building iron and steel war ships. A similar plant had since been erected at the shipyard of the Gorges et Chantiers de la Loire, at Penhouet, near St. Nazaire, illustrations of which were given, as also of another machine at Brest, which was now being constructed from the Author's designs. Other applications of hydraulic pressure were then referred to, such as for forging and stamping. The Authors held that the successful carrying out of hydraulic forging would depend greatly on the skill brought to bear in making the dies and moulds.

As to the productive power and efficiency of machine-tools generally, and the mode of increasing them, the Author observed that the cost of manufacturing depended upon the productive power of the tools employed, and upon the possession of facilities for transporting the material to and from them. Ample lifting and transporting arrangements should be provided in all cases. At present a large amount of lifting was done by manual labour, in which there was room for great improvement. Owing to the necessity hitherto of using belting or gearing for working them, power-cranes had only been applied to machine-tools to a limited extent as a means for increasing their output. The Author pointed out that by the adoption of portable hydraulic machine-tools a great saving in floor-space might be effected. The introduction of hydraulic capstans had practically annihilated space in docks and railway-yards, and as the hauling of a given weight on a good road required less power than lifting it, an extended application of such machinery to engine-works was to be anticipated. The suitability of this system to increasing the output of large engineering shops and ship-yards was evident, and safety in lifting was ensured in hydraulic cranes by the impossibility of workmen putting on them a greater load than they were calculated to bear.

On the third head, namely, the increased productive power and efficiency obtainable by the employment of hydraulic pressure for working machine-tools, the Author observed that so far as the prime mover was concerned, the power necessary in a hydraulic system to pump water into the accumulator was nearly always obtained from a steam-engine; but even at this early stage the hydraulic system, by the use of the accumulator, allowed of a considerable reduction in the size of the motor. A comparatively small prime mover running continually, stored up sufficient energy to meet any sudden demand from even the largest of the machines worked from it; while, on the other hand, the prime mover would have to be equal to this. This defect was to a small extent met by the use of fly-wheels, which were, however, objectionable from their liability to accidents, and from the strains to which the shafting was subjected. From 200 to 300 blows per minute had been obtained in hydraulic machines, and in machine-tools and cranes the accumulator acted as a perfect safety-valve. Then, for the transmission of power to points distant from the prime mover, hydraulic pressure was the most economical. By the use of hydraulic mains laid underground, all overhead shafting was dispensed with. Under the present system lines of shafting, to a great extent, regulated the position of the machines. In a recent case, 48,000 square feet were required with shafting, while 32,000 square feet only were necessary when arranged for hydraulic transmission. In this case the cost of all the roofing and flooring of a building 300 feet long, 53 feet wide, and 25 feet high was saved. A pipe of 1 inch bore could transmit nearly 6 5 h.-p. at a very moderate velocity of water, and a 2-inch pipe about 25 h.-p. All danger from the use of belts and pulleys was avoided, and when once laid in the ground it needed no further attention.

The next question was as to the suitability of hydraulic pressure to actuating the tools. It had already been employed for slotting and planing-machines, and its application to rotary machines might even become as economical as any other. The simplicity and fewness of parts in all hydraulic machine-tools was a source of great economy. In respect to the economical application of force through each individual machine when performing such an operation as punching, the machine was moving at its lowest speed, and friction was at a minimum when most work was being done. Again, hydraulic machines consumed no power except when actually doing work, while it was not unusual in a machine-shop to see all the shafting running in order to drive a small tool at its extremity. With hydraulic machines it was immaterial whether the machine was 2 feet or 2,000 feet from the accumulator, only the exact quantity of water necessary to perform the operation was consumed. In conclusion, the Author stated that apart from questions of economy attention might be directed to several of the advantages arising from the application of hydraulic power to special cases. In riveting-machinery it rendered it possible in one and the same machine to close the plates with a steady pressure, to fill the rivet-hole without forcing the metal of the rivets in between the plates, and to give the metal a sharp blow; not only could the heaviest machine be lifted, but the machines could be attached to their work. In punching and shearing machinery much greater accuracy was ensured from the perfect control of the moving punch or knife, whose descent could be arrested even after it had touched the plate. Steel plates were less injured when punched by steady hydraulic pressure. Hydraulic punching and shearing-machines required no foundations, and could be readily taken on board ship, thus saving much carrying to and fro of plates. It was often desirable to follow up the effects of a sharp blow by maintaining a continued steady pressure. This was illustrated by the Author, who described an "impact" accumulator, and pointed out the difference of effect of a number of light blows as compared with one heavy one in the case of hydraulic riveting. Similar conditions applied to forging. The indirect advantages due to the uniformity of all the work applied also to the flanging-machinery, and in fact to everything passing through dies and blocks. He thought that even small firms might find it advantageous to combine in the erection of a common pumping-station, and so to obtain many of the economical benefits due to carrying out operations on a large scale.

The second Paper read was on "Stamping and Welding under the Steam-Hammer," by Mr. Alexander McDonnell, M. Inst. C.E. It was observed that the making of iron forgings under the steam-hammer in moulds or dies of simple form had long been practised. They had commonly been of scrap or fagotted iron, were often roughly finished, and much heavier than necessary, requiring too much to be taken off by planing or shaping to finish them. Very few forgings had been produced of a complicated shape, or built up of several pieces, under the hammer when common bar-iron was used. The steam-hammer had always been employed for welding in completing the rings of waggon-wheels, and in stamping wheels according to the system of Mr. Arbel. So far as the Author was aware, little had been done to make smaller forgings, welding together several pieces. He thought sufficient care had not been taken in the drawing office to design forgings so that they could be stamped, and that proper precautions had not been observed by the manager of the works or the foreman-smith, to arrange the material, so that the welds should be made in the right way, the metal flowing in the right direction to fill the mould, and the grain of the iron placed so as to get the greatest strength. Stamping in moulds gave a uniformity and accuracy which afforded great advantages where large numbers of similar objects were made. The Author had carried out the system of stamping and welding carriage and waggon iron-work for some years at the Inchicore Works of the Great Southern and Western Railway of Ireland. He contrasted the cost of stamped forgings as compared with forgings by hand, showing that for the more complicated forms, the former process was the cheaper. Although for some purposes the steam-hammer was necessary, he believed many forgings would be better made by hydraulic forging-presses. Finally, he explained the method of making stamped forgings, by giving a detailed account of the manner of forging a number of different articles, which had been selected as fair samples of forgings of carriage and waggon iron-work.

Meeting on Feb. 13th., Mr. Brunlees in the Chair. A paper read was on "The Design and Construction of Repairing-Slipways for Ships," by Mr. T. B. Lightfoot, M. Inst. C. E., and Mr. John Thompson.

After reference to the first introduction of cradles on roller by the late Mr. Morton, of Leith, in the year 1819, a description was given of a modern slipway, capable of dealing with vessels of about 2,500 tons gross weight, and up to 300 feet in length. Four sections were dealt with in detail, viz., the foundations, the ways, the cradle, and the hauling machinery, and allusion was made to the gradient, which had generally to be determined by a consideration of the amount and value of land at disposal, by the depth of water to be provided over the cradle, and sometimes by the natural slope of the ground.

The foundations were described as not being difficult or expensive, except in special cases, as the weight of the vessel and cradle was spread over such a large area as to reduce the pressure per unit to a very small amount. Piling was objected to unless the whole length of the way was thus supported, as it was important to obtain uniformity of bearing thoughout the entire length in order to avoid excessive local stresses. The cast-iron rails upon which the cradle travelled were then referred to, and the method of laying and fixing them on the timber-ways was explained.

With regard to the submerged portion of the ways which usually had to be put in place with the assistance of divers, various proposals for shortening the slip, and so decreasing the expense of construction were dealt with. These were first, making the cradle telescopic, so that when run out the several divisions close up, while as soon as hauling commenced they opened out to receive the vessel; and, secondly, enclosing the upper part of the slip within watertight walls, provided at the bottom with a pair of gates. Both these systems had been adopted by the Authors, but the latter were only applicable in cases where there was a sufficient rise and fall of tide. When diving had to be resorted to, the submerged portion of the ways was first of all framed together on land, and the rails laid. It was then floated out over its final position, and sunk by laying on a sufficient weight of stones, the ground having been previously prepared by dredging and levelling up with ballast.

The construction of the cradle was next mentioned. The timber used was generally American oak, put together in the form of three ribs, one at the centre and two at the sides, over the outer lines of rails. The ribs were braced together and mounted on strong cast-iron wheels with wrought-iron axles running in cast-iron carriages. Across the ribs were beams of wood or iron carrying sliding bilge-blocks worked from the vessel itself. Ploughs, stays and pawl-gear were provided, as well as wrought-iron guides, for convenience in placing the vessel.

The hauling-up machinery was described as being now generally actuated by water-pressure, though in some cases, engines with gearing were use, especially in slipways for small vessels.

The Authors then detailed the working of a slipway, mentioning the preparation and running down of the cradle, which sometimes was permitted 90 to 40 feet over the end of the ways, and the floating on of the vessel, which was guided by hawsers from the quay or jetty, and by the cradle-guides. After hauling-up had commenced, the ship gradually settled down on the keel-blocks, and the sliding bilge-pieces being run in, in, it was drawn out of the water seated on the cradle. In launching the process was reversed. Two instances were then given of methods by which more than one vessel could be taken on a single slipway at one time. The first was by means of hydraulic presses placed under the keel of the ship, which enabled the weight to be transferred from the cradle to blocks supported entirely on the ground, so that by providing the cradle with swinging arms, it could be run down out of the way and prepared for receiving another vessel. In the second method (Thompson and Cooper's), two cradles travelled on distinct sets of rails, with slightly different inclinations, so that the vessel might be transferred from one to the other, according as the two cradles were simultaneously hauled up or lowered down.

Morton's hydraulic hauling-gear, in which the links had to be disconnected at the end of each upward stroke, in order to take out a length, and permit the ram to travel back and be reconnected, was then described; and after pointing out the serious loss of time occasioned by this operation, the Authors proceeded to show how, by improved gear, loss of time was avoided. With this apparatus there was no disconnecting of links, which merely travelled up and down the ways according as the rams were on their outward or inward stroke, connection with the cradle being made by pawls attached thereto, which geared with the links on their upward stroke, and slipped so soon as they were reversed. During the short time the links were stationary in reversal at top and bottom, water was accumulated under pressure, and given out when the rams travelled in one direction or the other.

Reference was made to Messrs. Hayward, Tyler and Co.'s hauling-gear also to that introduced by Messrs. Day and Summers, the former being objected to on account of its cost, and the latter from the diffi-