built at Beverley for the Grimsby Anchor Steam Fishing Company. There is still a good share of Government and private work in hand at this yard.

Messrs. John Scott and Co. launched from their yard on the 16th the screw steamer Giang Seng, which they have built for a Chinese gentleman in Singapore. The dimensions are:—Length, 240ft.; breadth, 34ft.; and depth to main deck, 17ft. 6in. The builders have also supplied and fitted the triple-expansion engines of 160 nominal horse-power, with two large steel boilers having a working pressure of 170 lb. The vessel has been built for the coasting trade round Singapore. She will carry 1500 tons of cargo, and steam eleven to twelve knots per hour. She has a Board of Trade passenger certificate, and can accommodate twenty first-class passengers above awning deck, thirty second-class passengers in the poop, and she has also third-class accommodatfon abaft forecastle. The vessel has two teak decks, and has ample accommodation for the captain, officers, and crew. She has been fitted and finished under the superintendence of Captain Follet, who has had a long and successful experience in the trade for which the vessel is intended. The launching ceremony was performed by Miss Lily Follet, of Liverpool. The vessel, as usual, was launched with steam up, and, on leaving the ways, immediately left for Burntisland, where she will load a cargo of coals for Singapore.

On Friday, the 17th inst., Messrs. Wigham, Richardson, and Co., launched from their Neptune Shipyard, Newcastle-on-Tyne, a fine steel screw steamer, which they have in course of construction for the Chinesische Kustenfahrt Gesellschaft, of Hamburg, being intended for their service in the East. The steamer is 310ft. in length by 38½ft. beam. She will be rigged as a two-masted schooner, and is being built to attain the highest class in the registry of the Bureau Veritas and Germanischer Lloyd. She has a handsome clipper bow with a finely carved figure-head. The vessel has been specially constructed for the Chinese coasting trade, and contains handsome, well ventilated and convenient accommodation for a large number of native and European passengers. The engines and boilers are also being constructed by Messrs. Wigham, Richardson, and Co., the former being of the quadruple-expansion type, self-balanced on the well-known Yarrow, Schlick, and Tweedy system, and are intended to propel the steamer at a high speed. This type of machinery is being extensively applied to the better class of vessels, including the large mail steamers building for the Norddeutscher Lloyd. These vessels are to be larger and faster than the Majestic and Campania. A goodly company witnessed the launch, amongst whom were Mr. Drury, of Darlington, and Mr. Sutton, of Newcastle, and Captain Kohler and Engineer Blesing, representing the owners. As the vessel left the ways she was named the Loongmoon by Mrs. John Tweedy, of Newcastle-on-Tyne.

On Thursday, April 16th, Sir Raylton Dixon and Co. launched from the Cleveland Dockyards, Middlesbrough, the handsomely-modelled mail and passenger steamer Albertville, built to the order of Messrs. The African Steamship Company, London, for the Compagnie Belge Maritime du Congo, for the line between Antwerp and the West Coast of Africa. The dimensions of the vessel are:—Length, 365ft.; beam, 44ft.; depth moulded, 26ft. The cabin accommodation will be of very handsome description, fitted for 110 first-class and 60 second-class passengers, with very spacious state-rooms, specially ventilated and provided with every improvement which experience has suggested as suitable for the intended trade and the comfort of passengers in a hot climate. The first-class dining-room is in a large house on deck, panelled with marble and inlaid woods in the handsomest possible manner. The first-class smoking-room, second-class smoking-room, and cabin entrances, are all most elaborately fitted and decorated. The decks are all of teak, and over the mid-ship part of the vessel a teak shade-deck extends to the sides of the ship so as to give shelter from the sun and to form a promenade above for passengers. The second-class saloon is placed aft, handsomely panelled in teak, with tables, revolving chairs, &c. The ship will be lighted throughout with the electric light, and also provided with refrigerating machinery and a large cooling chamber for the conveyance of fresh meat, provisions, &c. Machinery of 2000 indicated horse-power will be supplied by Messrs. Thos. Richardson and Sons, of Hartlepool, consisting of triple-expansion engines, having cylinders 27in., 43in., and 72in. by 48in. stroke, with two large boilers, working at 180 lb. pressure, and fitted with Howden's forced draught. The vessel was launched in the presence of Mr. Frederick W. Bond, of London, the chairman of the African Steamship Company, and named by Mrs. Bond. The Albertville is a similar vessel to the Leopoldville, built last year for the same line, but of larger dimensions and higher speed.

THE PATENT JOURNAL.

Condensed from "The Illustrated Official Journal of Patents."

Application for Letters Patent.

*** When inventions have been "comunicated" the name and address of the communicating party are printed in italics.

9th April, 1896.

7500. Securing Picking Bands to Pickers, J. and R. A. Hopkinson, Manchester.
7501. Pneumatic Tires, S. Bunting, Birmingham.
7502. Actuating Fret Saws, A. W. Nightingale, Glasgow.
7503. Velocipedes, J. Robson, Worcestershire.
7504. Cycle Saddles, E. Denman, Bristol.
7505. Blast Pipes of Locomotive Engines, R. Jenkins, Bristol.
7506. Cutting Tool, W. J. Brown, Stockton-on-Tees.
7507. Adjustable Lever-action Spanner, W. H. Williams, Bedford.
7508. Tailors' Measure and Drafting Tape, L. Jackson, Skipton.
7509. Cutters for Boot Heel Paring Machines, W. and E. Douglas, Kingswood.
7510. Waterproof Malt Sack, L. J. Meakin, Burton-on-Trent.
7511. Prismatic Curtain for Advertising Purposes, F. P. Cox, Liverpool.
7512. Taps, C. C. Linindoll, London.
7513. Tambourine, E. Howard, London.
7514. Pocket Knives, E. Stovold, London.
7515. Automatic Apparatus for Grinding Glass, G. E. Winkelmann, London.
7516. Centrifugal Oven for Oil Stoves, &c., G. E. Winkelmann, London.
7517. Multiple-throw Cams, J. Price, D. E. Radclyffe, A. H. Smith, T. Hann, and W. Bromley, London.
7518. Centrifugal Liquid Separators, R. A. Lister.—(*J. de L. Taché, Canada.*)
7519. Adjustable Tent Poles, T. H. Cothill.—(*P. Lewis, Canada.*)
7520. Folding Knives, &c., T. H. Cothill.—(*P. Lewis, Canada.*)
7521. Axles for Wheels of Vehicles, S. Pettit, London.
7522. Pipes for Smokers, D. Hampton, London.
7523. Picking Arms for Looms, A. Sykes and T. A. Audsley, London.
7524. Mitre Board, A. T. Southern, London.
7525. Water-closets, W. Cooper and T. Cooper, London.
7526. Construction of Walls, &c., J. Sheppard and F. Dashwood, London.
7527. Sealing Letters, G. F. Dewdney, Cardiff.
7528. Combined Cameras and Optical Lanterns, B. Doyle, London.
7529. Device for use in Cleaning Buttons, O. Watkins, London.
7530. Electrical Alarm Apparatus, G. H. Atkinson, London.
7531. Knife-cleaning Device, J. W. Ellis, London.
7532. Apparatus for Aerial Navigation, M. Henderson, London.
7533. Covered Wire for Millinery, &c., P. J. Baker, London.
7534. Bottles for Aerated Liquids, &c., W. Kilsby, London.
7535. Magazine Rifles, J. Fell, jun., London.
7536. Oil Presses, &c., M. Skull, London.
7537. Production of Pigments, P. Cannell-Bunn and W. Barrett, London.
7538. Production of Anthracene Compounds, H. E. Newton.—(*The Farbenfabriken vormals F. Bayer and Co., Germany.*)
7539. Supporting Hauling, &c., Ropes, J. Temperley, London.
7540. Apparatus for Raising, &c., Loads, J. Temperley, London.
7541. Apparatus for Raising, &c., Loads, J. Temperley, London.
7542. Cyclists' Riding Brace, A. Breese, London.
7543. Petroleum Engines, D. Best, London.
7544. Waterproof Garments, L. Frankenstein, Manchester.
7545. Cycle Wheels, W. Rodger and B. Southworth, Manchester.
7546. Railway Automatic Brakes, V. B. Beer, Manchester.
7547. Nut Lock, W. Hudson and C. E. Noren, London.
7548. Vaporisers, J. S. Judge, J. McKee, and G. Edmison, London.
7549. Starting Devices for Motors, E. J. Pennington, London.
7550. Steering Devices, E. J. Pennington and A. G. New, London.
7551. Propellers, E. J. Pennington and A. G. New, London.
7552. Gear Wheels, L. C. Papenfus and L. Loewenthal, London.
7553. Crimping Tongs, G. L. Thompson, London.
7554. Corsets, J. Stone, London.
7555. Duplex Tube, J. T. Thorpe, London.
7556. Electric Railways, H. C. Regan, jun., London.
7557. Commutator Brushes, R. Hirsch, M. R. Hirsch, and J. F. Trottman, London.
7558. Treadle Gearing, J. F. Green, London.
7559. Separating Fixed Gases, W. Hampson, London.
7560. Making Cardboard Boxes, H. C. Norman, London.
7561. Baking Pans, R. S. Mains, London.
7562. Eyelets, E. Kempshall, London.
7563. Coating Confectionery, W. B. Phinney, London.
7564. Nail-strip Cutting Machine, J. A. Horton, London.
7565. Manufacturing Cycle Frames, F. A. Ellis, London.
7566. Motor-driven Velocipedes, L. Rub, London.
7567. Ornamental Strips of Clay, W. C. Lawton, London.
7568. Preventing the Stealing of Bicycles, A. G. V. Petersen, London.
7569. Manufacturing Spinning Tops, C. W. McMinn, London.
7570. Small-arms, J. Hourat and J. Castadère, London.
7571. Knitting Machine Cylinders, L. N. D. Williams, London.
7572. Circular Knitting Machines, L. N. D. Williams, London.

10th April, 1896.

7573. Portable Safety Bicycle Stand, J. Mills, Gloucester.
7574. "Gnu" Trouser Guard, R. J. and W. R. Muckley, Cheshire.
7575. Hardening Steel Pens, &c., A. H. Howard, London.
7576. Fire-grates of Refuse Destroyers, C. Christmas, Birmingham.
7577. Bracket for Window-blind Rollers, J. Cook, St. Helens.
7578. Shoe Machine Awls, A. Austin, Stafford.
7579. Kilns, E. H. Davies, Hereford.
7580. Tip-carts, T. Rowan and H. Rowan, Glasgow.
7581. Rotary Motors, W. G. Potter, London.
7582. Printing from Stencils, &c., J. R. Turnock, Hereford.
7583. Root-harvesting Machines, A. S. Logan, Newcastle-on-Tyne.
7584. Preventing the Fraudulent Re-filling of Bottles, R. H. Thomas, Youghal.
7585. Gauge Glasses, J. F. McIntosh, D. M'Callum, and R. Watson, Dundee.
7586. Improved Dust Screen for Windows, E. Young, Glasgow.
7587. Shuttles of Looms for Weaving, H. Whittaker, Halifax.
7588. Electric Ram Lift, T. Meacock, Birmingham.
7589. Manure Drills, J. Hornsby and J. Innocent, Grantham.
7590. Equally Dividing off Spaces, G. Key, Birmingham.
7591. Cycle Gear Cases, W. H. Higgitt and W. Crowson, Birmingham.
7592. Switches for Tramway Lines, H. Schmalisch, Glasgow.
7593. Coiling Spiral Springs, C. A. V. Hallgren, Glasgow.
7594. Mangling Machines, H. C. Longsdon and F. Wilkinson, Keighley.
7595. Displaying Wines, E. A. Edwards and S. Willoughby, Manchester.
7596. New Colouring Matters, Levinstein, Ltd., and I. Levinstein, Manchester.
7597. New Colouring Matters, Levinstein, Ltd., and I. Levinstein, Manchester.
7598. Muffles, J. H. Robinson, Liverpool.
7599. The "Wharam" Screw, W. Wharam, Cheshire.
7600. Boot Finishing Machines, W. and E. Douglas, and C. J. Ward, Bristol.
7601. Machine for Line Shading, L. Bonnaud, Brussels.
7602. Packing Tobacco for Smokers' Use, S. Smith, Norwich.
7603. Motive-power Engine, F. W. Lanchester, London.
7604. Stirrup-irons, A. Hamilton, London.
7605. Metal-shearing Machines, W. B. Challen and Taylor and Challen, Ltd., London.
7606. Waste or Slop Water-closets, A. Hocking, London.
7607. Fire-lighter, S. Russell, London.
7608. Cycle Gearing, O. B. Whitney, London.
7609. Machine Working by Explosions, A. E. Tavernier, London.
7610. Dyeing Straw Plait, T. Lye and W. T. Lye, London.
7611. Pneumatic Tire Valves, J. May, London.
7612. Explosive Projectiles, E. Davies and H. M. H. Goodfellow, London.
7613. Machinery for Drying Tea Leaf, N. W. H. Sharpe, London.
7614. Cycle Plate for Name, &c., J. V. D. Jéquier, London.
7615. Making Steel Sheets, R. Farley and E. Tonks, London.
7616. Tobacco Pipes, H. Allcock, London.
7617. Turbines, S. C. Davidson, London.
7618. Steering Apparatus for Ships, J. Johannsen, London.
7619. Calling the Guard in Trains, J. Chomé, London.
7620. Stopping-up the Key-holes of Doors, J. Chomé, London.
7621. Connecting Electric Circuits, J. D. F. Andrews, London.
7622. Insulating Materials, &c., J. D. F. Andrews, London.
7623. Stoppers for Bottles and Jars, S. Broadhurst, London.
7624. Utilising the Gases from Combustion, A. Guasco, London.
7625. Collapsible &c., Boxes or Cases, E. H. Archer, London.
7626. Detachable Spur Fastening, G. Kühn, London.
7627. Packing of Hydraulic Rams, &c., C. Eastwood, Liverpool.
7628. Shovel for Malt, &c., J. K. C. Chesshire, Birmingham.
7629. Pneumatic Tires, J. R. McKie, Liverpool.
7630. Ventilating Arrangements of Ships, G. Walker, London.
7631. Washing Granular Substances, T. Parkinson, London.
7632. Heating Steam Engine Cylinders, W. I. Last, London.
7633. Ink Bottles, D. H. Jones, London.
7634. Pencils, G. W. Johnson.—(*The Eagle Pencil Company, United States.*)
7635. Gear Cases for Velocipedes, W. A. Landau, London.
7636. Shirts, F. G. Metcalf, London.
7637. Tube Scraper, E. Gravesen, London.
7638. Advertising, L. C. Moore, London.
7639. Buffers for Vessels, J. Ciocki, London.
7640. Car Door Fastener, E. A. Manchester, London.
7641. Puzzles, J. G. Gareis, London.
7642. Pulley Block Sheaves, &c., V. L. Regad, London.

11th April, 1896.

7643. Manufacture of Roofing Tiles, A. Weil, London.
7644. Saucers for Flowers and Plants, H. Kinsey, Swansea.
7645. Sleeve Links, A. J. Austin, Birmingham.
7646. Skating Cycle, J. M. Chambers, London.
7647. Tricycles, A. Wichard and G. A. J. Schott, Bradford.
7648. Apparatus for Use of Umpires, R. Gillett, London.
7649. Electric Cables or Conductors, H. Edmunds, London.
7650. Coverings for Electric Cables, H. Edmunds, London.
7651. Tubes for Steam Boilers, O. Meredith, Birkenhead.
7652. Welding Lap-weld Tubes, S. Y. Goddard, Wolverhampton.
7653. Lubricating Cap Washers, C. Brigg, Bradford.
7654. Automatically Weighing Coal, J. Taylor, Glasgow.
7655. Bottling Liquids, W. H. Courtenay, Birmingham.
7656. Ventilating Boots and Shoes, W. Bacon, Coventry.
7657. Cycles, M. Carswell, jun., Glasgow.
7658. Controlling Windows, &c., G. S. Robb, Glasgow.
7659. Drawing Pins, H. Marles, Brighton.
7660. Velocipedes, A. Shelmerdine, Liverpool.
7661. Looms for Weaving, C. Hahlo, C. E. Liebreich, and J. E. Thompson, Bradford.
7662. Beaters for Whisks, Mixers, &c., J. Morton, Wishaw.
7663. Beaters for Whisks, Mixers, &c., J. Morton, Wishaw.
7664. Connecting Metal Pipes, G. Chisholm, jun., Stirling.
7665. Vacuum Motors, A. Shiels, London.
7666. Valves for Beer Engines, A. Bruce, Glasgow.
7667. Treatment of Diseases of the Rectum, O. Schmidt, Cologne.
7668. Vehicles Propelled by Steam, &c., F. Lister, Keighley.
7669. Kitchen Ranges, G. F. Calderwood, J. Learmonth, and the Planet Foundry Company, Ltd., Manchester.
7670. Trilby Cycle Brake, A. F. Germain, Brighton.
7671. Ruling Lines, J. Joly, Dublin.
7672. Furnishing Needle Cases, R. Wheatley, sen., and R. Wheatley, jun., Birmingham.
7673. The "Haggard" Boatswains' Call, E. Emanuel Portsea.
7674. Bottle, G. M. Davies, Cardiff.
7675. Bottle-rinsing Machine, J. Hube, Berlin.
7676. Working Railway Signals, Hurst, Nelson, and Co., Ld., and G. T. Wheatley, Glasgow.
7677. Rein Holder, H. Green and J. Powell, Birmingham.
7678. Letter Boxes, T. Weir, Dublin.
7679. Silent Door Hook for Ships, W. Logan, Sunderland.
7680. Gate Latch, T. B. Heathorn, London.
7681. Direct-acting Pumps, C. G. Krakau, Kent.
7682. Anti-vibration Bicycle Handle, A. W. Murray, Dublin.
7683. Repairing Pneumatic Tires, F. Forrester and T. R. Hewlett, Manchester.
7684. Valves for Pneumatic Tires, J. Cartwright, Birmingham.
7685. Hydraulic Thrust Bearings, C. A. Sadler, Birmingham.
7686. Apparatus for Bending Wood, J. Polke, London.
7687. Apparatus for Making Barrels, J. Polke, London.
7688. Drying and Seasoning Wooden Articles, J. Polke, London.
7689. Egg-shaped Boxes, F. Ginzler, A. Garner, and W. Garner, London.
7690. Lasts for Boots and Shoes, W. Firman, London.
7691. Pneumatic Tires, E. Hale, Liverpool.
7692. Making Vanilline, O. Preu, London.
7693. Generation, &c., of Acetylene Gas, P. Woog, London.
7694. Electric Traction, F. C. Esmond, London.
7695. Detachable Waterproof Sleeves, C. W. Phillips, London.
7696. Neckties and Bows, E. G. Williams, London.
7697. Cigar and Cigarette Holders, J. H. Miall, London.
7698. Umbrellas and Walking Sticks, A. S. Woollett, London.
7699. Holders for Electric Street Lamps, J. Jakoubek, London.
7700. Globes or Glasses for Incandescent Gas Lamps, S. P. Catterson and Sons, Ld., and W. P. Catterson, London.
7701. Heads for Casks, &c., T. G. and A. Stevens, Greenhithe, Kent.
7702. Advertising on Hats, L. M. Engel and H. A. Marler, London.
7703. Levelling and Surveying Instrument, L. E. M. Viard, London.
7704. Apparatus for Tilting Beer Barrels, &c., H. Searle, J. Swallow, J. B. Swallow, and P. H. Searle, London.
7705. Carriage Wheels, A. Reichwald.—(*A. Resow, Germany.*)
7706. Edge-setting Machines, M. T. Deune and P. Cave, London.
7707. Upholstering Ships' Cabins, J. Finch and J. H. Rider, London.
7708. Buckles, A. Richter.—(*W. Berg, Germany.*)
7709. Manufacture of New Derivatives of Amido- 1 alphyl- 2 alkyl- 5 Pyrazolones, O. Imray.—(*The Farbwerke vormals Meister, Lucius, and Brüning, Germany.*)
7710. Construction of Submarine Bridges, O. Imray.—(*The Channel Bridge and Railway Company, Ld., France.*)
7711. Manufacture of Fuzes or Match Cords, M. Wagner, London.
7712. Compounds of Albumen and Protein Bodies, A. Classen, London.
7713. Sliding and Swinging Sashes of Windows, S. Naylor, London.
7714. Weaving Selvages, G. Browning, W. A. Johnson, and F. Maydwell, London.
7715. Photographic Washing Vessel, A. A. Bradburne, London.
7716. Connection for Electric Light Cables, R. J. Hatton and W. T. Henley's Telegraph Works Company, Ld., London.
7717. Flaying Knife, R. Graeme, London.
7718. Cloths for Filter Presses, A. J. Boult.—(*H. W. J. van O. Bastiaans, Germany.*)
7719. Revolving Receptacles, F. W. Schafer and A. E. Batson, London.
7720. Ornamentation on Palm Leaves, G. Walker, London.
7721. Testing and Disinfecting Drains, C. T. Kingzett, London.
7722. Envelope, G. A. Tydeman and E. Newton, Waltham Cross.
7723. Formation of Printed Designs upon Fabrics, A. Scheurer, London.
7724. Manufacture of Double Barrels for Fire-arms, P. L. O. de Gérente and Y. A. M. P. Goubaux, London.

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7725. Printing Designs upon Calico, I. Frankenburg, Manchester.
7726. Attaching Containers to Stands, T. J. Sturgeon, London.
7727. Sewing Machines, W. H. Dorman, Stafford.
7728. Packing for Taps, Cocks, &c., W. J. Simmons, Bristol.
7729. Show Cases, J. Gibbs, Bristol.
7730. Pasting Machines, J. J. Cramp, Coventry.
7731. Boots and Shoes, C. E. and W. T. Wright, Leicester.
7732. Driving Gear for Cycles, H. B. Webber, Dorking.
7733. Shoulder Pad for Coats, &c., W. H. Sladdin, Brighouse.
7734. Organ Stop, J. T. Hanson, London.
7735. Metallic Packings, J. Wood, Manchester.
7736. Pickle Fork, G. A. Brookes, Manchester.
7737. Marking Patterns, R. Greenhalgh, Manchester.
7738. Raising Nap on Fabrics, J. D. Tomlinson and J. Porter, Manchester.
7739. Machine Belting, J. Sharples, Birmingham.
7740. Attaching Blinds to Rollers, G. M. Davies, Cardiff.
7741. Railway Game, H. J. Tremellen, Newport, Mon.
7742. Colour Game, H. J. Tremellen, Newport, Mon.
7743. Swivels, W. Dipple, Birmingham.
7744. Match-boxes, W. J. Clapp and F. P. Robjent, Newport, Mon.
7745. Casting Partly Chilled Objects, W. H. Browning and J. G. Heywood, Manchester.
7746. Washer for Cleaning Clothing, E. W. Margetts, Stourbridge.
7747. Pneumatic Tires, W. G. Potter, London.
7748. Rotary Motors, W. G. Potter, London.
7749. Vessels for Warming Plates, T. F. Senior, Sheffield.
7750. Closing Gates, E. G. Herbert, Manchester.
7751. Boots, C. C. Hutchinson, London.
7752. Attachment Bosses of Saddles, J. B. Brooks, Birmingham.
7753. Umbrella Ring, F. Roberts, London.
7754. Swivel, E. Wade and W. Mindham, Barnsley.
7755. Swing-bar Balance, J. T. Bucknill, Thornfield Bitterne.
7756. Steam Traps, W. Donald, Glasgow.
7757. Packing for Piston-rods, J. O. Morgan, Newcastle-on-Tyne.
7758. Oil Stoves, A. H. Griffiths and T. B. Smith, Birmingham.
7759. Timing the Game of Billiards, J. Newman, Durham.
7760. Double Pole Switches, F. W. Heaton and H. Smith, Manchester.
7761. Shut-all Bolt for Doors, J. N. M. M. Brisc Dublin.

7762. TRUSSING SECTIONS of RAILWAYS, G. V. de Luca, London.
7763. STOPPERING of BOTTLES, &c., S. H. Baines, London.
7764. MEANS for GENERATING STEAM, P. Pinckney, Portsmouth.
7765. MACHINERY for TRUSSING STRAW, R. Maynard, London.
7766. COLOURING MATTER, J. Y. Johnson.—(*The Badische Anilin und Soda Fabrik, Germany.*)
7767. DRIVING GEAR of BICYCLES, P. M. Carter, London.
7768. RESTS for CYCLES, The Automatic Cycle Stand Ld., and J. J. Shedlock, London.
7769. HEATERS, G. A. Watson, London.
7770. GAME APPARATUS, R. Booth, London.
7771. PREVENTION of THEFTS from PILLAR BOXES, D. Shawe, London.
7772. SPIRAL SPRING TIRE, H. L. Todd and W. Wright, London.
7773. LIGHTING of LAMPS, R. Godfrey and J. P. Norrington, London.
7774. MACHINERY for CLEANING BOOTS, C. C. Eminson, London.
7775. SEWING MACHINES, M. T. Denne, London.
7776. PROCESS for HARDENING IRON, A. Tauxe, London.
7777. STOOLS, The Patent Stowaway Stool Co., and T. H. Lewis, London.
7778. METHOD of CLOSING BUNGHOLES, C. E. Müller, London.
7779. ADJUSTABLE CORNICE POLE JOINTS, E. Corbridge, London.
7780. FOOTBALL and CRICKET BOOTS, W. Barber, London.
7781. A NEW CLOTH PLEATER, &c., W. B. Mulligan, London.
7782. EXTENSION TABLE, H. Grant, London.
7783. OBTAINING GOLD, W. P. Thompson.—(*E. Wohlwill, Germany.*)
7784. LOOMS, H. R. Ross, Manchester.
7785. PROTECTING SHIPS' BOTTOMS, &c., J. Sanders, London.
7786. CRAVAT ATTACHMENT, C. A. Jensen.—(*C. J. Schildhorn, Germany.*)
7787. BRAKES for CYCLES, A. Frampton, London.
7788. COLOURING MATTERS, O. Imray.—(*G. H. Weiss, Germany.*)
7789. ELECTRIC ARC LAMPS, J. Brockie, London.
7790. BUTTER DRYING APPARATUS, T. Bradford, London.
7791. STOP MOTIONS for ENGINES, L. St. Peter, London.
7792. CORSETS, E. and S. Kohnberger, and A. Neumann, London.
7793. MANUFACTURE of a NEW PRODUCT, C. Stahlschmidt, London.
7794. SHADE HOLDERS, H. A. C. Hellyer, London.
7795. SHAFT and BLAST FURNACES, &c., F. Burgers, London.
7796. OBTAINING SALT from BRINE, W. Shedlock, London.
7797. DRIVING MECHANISM for FUNNELS, G. R. Gaunt, Bradford.
7798. LETTER FILE, A. Kojer, London.
7799. INKPOT, S. Coppen, London.
7800. MOTIVE POWER ENGINES, W. Clarke, London.
7801. ZOETROPIC PICTURES, B. J. B. Mills.—(*A. and L. Lumière, France.*)
7802. STERILISING MILK, CREAM, &c., A. T. Pfeiff, London.
7803. ROOT CUTTING or PULPING MACHINES, S. B. Bamford, London.
7804. DRESS FASTENERS, B. A. Spaull, London.
7805. CORN and SEED DRILLS, J. Wilson, London.
7806. INDIA-RUBBER SPRINGS, &c., A. G. Spencer, London.
7807. CYCLES, C. Hill, London.
7808. NAVIGABLE BATTLE FORTS, J. F. Crease, London.
7809. PHOTOGRAPHIC APPARATUS, G. R. Sanson, London.
7810. WHEELS, F. W. Horridge, London.
7811. GUN FITTING, A. W. Swallow, London.

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7812. DRILL CHUCKS, D. Weir, London.
7813. CYCLES, W. G. MacIvy, London.
7814. PERAMBULATOR-MAILCART BODIES, G. P. Taylor, Birmingham.
7815. WHEELS of CYCLES, R. Malkin and T. Bowyer, Manchester.
7816. STEEL RE-HEATING FURNACES, W. Trewhitt, Middlesbrough.
7817. TAKING PHOTOGRAPHS, J. Oulton W. Shaw, and R. H. Adams, Bradford.
7818. METALLIC SOUND-RESISTING BOARD, F. C. Steinmetz, London.
7819. APPARATUS for SUPERHEATING STEAM, G. Sinclair, Glasgow.
7820. MOVABLE PARTITIONS, &c., C. Strapps, Manchester.
7821. LACE-SECURING ATTACHMENT, J. G. Rollason, Birmingham.
7822. OIL ENGINES, H. N. Bickerton, Manchester.
7823. TRIVETS, T. le Poidevin, Guernsey.
7824. CYCLE TIRES, T. Guthrie, Newcastle-on-Tyne.
7825. APPARATUS for COMPRESSING AIR, M. E. Clark, Manchester.
7826. POLISHING CLOTH, J. J. Ashworth, Manchester.
7827. SPLIT PIN, J. Barker, Oldham.
7828. MATS for the SEATS of TRAMCARS, H. Haley, Manchester.
7829. MATCH-BOXES, F. Hutchins, London.
7830. MACHINE for SOWING TURNIP SEEDS, W. Doyle, Dublin.
7831. SPEED of VESSELS, J. Davis, Bradford-on-Avon.
7832. AUTOMATIC TAPPING ATTACHMENTS, F. A. Errington, London.
7833. RIVETING MACHINES, J. Johnson.—(*C. B. Albree, United States.*)
7834. ELECTRIC RAILWAYS, A. S. Krotz, W. P. Allen, and O. S. Kelly, Manchester.
7835. TWIN PEG and BALL TOY, H. J. Tremellin, Newport, Mon.
7836. VALVE MOTION of BEER, &c., ENGINES, A. Bruce, Glasgow.
7837. LINOTYPE PRINTING MACHINES, R. H. H. Baird and I. Hall, Glasgow.
7838. STEAM BOILER FURNACES, T. Hineson, Ashton-under-Lyne.
7839. LABEL and TICKET HOLDERS, S. Learoyd, Huddersfield.
7840. GARDEN ROLLERS, F. Brangwin and H. F. Baly, London.
7841. POSITIVE DRIVE for SPINDLES, T. Sowerbutts and J. Watson, Accrington.
7842. TILT for SUPPORTING TARPAULINS, J. Tilley, North Shields.
7843. OIL TANK WAGONS, A. S. Nelson, Glasgow.
7844. FLANGING the MANHOLES in BOILERS, W. Fairweather.—(*The Babcock and Wilcox Company, United States.*)
7845. SECURING SPOKES in CYCLE WHEELS, A. C. Tennant, Seacombe, Cheshire.
7846. PHOTOGRAPHIC CAMERAS, R. Dobson, Glasgow.
7847. RUBBER TIRES, J. D. Beebe, London.
7848. CAR MOVERS, P. H. Jacobus, London.
7849. DISENGAGING BOATS on SHIPS, R. Anderson and W. Prentice, London.
7850. SHIPS' DAVITS, R. Anderson and W. Prentice, London.
7851. BOTTLE LABELLING MACHINE, H. S. Grace and A. D. Reynolds, Birmingham.
7852. MUSIC LEAF TURNER, H. B. Kirk, London.
7853. DEVICES for ELEVATORS, Otis Elevator Company, Limited.—(*Otis Bros. and Co., United States.*)
7854. REGULATING ELECTRIC MOTORS, Otis Elevator Company, Limited.—(*Otis Bros. and Co., United States.*)
7855. RAILWAY PERMANENT WAYS, J. Butterworth, London.
7856. TYPEWRITING MACHINES, J. Y. Johnson.—(*The Philadelphia Typewriter Company, United States.*)
7857. MACHINE for STONING RAISINS, E. Sutherland, London.
7858. VEHICLES PROPELLED by OIL, A. G. New, London.
7859. RETAINING RAILWAY WINDOW SASHES, W. Shears, London.
7860. PRINTED SHEET DELIVERING MECHANISM, W. Scott, London.
7861. LADIES' IMPROVED SKIRT for CYCLING, W. Evans, London.
7862. LEAD PRESSES, A. J. Boult.—(*H. B. Cobb, United States.*)
7863. AXLE-BOXES, F. A. Sürth, London.
7864. HOOKS and EYES, J. F. Schoeppl and W. Heeren, Leeds.
7865. SEPARATING LAMINATED PACKS, F. McCarty, London.
7866. COPING BRICKS, &c., J. Hamblet and I. Parkes, London.
7867. BAND SAW GUIDES, W. McBeth, Canada.
7868. DRYING WHITE LEAD, T. C. Sanderson, London.
7869. GENERATING ACETYLENE GAS, H. A. Kent, London.
7870. PNEUMATIC TIRES, The Scottish Manufacturing Company, Ltd., and A. Macdonald, Glasgow.
7871. PNEUMATIC TIRES, The Scottish Manufacturing Company, Ltd., and A. Macdonald, Glasgow.
7872. HOISTING MECHANISM, P. Jensen.—(*P. Egan, United States.*)
7873. POWER TRANSMITTERS, P. Jensen.—(*P. Egan, United States.*)
7874. WELT-SEAM TRIMMING MACHINES, Z. T. French and W. C. Meyer, London.
7875. FIRE BUCKETS, W. R. Myers, London.
7876. FIRE-ESCAPES and LADDERS, J. C. Merryweather, London.
7877. MAKING CARPETS, A. H. Brinton and F. E. Tucker, London.
7878. FURNACES, W. R. Jones, London.
7879. IMPROVED BLIND ROLLER, J. W. Griffiths, London.
7880. COFFEE SUBSTITUTES, R. Haddan.—(*Kathreiners Malzkaffee Fabriken mit beschrankter Haftung, Germany.*)
7881. ELECTRIC TRANSFORMERS, J. Devonshire.—(*W. S. Moody, United States.*)
7882. ELECTRIC MOTORS, J. Devonshire.—(*W. B. Potter, United States.*)
7883. ELECTRIC MOTORS, J. Devonshire.—(*C. P. Steinmetz and E. J. Berg, United States.*)
7884. ELECTRIC POWER SYSTEMS, J. Devonshire.—(*E. J. Berg, United States.*)
7885. INCANDESCENT LAMP BASES, J. Devonshire.—(*J. H. and A. Pelterquist, United States.*)
7886. TANNING HIDES, V. Gallien, London.
7887. FIRE-GRATES and STOVES, W. H. Harvey, London.
7888. PRODUCING AERIAL DISPLACEMENT of ONE or MORE PERFORMERS on the STAGE of a THEATRE, W. P. Thompson.—(*C. E. Pritchard and J. B. Braut, France.*)
7889. ACTUATING the CUT-OFF GEAR of CORLISS and other ENGINES, J. S., T. A., and E. R. Walker, Liverpool.
7890. LAMP or STOVE WICKS, E. E. Joyce, Liverpool.
7891. FASTENINGS for BAGS and MUSIC CASES, A. D. Southgate, W. G. Southgate, and A. Scherzinger, London.
7892. PLASTERING COMPOUNDS, J. E. Summers and J. H. Ogburn, London.
7893. RADIANT HEAT BATHS, J. H. Kellogg, London.
7894. MAKING an ALIMENTARY PRODUCT, J. H. Kellogg, London.
7895. ORNAMENTAL FABRICS, A. H. Kursheedt, London.
7896. ELECTRIC HAIR CUTTERS, F. M. Bell and J. L. Sloss, London.
7897. MILITARY INTRENCHING TOOLS, &c., T. Rowe, London.
7898. CULTIVATING BACTERIA, H. H. Lake.—(*L. von Lorentz, Germany.*)
7899. OVENS for DRYING and BURNING TILES, R. Stanley, London.
7900. BAND BRAKES, C. R. Hutchings, London.
7901. APPARATUS for MIXING AIR and GAS, J. M. Mitchell, London.
7902. CARVING MACHINES, S. Pitt.—(*F. Snow, United States.*)
7903. CAGES for FOWLS and other ANIMALS, C. Hüsgen, London.

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7904. COFFEE, H. Boisselier, Enfield.
7905. FASTENING the SOLES to BOOTS, H. W. Boswell, Dartford.
7906. HEMSTITCH MACHINES, J. Walker, Belfast.
7907. BREECH-LOADING GUNS, E. C. Green, Cheltenham.
7908. TILES, F. J. D. Hüllinghorst and G. Ewart, London.
7909. MACHINE for CONTRACTING TIRES, W. G. Mullett, Bristol.
7910. PROCESS to OBTAIN AMMONIA, J. Plummer, Midlothian.
7911. TOY GUNS, &c., R. Smith, Rishton, near Blackburn.
7912. TOASTING APPLIANCES, J. R. G. d'Almeida, London.
7913. FURNACES, E. Johnson and J. Thompson, Lemington-on-Tyne.
7914. PRINTING PRESSES, F. Waite and Waite and Saville, Ld., Bradford.
7915. ROLLER BLINDS, J. Oulton, W. Shaw, and R. H. Adams, Bradford.
7916. BOOTS, R. G. Jones, Swansea.
7917. COMBINED BOILER, BATH, &c., W. Mould, Birmingham.
7918. STEAM-BOILER and other FURNACES, J. Murray, Glasgow.
7919. TRANSIT BASKET, A. E. Catchpole and Harrod's Stores, Ld., London.
7920. DRAUGHT EXCLUDERS for DOORS, W. H. Kewer, London.
7921. HARROWS, R. A. Dennett, London.
7922. PULLEY BLOCKS, G. T. Winnard and J. Bedford, Sheffield.
7923. SUPPLYING ACETYLENE GAS to VEHICLES, T. Durnan, Sheffield.
7924. AXIS TRACTOR, R. C. Macdonald, Glasgow.
7925. PRESERVING STUD HOLES in SHIRT FRONTS, A. H. Binnie, Glasgow.
7926. SIPHON FLUSHING CISTERNS, H. E. Brice, Birmingham.
7927. WAIST BELTS, H. T. Ollard, Birmingham.
7928. ELECTRIC SIGNAL INDICATOR, M. Mercier, Manchester.
7929. OUTER COVERS of PNEUMATIC TIRES, A. Latimer, Birmingham.
7930. RACK for HOLDING COATS, &c., J. Penrose, London.
7931. INHALATORY APPLIANCES, A. M. Hugill and J. Overton, Manchester.
7932. CABINET-MAKING, J. Schuler and M. Wuzel, Halifax.
7933. GAS COOKING APPLIANCES, E. P. Greenwood, Manchester.
7934. WINDOW FASTENER, T. Howard and J. Hallan, Hendon.
7935. SPINNING and TWISTING MACHINES, J. Boyd, Lanarkshire.
7936. FIRELIGHTER, C. H. Silson and F. Robinson, Bradford.
7937. HARNESS for HORSES, E. Garnier and S. J. Prescott, London.
7938. LOOSE SOCKETED SEWER PIPE JOINT, C. Lee, London.
7939. TRANSMISSION of POWER, F. R. Simms.—(*W. Maybach, Germany.*)
7940. HEATING APPARATUS, F. R. Simms.—(*W. Maybach, Germany.*)
7941. HARDENING STEEL PLATES, J. A. Mays, London.
7942. SMOKING PIPE, S. Comoy, Accrington.
7943. INDIA-RUBBER STAMPS, J. S. Elder, Glasgow.
7944. BICYCLES, P. M. Staunton, Dublin.
7945. UPRIGHT LEVER with CENTRE SPRING, J. R. Knight, Blackrock.
7946. SASH WINDOW FASTENER, H. Stringer, Willenhall, Staffs.
7947. SASH-LIFT BOWS, B. Drysdale and T. R. Voce, Birmingham.
7948. COMBINED TROUSERS and KNICKERBOCKERS, B. P. Hughes, London.
7949. LET-OFF MOTIONS for LOOMS, J. Crabtree, J. Robinson, and J. W. Haworth, London.
7950. SELVEDGE WEAVING APPARATUS, E. T. Whitelow, Manchester.
7951. COMPOUNDS for the INSIDE of BARRELS, G. Stacey, London.
7952. HORSESHOES, W. H. Crawcour, London.
7953. MANUFACTURE of STOCKINGS and SOCKS, W. L. Hill, London.
7954. DETACHABLE BUTTONS, A. E. Webb, London.
7955. INCANDESCENT GAS BURNER, &c., C. Howard, London.
7956. CONSTRUCTION of UNIONS, &c., G. S. Trafford, London.
7957. BOXES, H. and H. Inman, London.
7958. ROOFING TILES, G. Power, London.
7959. VENT PLUG, S. H. Robinson, London.
7960. DEVICE for PRESERVING the EYESIGHT, B. A. Dorst, London.
7961. DRIVING GEAR for BICYCLES, W. D. Scott-Moncrieff, London.
7962. CENTRIFUGAL GOVERNORS, J. N. and W. Paxman and J. C. Peache, London.
7963. PRINTING MACHINES, E. Graber and L. Hepworth, London.
7964. LAMP CHIMNEY, G. Rowlands, London.
7965. FUNNEL, L. Kemp and J. E. Smurthwaite, London.
7966. TIRES for CYCLES, F. W. Randall, London.
7967. LAMPS, W. Staveley, London.
7968. BOTTLE and STOPPER, W. Youlten, London.

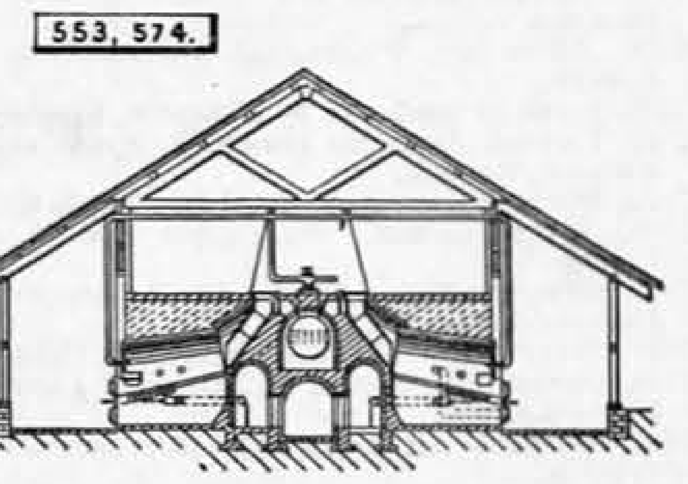
SELECTED AMERICAN PATENTS.

From the United States Patent Office Official Gazette.

553,574. INCINERATOR, *C. Thackeray, Montreal, Canada.—Filed July 30th, 1894.*

Claim.—(1) An incinerator having a main flue for the products of combustion, auxiliary flues running parallel thereto, suitably controlled communicating passages between the main and auxiliary flues, series of furnaces and combustion chambers laterally adjoining the auxiliary flues, main transverse communicating passages, suitably controlled, between said combustion chambers and the main flue, and auxiliary transverse communicating passages, suitably controlled, between said combustion chambers and said auxiliary flues, for the purpose set forth. (2) An incinerator having a main flue for the products of combustion, a series of main furnaces and combustion chambers laterally adjoining said flue, suitably controlled transverse communicating passages between the combustion chambers and said flue, and a series of auxiliary cells arranged in alternate order with said main furnaces and communicating on each side with same, for the purpose set forth. (3) An incinerator having a main horizontal flue for the products of combustion, a chimney located at one end of same,

553,574.

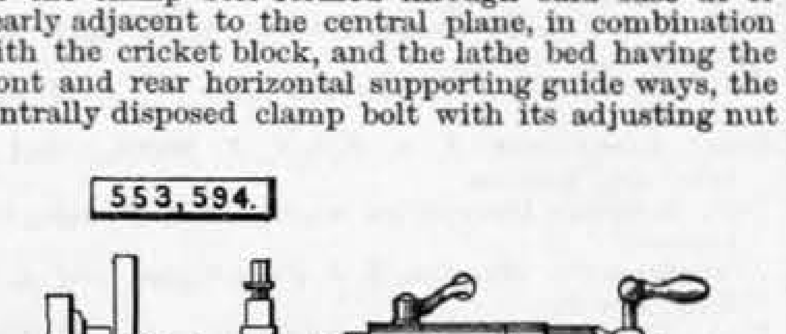


a central auxiliary flue and outer auxiliary flues running parallel with the main flue, suitably controlled communicating passages between said central auxiliary flue and main flue, series of furnaces and combustion chambers laterally adjoining the outer auxiliary flues, main transverse communicating passages, suitably controlled, between said combustion chambers and the main flue, auxiliary transverse communicating passages, suitably controlled, between said combustion chambers and said auxiliary flues, series of auxiliary furnaces or cells arranged in alternate order with said main furnaces and communicating on each side with same, a steam boiler located in said main flue, and suitable conductors connected with said boiler, and serving to convey superheated steam to said furnaces or cells, for the purposes set forth.

553,594. ENGINE LATHE, *F. F. Prentice, Worcester, Mass.—Filed February 4th, 1895.*

Claim.—(1) The tail stock for engine lathes, having the horizontal base or seat-plate 4, the body or standard 5 integrally disposed upon said base wholly in rear of its central line, with the integral forwardly over-hanging tail-spindle bearing 6 at the top of said body, the upright front of the body backwardly recessed as at 8, below said bearing; and the hole 9 for the clamp bolt formed through said base at or nearly adjacent to the central plane, in combination with the cricket block, and the lathe bed having the front and rear horizontal supporting guide ways, the centrally disposed clamp bolt with its adjusting nut

553,594.



above the foot and beneath the spindle bearing, all substantially as shown and described. (2) The combination of the low cricket block having the top seating surface with transverse guide, the tail-spindle support composed of the base or seating plate adjustably mounted on said cricket block, the body standard integral with said base and standing thereon substantially in rear of the central vertical plane, the back of said body forwardly arched and carrying the integral forwardly overhanging bearing at the top thereof, the tail-spindle mounted in said bearing, the clamp bolt arranged through an opening in said base approximately adjacent to the centre plane, with its operating nut disposed above the top of the base and beneath the bearings, the binding shoe on said bolt, and the set over adjusting screw in said cricket, all substantially shown and described.

553,607. CANE MILL, *C. A. Calvert, Buffalo, N.Y.—Filed July 2nd, 1895.*

Claim.—(1) In a cane mill, an imperforate bottom plate provided with a raised flange or rim forming a pan, and with journal pockets having their walls extended above the bottom of the pan and their bottoms on a level therewith, and provided in their inner walls with openings or passages arranged above the bottom of the pan, whereby the pockets communicate with the surrounding space of the pan, substantially as set forth. (2) In a cane mill, the combination with the bottom plate having a raised rim or flange forming a pan, and a pair of opposing journal pockets extending above the bottom plate, of a horizontal bridge piece connecting said pockets, having a bearing for the lower journal of a scraper and raised above the bottom plate, whereby a space is left between the

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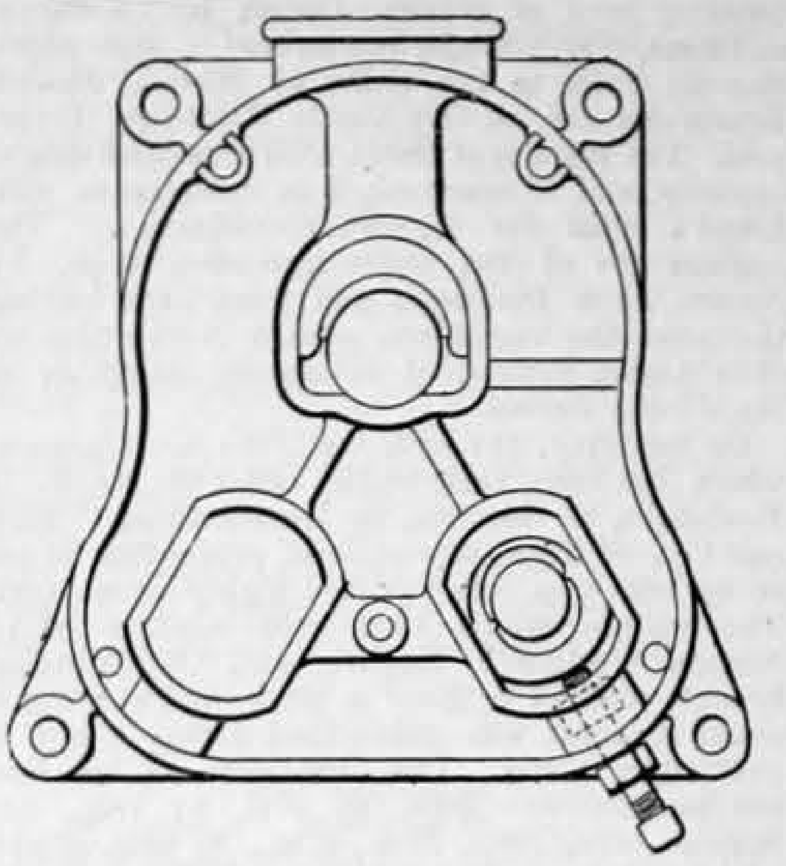
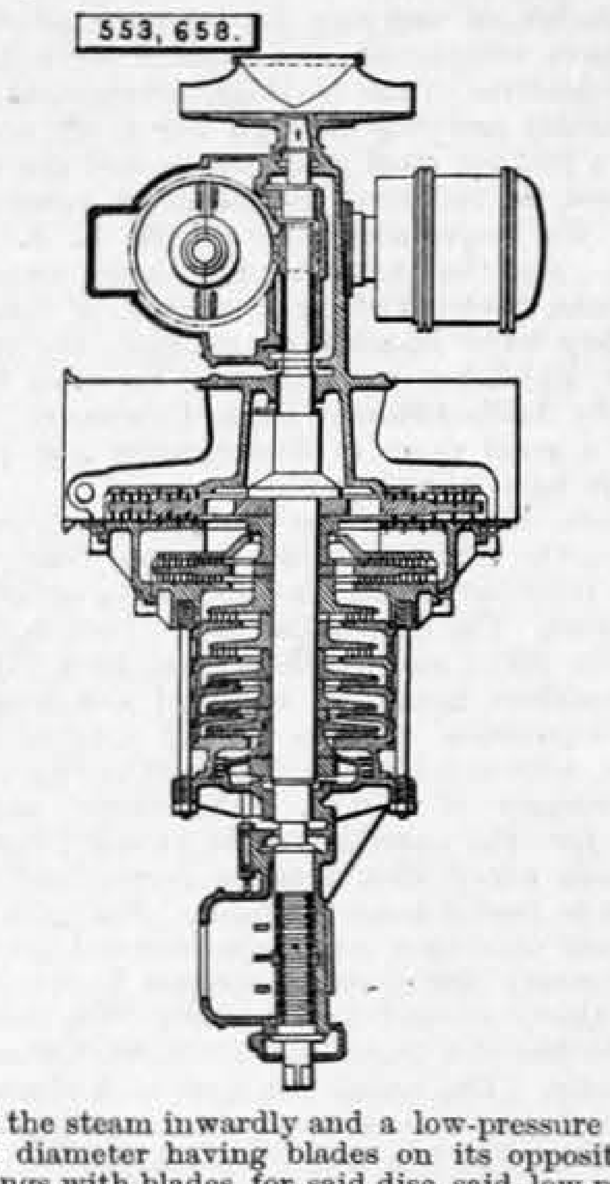


bridge piece and the bottom plate for the removal of chips, substantially as set forth.

553,658. TURBINE MOTOR, *C. A. Parsons, Newcastle-upon-Tyne, England.—Filed February 21st, 1895.*

Claim.—In a steam turbine, a shaft, high-pressure discs thereon having lateral blades, fixed rings intermediate of the discs having lateral blades alternating with the blades of the discs, said rings extending inwardly toward the shaft, and providing passages to

553,658.

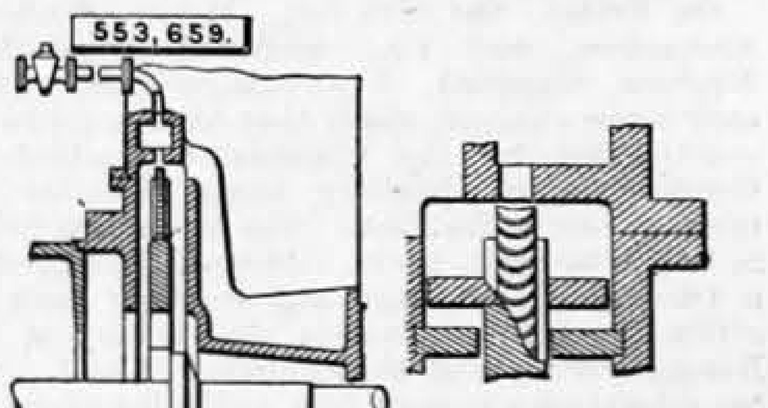


direct the steam inwardly and a low-pressure disc of larger diameter having blades on its opposite sides and rings with blades for said disc, said low-pressure disc having perforations at the central portion for the passage of the steam through to the opposite side of the disc, substantially as described.

553,659. STEAM TURBINE, *C. A. Parsons, Newcastle-upon-Tyne, England.—Filed February 21st, 1895.*

Claim.—In combination in a steam turbine, the casing, the disc therein having openings A' therethrough and the buckets F disposed on the sides of

553,659.

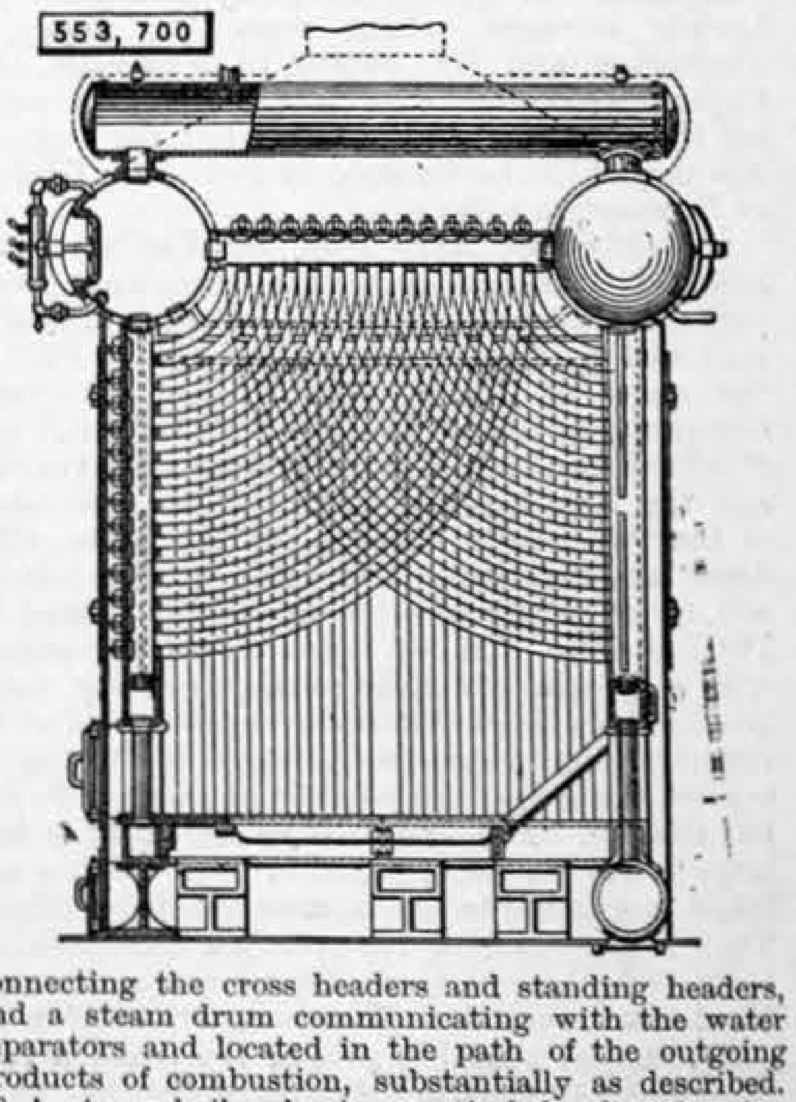


the disc, the blades E fixed to the casing and the peripheral buckets B with means for directing the jet thereto, substantially as described.

553,700. MARINE BOILER, *R. R. and H. L. Zell, Baltimore, Md.—Filed February 24th, 1893.*

Claim.—(1) A steam boiler, comprising side walls made up of series of water-tubes having top and bottom headers, front and rear walls made up of standing headers with intermediate doors, the doors of the one wall being opposite the headers of the other wall, a mud-drum communicating with the bottoms of the headers of the rear wall, water separators communicating with the standing headers at their upper ends and with the top headers of the side wall tubes, cross headers connecting the water separators, curved tubes

553,700



connecting the cross headers and standing headers, and a steam drum communicating with the water separators and located in the path of the outgoing products of combustion, substantially as described. (2) A steam boiler, having vertical headers forming part of the end walls of the combustion chamber, and water-tubes traversing said combustion chamber diagonally from opposite headers, and doors in the end walls of the combustion chamber between the headers, substantially as described.