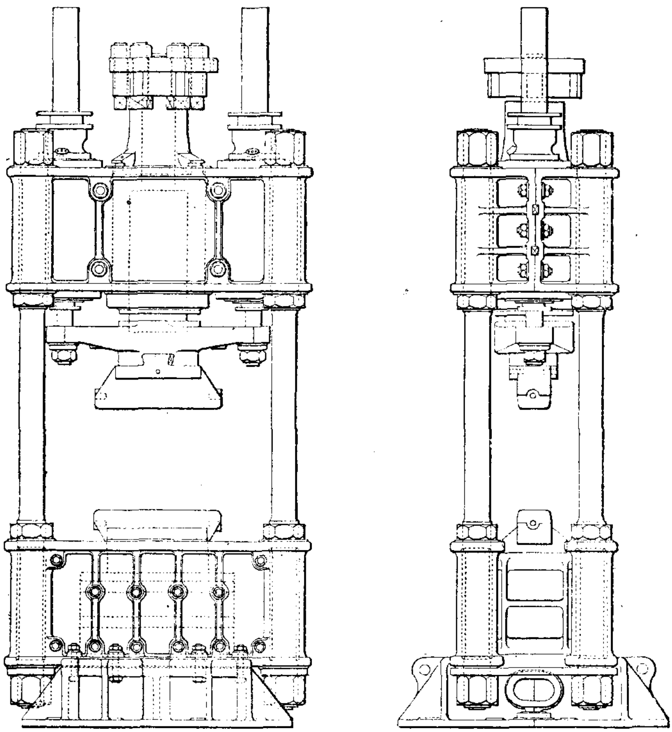
Correspondence.

Mr. Fritz Baare, of Bochum, furnished particulars of the 4,000-ton forging-press, of his design, at the Bochumer Verein für Bergbau und Guss-Stahl Fabrikation, Bochum, Westphalia, of which he was the General Secretary, which had been at work since October, 1891. In this press a differential ram was used, the ratio of the smaller to the larger section being 1 to 3. It was thus possible to obtain three different degrees of pressure in the proportion 1 : 2 : 3, according as the water acted on the smaller or the annular section, or on both at the same time. The three grades of pressure could be alternated at will during the process of forging. One lever regulated every movement of the working-ram. The forging proper was effected with water at a pressure of 8,400 lbs. per square inch. The idle part of the stroke and the return stroke of the working-ram were performed with low-pressure water at 700 lbs. per square inch, which also actuated the gear for lifting and moving the ingots and forgings. The general arrangement of the press-pumps and the heating-furnaces, which produced daily about 30 tons of finished forgings, had been already described.[1] The pressure-water was obtained from two twin differential pumps; the first, with a cylinder of 30·4 inches diameter and 36·8 inches stroke, supplied water for the 4,000-ton press and also for one 1,200-ton and two 800-ton presses. Two accumulators, loaded by 50 atmospheres air-pressure, with 8·9-inch rams and 120 inches stroke, on the Prött-Seelhoff system,[2] were inserted in the piping between the pumps and the press. The pressure-water was supplied by one of the twin differential pumps which delivered the momentary excess of water into a weighted accumulator of 18 inches diameter and 140 inches stroke. The pumps were put in motion or stopped automatically by the accumulators acting on the steam stop-valves. The press was served by two independent 75-ton cranes moving on a circular line of rails 110 feet in diameter and turning on a pivot at the top of the press. The forgings were lifted by means of an 18·4-inch ram of 80 inches stroke, the cylinder of which was fixed on a travelling crab. This arrangement possessed the advantage that in the case of overweighting during forging, the ram went down and forced the water back to the accumulator, thus preventing any straining of the crane and chains. The motion of the traveller Mr. Baare.

[1] Stahl und Eisen, No. 3, 1892. [2] *Ibid*, No. 1, 1891.

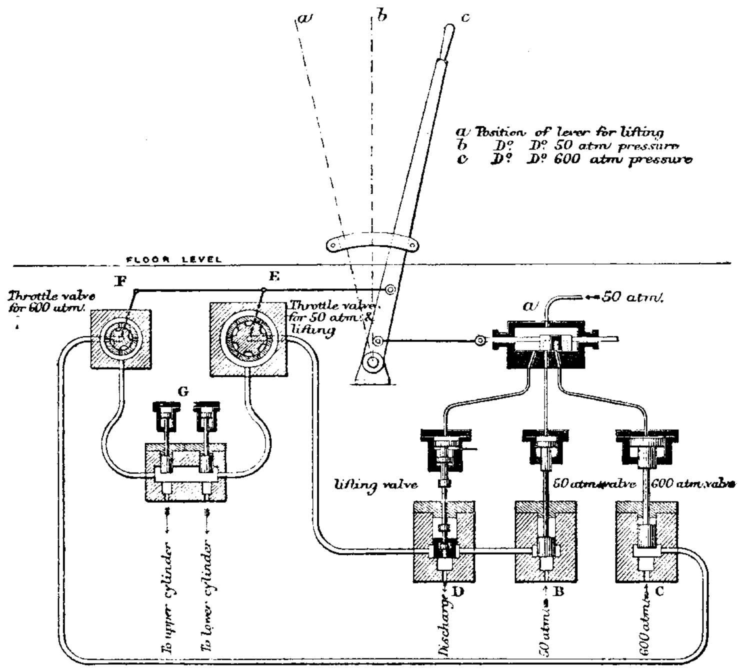
Mr. Baare. and the circular motion of the cranes was effected by hydraulic four-cylinder engines. The turning of the ingots was effected by two quadrangular shafts situated below the floor-level, each being actuated by a hydraulic three-cylinder engine; the same shafts were used for withdrawing short ingots from the furnaces. There were four furnaces of various sizes for heating the ingots. The arrangement of the 4,000-ton press was shown in *Figs. 13.* The

Figs. 13.



lower part of the ram had a diameter of 38 inches, and the upper part was 22 inches in diameter. The stroke was 64 inches and the clearance between the ram and the flat anvil was 74 inches; so that ingots 68 inches square could be pressed. The upper and lower frames were of cast-steel joined by four forged steel columns 16·8 inches in diameter. The space between the two frames was 13 feet 6 inches. The cylinder was of cast-steel about 40 tons in weight; the upper frame supported the two lifting-cylinders, the differential rams of which were 17·2 inches and 10·4 inches diameter, and were kept in communication with the 50-atmosphere pressure. The power lifting the main ram was 96 tons; that is, 64 tons in excess of the weight of the moving parts. The total weight of the fixed parts of the press was 240 tons; the total weight of the press was therefore 154 lbs. for every ton of maximum working-pressure. The replacement of the two upper and one lower leathers was easy, and required only about two Mr. Baare.

Fig. 14.



hours. The stroke of the lever which controlled all the motions of the main ram was 18 inches, and the force required to move the lever was only about 5½ lbs. *Fig. 14* showed the arrangement of the valves when the press was at rest. As the inlet-valves B and C were thrown open suddenly when discharged, two throttle-valves E and F were inserted in order to reduce any possible shocks. The stroke of the lever was divided into three equal periods. The first consisted in the discharge of the water and the consequent lifting of the ram; in the second period, the 50-atmo-

Mr. Baare. sphere pressure was admitted; in the third period, the working pressure of 600 atmospheres was applied. After every stroke the man at the lever lifted the working-ram sufficiently to allow of the ingot being moved freely; he then put the lever between the first and second positions, thus bringing the press to a standstill. He afterwards moved the lever to the second position until the ram touched the ingot, and finally to the third position, putting on the full pressure. It was evident that, with this method of manœuvring, high-pressure water was only consumed when the ram was actually pressing the ingot. When the work was light, as many as thirty strokes per minute could be made. The pumps worked almost continuously, and the steam was cut off at one-tenth to one-fifth of the stroke.

Mr. Berrier-Fontaine. Mr. MARC BERRIER-FONTAINE gave his experience of the use of a 150-ton forging-press which was fitted up in the shipbuilding yard of Le Mourillon at Toulon Dockyard in 1884, and was used for stamping a variety of small pieces. This sort of work it did in a most satisfactory manner, and he estimated that the amount of work done by it was, on an average, about six times what could be turned out in the same time by the same number of workmen using hand-hammers. In many cases the ratio was much higher and, for some classes of folding, bending, flanging, or stamping work that could be accomplished by a single stroke of the ram with suitable dies, the work done by that small hydraulic press not unfrequently amounted to twenty times, or even to forty times the amount which could be done by hand in the same time.

One of the most valuable characteristics of such small hydraulic presses was, that they could be put to a great variety of different uses, which need not necessarily have been foreseen when they were designed. A press, in fact, was nothing else than a very simple machine capable of exerting a compressive effort, determinate and perfectly constant; but by the simple interposition of suitable tools, such as straight or curved shears, punches of different shapes, dies, stamps, or moulds, as the case might require, it could turn out work of the most varied description. It was mainly owing to this adaptability that the use of small hydraulic presses was valued so much in the shipbuilding yard at Le Mourillon, that it was becoming more and more frequent, and extended every day to some new class of work to which it had not been contemplated beforehand that it could be applied.

Another important advantage of a complete hydraulic plant such as that at Le Mourillon was the saving of motive power which its use allowed. Without attempting to measure accurately the relative efficiency of hydraulic tools during their periods of actual work, a measure which was, after all, of but little practical utility, and though it might even be granted that such efficiency was rather low; yet, as the periods of actual work amounted to a very small fraction only of the working day, and as, during the periods of rest, there was absolutely no loss of motive power; as, moreover, the use of hydraulic accumulators admitted of the whole of the motive power produced during such periods of rest being stored up for subsequent use during the periods of useful work—the practical result was that, on the whole, the total loss of motive power during a whole day's work was, as a matter of fact, incomparably less for a hydraulic plant than it would be for an equivalent plant of tools driven either by shafting and belting or by separate steam-engines. Thus, in the works at Le Mourillon, a motive power of not more than 20-HP. was enough to serve a very important assemblage of hydraulic tools of all description; while a steam-engine of about 80 HP. would be required for driving an equivalent plant of tools with mechanical transmissions. To sum up: a remarkable facility of adaptation to work of the most varied description, and a considerable saving of motive power and consequently of working expenses, were the most important advantages of such a complete hydraulic plant as that which, twenty years ago, had been adapted for the shipbuilding yard at Le Mourillon. Mr. Berrier-Fontaine.

Mr. A. B. Brown had employed a 1,500-ton press for more than a year and a half at Rosebank Iron Works, Edinburgh; and the experience obtained from it showed that simplicity could only be obtained by working with a combination of low-pressure water at 800 lbs. per square inch (which also served the cranes) and a steam intensifier for 3 tons per square inch. The low pressure being regulated under a steam-loaded accumulator served by compound engines, got rid of all momentum; while a very rapid motion was obtained on the forging-press with simple valve-gearing, the engines starting and stopping automatically. Mr. Brown.

Mr. C. Dufour, of Paris, thought that, although on the Continent the opinion that the forging-press was preferable to the steam-hammer for steel was extending daily, yet it was not by any means universal. For example, in 1893, some of the great railway companies would not hear of their axles being forged by the press. For iron, the majority of workers preferred the steam-hammer, and it was certain that their opinions could not be altered in a day. Many others maintained, with the Author, that the action of the Mr. Dufour.

Mr. Dufour. steam-hammer was only superficial, while that of the forging-press reached to the centre. According to results of tests made on material forged by both tools, there was practically no difference in the physical properties of the material turned out. In his opinion the principal advantage of the press rested in its great economy as compared with the steam-hammer. According to the observations of Mr. Charles Davy, a 3,500-ton press compared at least with a 100-ton hammer; Mr. Dufour believed, from his experience with the two tools,[1] that a 4,000-ton press was nearly equivalent to a 100-ton hammer.

It might be of interest to state that experiments similar to those of Mr. Coleman Sellers had been made at the Forges Arbel, Rive de Gier in 1886 by Mr. Chomienne, and published by him in January, 1888. Mr. Dufour was of opinion that the only delicate parts of the forging-press were its high-pressure pipes and valves subjected to water pressure of 300 to 500 atmospheres, or even more.

Mr. Head. Mr. JEREMIAH HEAD considered that no remarks had been made by any speaker upon what appeared to him to be one of the chief points submitted, viz., how far the press illustrated in Fig. 7, Plate 3, was an improvement upon those which preceded it. He had had an opportunity of watching a press in operation forging some ingots into flat slabs and others into blooms about 8 inches square in section. The press was very tall, the entablature and base being connected by four tension-rods in the usual way. When the flat slabs, which extended right across the anvil face, were being formed, there was no undue movement of the framework of the press; but when 8-inch blooms were being forged, and occasionally turned over sideways so as to cause the resistance to be entirely on one side of the vertical centre line of the press, the entablature moved sideways considerably, the framework altered from rectangular to rhomboidal form, and the section of the bloom became also rhomboidal. The latter deviation once started could not be corrected. As a matter of fact the smaller blooms were always more or less rhomboidal in section when finished. The assumption by the press of abnormal forms not only affected its efficiency, but it also tended to its ultimate disintegration.

One of the chief advantages of the press, Fig. 7, Plate 3, seemed to be that by putting the rams below the floor-level the tension-rods

[1] "Étude sur les presses à forger," (Bulletin de la Société de l'Industrie Minérale, Decembre, 1892;) abstracted in the Minutes of Proceedings Inst. C.E., vol. cxiv. p. 445.

could be greatly shortened and firmly held at or about the level at which the pressure on the bloom was exerted. The resistance to bending was thus greatly increased and the framework of the press largely saved from deformation. Mr. Head.

The valves and supply-pipes in Fig. 7 seemed to be so arranged that either the centre ram, or the pair of side rams, or all three, could be brought into operation. Whenever the resistance offered by the work happened to be entirely on one side of the centre of the anvil, this arrangement would tend to twist the entablature, and though in small presses no practical harm might result, yet in large presses with broad anvils it might be desirable to supply the larger rams each with its own separate pump, so that they would always be obliged to travel *pari passu*. In such cases the force of the squeeze would diminish in proportion as the centre of resistance was away from the centre of the anvil. The men would soon find out that to get full power they must keep the work in the centre, and would learn to manipulate it accordingly.

Mr. C. Schumacher called attention to the fact that in the Greenwood and Batley press, which was made under his patent, the pressure was generated by direct steam-driving apparatus. The principle of this steam-driving apparatus itself was known before, but the arrangement and its combination with the press showed considerable improvements; in particular, the absence of any valves and the filling of the hydraulic cylinder of the press without pressure from the tank above it, whilst the hydraulic ram sank down on the work by its own weight. The squeeze of this press was equal to the steam-pressure under the direct-acting steam multiplied by the proportion of the areas of the two hydraulic rams. If a certain stroke was required to forge an ingot the stroke of the steam-piston was always proportional to the stroke of the press; therefore, the consumption of steam was proportional to the stroke of the hydraulic ram. The steam-pressure produced in the steam-cylinder was also proportional to the resistance of the ingot. In this press the steam was distributed and not the high-pressure water (sometimes as high as 7,500 lbs. per square inch), another great advantage of the system. Everyone who had worked with high-pressure distributions was well aware of their difficulties, the many repairs, and the changes of leathers and other tightenings. For high pressures and large strokes, the Kalk Machine Tool Works employed with decided success a patent double steam-driver, which worked alternately, and thus forced a continuous current of high-pressure water into the press. They had supplied to Messrs. Krupp, of Essen, a large hydraulic press, Mr. Schumacher.

Mr. Schumacher. with double steam-driver, for bending armour plates, exerting a maximum pressure of 6,000 tons.

Professor Thurston. Prof. R. H. THURSTON had watched the development of the hydraulic forging-press since his introduction to it at Vienna, where in 1873 Mr. Haswell was using it for the shaping of wheel-hubs and other parts in locomotive construction. He edited an account of Professor W. P. Blake's remarkable work,[1] and in his own report[2] drew most favourable conclusions. The Whitworth system of steel compression was also at the time in successful operation, and since that time the forging-press had gradually found its way into use in America. To-day there were in American steel-works presses of 10,000 and 14,000 tons capacity, for forging ingots and billets and for compressing steel, and so far as he could learn, they had proved in every way successful. The drop-press was in very common use also, and the drop-forgings were used in all small works. The makers of that class of forged product had become exceedingly skilful in the preparation of dies, and in securing perfect forgings without surplus metal or deficiency in filling the dies. He published some years ago a table of pressures attainable by the use of the drop-press[3] when investigating the relative merits of two forms of drop-press and the common hammer. He then found that the most efficient presses examined had an efficiency of 90 per cent., and that the thinner the piece and the less the compression, the higher the pressures and the greater the necessity for mass and solidity of setting in the case of the anvil. Many years ago, probably about 1875, Professor Kick of Prague[4] showed that the distortion of metal by the action of the steam-hammer and by the press consumed very different amounts of power, and he indicated that the drop was preferable to the hydraulic press when the pressures required were very great; but the slow action of the press might, he stated, secure the desired result in some cases with an expenditure of one-tenth the power required with successive blows of the hammer. The investigation Professor Thurston carried out involved, among other points, the study of the behaviour of copper under compression, and a figure exhibiting graphically the results obtained was published.[5]

[1] Reports of the U.S. Commissioners to the International Exposition at Vienna. Edited by R. H. Thurston. Washington, 1875.

[2] Report on Machinery and Manufactures: with an Account of European Manufacturing Districts. By R. H. Thurston. Washington, 1875.

[3] Transactions of the American Society of Mechanical Engineers, vol. 5: "Pressures attainable by the use of the Drop Press."

[4] Minutes of Proceedings Inst. C.E., vol. xliv. p. 302.

[5] "Materials of Engineering." R. H. Thurston. Vol. iii. p. 283, Fig. 7.

The final resistance in the testing-machine was, for these cylinders of rolled copper, about 25,000 lbs. per square inch of original section. Professor Thurston.

He found the resistance to compression up to within one-half the original length, in short cylinders, to be, as an average, about

$$C = 145,000 \sqrt[3]{c},$$

where c was the fraction of reduction of length, and C was in pounds per square inch of original section. In pounds per square inch of final enlarged section

$$C = 72,000 \sqrt[3]{c}, \text{ nearly.}$$

Mr. TWEDDELL, in reply to the communication of Mr. Fritz Baare, observed that while possibly the differential cylinder might be a cheaper way of obtaining three powers, than having three rams, there were many reasons in favour of the latter plan. In an arrangement for working valves, designed by Mr. Fielding, one lever performed all the operations, in addition to allowing low-pressure water to automatically fill the main cylinder, until the full pressure was required. A similar system of low-pressure and high-pressure service was also used. Mr. Tweddell.

He had omitted to mention that Mr. Thomas Bell Lightfoot had patented a hydraulic press in 1876 for working metals.

Having been responsible for the designs of all the hydraulic machine tools at Toulon, as well as that of the 150-ton hydraulic forging-press referred to by Mr. Berrier-Fontaine, he was gratified to find that the economical results were considered to be so satisfactory.[1] In reference to Mr. Dufour's remarks, considering the somewhat shadowy basis on which any comparison of the power of a steam-hammer and hydraulic press rested, the results obtained by Messrs. Davy and Dufour were wonderfully similar. There could be no question as to the accuracy of Mr. Dufour's opinion as to the weak point in the hydraulic forging-press being the high-pressure valves, but this did not apply to the pipes. But with careful designing and doing away with every unnecessary detail and refinement, and ensuring as great rigidity as possible, there were far fewer weak points in a press than in a hammer.

The remarks of Mr. Jeremiah Head fully bore out the necessity of rigidity in a forging-press; up to the present time presses of the

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[1] "On the Hydraulic Machinery in the Iron Shipbuilding Department of the Naval Dockyard at Toulon," Proceedings Inst. Mechanical Engineers, June, 1878.

Mr. Tweddell. type shown (Fig. 7) had only been made up to a 500-ton power, but the three rams were not an essential feature of the design, and, undoubtedly, any such triple arrangement was open to the objection named. But, on the other hand, this design allowed of very ample guides being provided, and in practice, the difficulty so far had not been found to exist. As stated in the body of the Paper the design left a clear headway for cranes, and required less costly house and buildings. It was slightly more costly, but if anyone allowed cost or a desire to save weight to unduly influence his judgment, when putting down a 2,000, 5,000 or 10,000-ton forging-press, he would find it a ruinous policy in the long run.