ON AN IMPROVED CONSTRUCTION OF
HYDRAULIC PRESSES·
FOR PACKING COTTON, JUTE, &c.,
WITH IMPROVED ENGINES AND PUMPS.

BY MR. ROBERT WILSON, OF PATRICROFT.

The object of this paper is to point out the advantages of working Presses and other Hydraulic Machinery at a high speed; this at one time was considered impracticable, but the writer's experience of the packing of cotton and other fibre in India shows that it is not only practicable but can be carried out with great advantage. Until late years hydraulic power was used only for very slow direct action; and in packing presses for goods, the motion was so slow as hardly to be perceptible to the eye, requiring 10 to 12 minutes to raise the ram of the press $3\frac{1}{2}$ to $4\frac{1}{2}$ ft., which can now be accomplished in less than half a minute. When the writer proposed to apply direct-acting hydraulic power to the presses used for packing cotton in India, it was considered quite unsuitable for presses with a rise of ram of 12 ft., as it was generally thought that this rise could not be obtained in less than 15 to 20 minutes, which would only allow of three bales at most being turned out per hour, giving no advantage over the hand-presses at that time generally used in the cotton districts in India. So little confidence was placed in the writer's plan for accomplishing this amount of rise of ram in one minute, that it was with difficulty a firm of merchants in Bombay were at length induced to make a trial of a cotton press on this principle, a guarantee being required by them that the ram should be run up a height of 12 ft. in not more than 5 to 6 minutes, which, if performed, would turn out eight bales per hour.

The Press, which is illustrated by the model exhibited, was made and sent out to India in 1857. Its weight is about 30 tons, and it is fitted with two 11-inch rams, and a cotton box $13\frac{1}{2}$ ft. long by

16 in. broad, having a rise of ram of 12 ft., and capable of compressing $3\frac{1}{2}$ cwt. of cotton into 8 cub. ft. in the press, with a pressure of 500 tons upon the bale. The report received of the working of this press was most satisfactory, stating that twelve bales could be turned out per hour, and that the press could be run up in little more than one minute. This result was obtained through the medium of the horizontal direct-acting high and low-pressure pumping engines invented by the writer, which are shown in Figs. 1 to 4, Plates 61 and 62. The high and low-pressure engines were constructed in pairs from the same design, with cylinders 20 in. diameter and 24 in. stroke, each pair working four direct-acting pumps, the low-pressure engines pumping water up to a pressure of 1,680 lb. or $\frac{3}{4}$ ton per sq. in., and the high-pressure ones up to a pressure of 3 tons per sq. in.; this difference was brought about by making the pump rams of the low-pressure engines four times the area of those of the high-pressure. The mode of working was as follows:—in starting the press, the resistance of the cotton being then slight, both high and low-pressure engines were set to work, so as to run up the press as quickly as possible; when the resistance of the cotton counterbalanced the low-pressure engines, these stopped of their own accord, and the high-pressure engines finished the bale.

Upon the result of the first press being ascertained, five more presses were ordered to complete a set that would keep the two pairs of engines continually at work, and so obtain the full advantage of the engine power. The proprietors of hand-power presses, seeing how rapidly they would be pushed out of the packing trade, put forward numerous objections to these powerful competitors; amongst others that the great pressure exerted to compress the bale destroyed the fibre of the cotton. On the arrival of the cotton at Liverpool this matter was carefully gone into, and all objections vanished after the first season; and the screw presses were speedily abandoned for the new hydraulic ones.

So far a great success had been achieved, but not sufficient to satisfy the writer; and in 1862 he designed the three-cylinder press shown in Fig. 5, Plate 63, fitting it with three 9-inch rams, and making it of similar size and power to the first hydraulic presses.

The object of this second plan was to obtain with only one pair of engines a result similar to that previously got with the two pairs, and thereby to save the expenses of one entire pair of engines—namely the low-pressure pair—for every four presses. The method of working the three-cylinder press is as follows:—the water from the pumps is admitted at first into the centre cylinder only, thus raising the follower F together with the two outside rams which are attached to it, the two outside cylinders, as their rams rise, being supplied with water by gravity from the supply tank to fill up the space left by the rising rams. When the resistance balances the pressure of the centre ram, the water from the pumps is admitted to the two outside cylinders, thus exerting the pressure of the three rams to finish the bale. After this press was brought out, very few of the old two-cylinder presses were made.

Now came a new era in the cotton-pressing business in India, caused by the opening of the Suez Canal. The measurement for vessels going round the Cape of Good Hope was 50 cub. ft. per ton weight, and for this measurement the power of the presses was ample; but when the Suez Canal was opened the measurement for vessels going by the new route was reduced to 40 cub. ft. per ton weight, and it was found that more powerful presses were wanted for compressing the bales to the required measurement. It was desirable to keep the length and width of the bales the same as before; but unless the hydraulic cylinders were made of some material superior to the cast iron up to that time employed, this could not be done, as the thickness of metal in the cylinders already took up all the space available in the construction of the size of press required. The writer therefore turned his attention to the adoption of steel cylinders in place of iron. When it was found that these could be obtained to withstand the necessary pressure, and that by this substitution the diameter of the three rams could at the same time be increased to 11 in., they were immediately adopted extensively. The new presses were made much larger and stronger than formerly, and weighed 40 tons each, the cotton box being increased in height to $14\frac{1}{2}$ ft. or even 15 ft., as there was now

keen competition in the trade, and too much time had been spent in filling the box with the loose cotton. The introduction of steel cylinders led to the alteration of many of the old three-cylinder presses with 9-inch rams, the 9-inch cylinders and rams being replaced with 10-inch steel cylinders and rams to correspond, thus gaining 23 per cent. more power. The old two-cylinder presses with 11-inch rams were also many of them altered to three-cylinder presses with steel cylinders and 11-inch rams, so as to obtain the extra cylinder for economy, and also to obtain 50 per cent. more power.

Whilst these changes were taking place in some parts of India, in other parts the greater power required was being obtained by the aid of an auxiliary press or finisher, shown in Figs. 6 and 7, Plate 64, of great power, but only of short range. This press fitted with two 21-inch rams, and capable of exerting a pressure of above 2,000 tons, is worked in conjunction with the old presses, in which the bale is half packed and then transferred by means of an extractor E, Fig. 7, to the finisher, where the final compression takes place. Bales made in this manner however are hardly satisfactory, as the shape is not so square as when finished in one press, and consequently the measurement is not so good.

To obviate this objection the Compound Press has been designed, illustrated by the model and shown in Figs. 8 to 11, Plate 65, by which the bale can be finished to the size required without being removed from the press. The weight of this press is 53 tons, and its working is somewhat different from that of the other presses already described. The preliminary pressure is given to the cotton through a ram of 11 in. diameter, which forces the bottom follower F' upwards to within say 5 or 6 in. of the size of bale required. The bottom follower carries with it whilst rising two side pillars or supports, which are locked as soon as it reaches the top of its stroke; these along with the 11-inch ram take the strain of the two 19-inch rams R R, which now finish the bale from the top, working downwards, and exerting a pressure upon it of 1,700 tons. The bale produced by this press, although not subjected to as great a pressure as when made by the auxiliary finisher, measures equally small in consequence of its better shape.

Up to the present time all the presses in India have had, on account of their height, to be placed in two-storied buildings, which were a great expense, especially up country. To obviate this, a Horizontal Press has now been brought out by the writer, the design being based upon the result of numerous experiments, from which he found that the pressure required to compress cotton, jute, &c., into half their natural bulk, is very slight, being only about 3 to 4 lb. per sq. in. of surface exposed to the pressure. The horizontal press, illustrated by the model and shown in Figs. 12 to 15, Plates 66 and 67, is fitted with three rams, Fig. 14, the centre one C being 9 in. diameter and the two outside ones R R each 14 in. diameter. The box B, in which the cotton or other fibre is placed, is reduced to half the ordinary length and increased to double the depth. A plate P descending by its own weight compresses the fibre in the box into half its original bulk, and having done so, forms the upper side of the box, and is secured in its place by locking bolts L. Horizontal compression is then given endways, first by the centre one of the three rams, until the resistance counterbalances it, after which the compression is given by all three rams. The bale when finished drops through a trap-door D at the bottom of the box upon a truck, and is removed along a tram or roadway. This press weighs 47 tons, and is capable of exerting a pressure of 1,100 tons.

Some doubt was felt by the writer about this press being suitable for packing cotton, on account of what is known as "cross-packing"; for, strange as it may appear, it is a fact that, if cotton is pressed, however slightly, in one direction, and then again at right angles, the bale will be "cross-packed," that is, the fibres throughout will be interwoven so as to render it impossible to separate them without force. Thus samples cannot be taken from the centre of the bale; and this is greatly objected to by the Liverpool merchants, although the "cross-packing" does not injure the cotton for spinning. The horizontal press was found to cross-pack, and consequently had to be abandoned for pressing cotton. In the meantime however its performances in packing jute, cuttings, &c., which had up to that time been packed in the vertical presses, were really extraordinary, two presses in one establishment turning out as many as 18 bales

each per hour, against 14 bales per hour for each vertical press with double the pumping power.

Naturally as the presses increased in size the engines for supplying them with water were increased likewise; but they were of a similar type to those first sent out, until the introduction of the compound press, when a very great improvement was effected by the writer, by increasing the number of direct-acting pumps from four (that is, one at each end of the piston-rods of the pair of engines) to twelve, as shown in the plan, Fig. 2, Plate 61, the effective number in operation at any time being reduced as required to overcome the increase of resistance in the press. The twelve pumps, one of which with its valves is shown in section in Fig. 3, Plate 62, are all the same size as the four formerly used, and are worked as follows. At the commencement of the operations, the pressure being slight, all twelve pumps are set to work until the resistance becomes too great, when one set of four pumps is relieved by opening a valve at the distribution box of the press, which allows the water to flow without pressure back into the tank from which it was drawn. The pumps now deliver less water at a higher pressure, until the resistance of the fibres in the press again counterbalances the power of the pumps; four more of the pumps are now relieved, and the engine with its remaining four pumps and full pressure of water finishes the bale.

In conclusion it may be stated that the direct-acting engines have lately been introduced into a warehouse in Manchester for working packing presses, hoists, cranes, &c., and are giving great satisfaction; they are also conducive to the comfort of all employed in the warehouse, as the vibration and noise caused by the gearing formerly in use have been entirely avoided.

Mr. WILSON exhibited working models of the several presses described in the paper, showing that the horizontal press was more convenient than the vertical presses, and enabled a greater number of bales to be pressed in the same time.

Mr. H. SHIELD said that, without going into the history of the gradual replacement of wooden screw presses and then of iron screw presses, and of the other improvements in presses that had taken place by the abandonment of the screw and lever press in favour of hydraulic power, he wished to draw attention to a diagram, Fig. 18, Plate 69, which he thought would be of interest as showing the work that had to be done in the press in pressing cotton to the density now required for the trade which had established itself especially between India and this country. In this diagram the curve was intended to represent the total pressure at various portions of the stroke in a compound press, something of the same description as the compound vertical press described in the paper, which might be taken to be really the only press that had any great future in it or that had done much in the recent past. The Watson press illustrated in Figs. 16 and 17, Plate 68, of which a working model was also exhibited, was one of which twenty-nine, manufactured by Messrs. Fawcett Preston and Co., Liverpool, had already been sent out to India within the last few years, their general features being as follows. The box was in cross section about 4 ft. by 1 ft. 4 in., with a rise of 14 ft. 6 in., and the lower cylinders were fitted with two rams of $6\frac{1}{2}$ in. diameter. As soon as the box was filled and the hydraulic pressure turned on, these two small rams ran up very quickly, and, as was seen by the diagram, Fig. 18, so slight was the resistance in the box at the beginning of the pressing that for about the first 11 ft. the pressure gauge failed to record the pressure on the rams; the index of the gauge kept wavering, but did not indicate what the pressure was, the amount being very slight indeed until the first 11 ft. had been passed through, when there was a pressure of $2\frac{1}{2}$ cwt. per sq. in. on the rams; and it was seen that from the eleventh to the twelfth foot the pressure increased from $2\frac{1}{2}$ to 5 cwt. per sq. in., the corresponding total pressure on the bale being thereby doubled from 8 to 16 tons. In the next foot the pressure was again doubled, so that at the end of the thirteenth foot it was 10 cwt. per sq. in.; and at 14 ft. it was 18 cwt. The peculiar principle of this press was that at the moment when the lower follower, which was provided with teeth, arrived at the top of its stroke, a grid was thrust in sideways

between the teeth of the follower, and took the place of the follower in supporting the bale, the grid itself being firmly supported on the framework of the press. When the grid had taken its place, the follower immediately began to descend, and while it was descending the refilling of the box for the next bale was being proceeded with. The finishing pressure upon the bale left on the grid was given from the top downwards by means of two rams of 16 in. diameter working at a much higher pressure than the bottom rams. How rapidly the pressure increased in this final pressing was seen from the diagram, which showed that, when the top rams first began to work and had passed through only 3 in. of their stroke, the pressure upon them was 8 cwt. per sq. in.; at 6 in. the pressure was 10 cwt., at 9 in. 15 cwt., at 12 in. 25 cwt., and at 15 in. 45 cwt. per sq. in.; this final pressure at the end of the stroke gave a total pressure upon the bale of over 900 tons with two 16-inch rams. The work thus done in the top of the press was represented in Fig. 18 by the upper curve, which was also shown inverted by the dotted line and combined with the curve from the bottom of the press, so as to form one continuous curve for the whole operation. That showed pretty clearly what the work to be done was. How to do that work was a different question altogether; but he thought at any rate it was well to know what had to be done, namely to run up against a very light pressure to begin with, and to finish with a very heavy pressure. It was also seen that the real work of the press was measured by the final pressure required upon the bale; and that it would not be correct to compare one press for compressing bales to weigh 25 lb. per cub. ft. with another compressing to 40 lb. weight per cub. ft., and to suppose that their powers were at all in proportion to the density of the bale. That was not so: the entire measure of the power and cost of a press, and also of its commercial value, was regulated by the rapidity of its work and the final pressure necessary to be obtained for compressing the bale to the desired density; and the nearness with which the actual weight of the compressed bales could be made to approximate to their measurement was an important matter in the saving of freight, its importance having arisen, as mentioned in the paper, mainly since the Suez Canal had been opened.

One point alluded to in the paper, in which he thoroughly agreed, was that it was wrong to suppose that any pressures yet applied would injure the fibre of the cotton for spinning. He did not mean to say it would not be possible with very great perseverance to arrive at such a result; but it certainly had not yet been done, and it would not be done by any pressure not exceeding that which would make cotton bales weigh not less than their measurement; and as there would be no object whatever in compressing a bale so much as to make its measurement less than its weight, there was not the slightest fear of any such result being arrived at. There was a considerable interval yet left before equality of weight and measurement would be reached, which would require the cotton bales to be compressed to a density of 56 lb. per cub. ft., instead of the present maximum density of 40 lb. per cub. ft. If it were desired to increase the density to 56 lb. per cub. ft. he did not think there was any doubt it could be done; but he hardly thought it likely that the cotton would be wanted to be so compressed to the full extent of its dead weight; and he should imagine that a maximum density of 50 lb. per cub. ft. was about as much as shippers would like to carry for stowing purposes; he thought the cotton would stow better and make a better cargo at a density of 50 lb. per cub. ft. than at 56 lb.

In the compound vertical press that he had described, Plate 68, the salient feature was the movable grid upon which the partly compressed bale was supported under the finishing pressure of the top rams. Whether in the first pressing one ram or two rams or three rams were used was a matter of no importance: the point to be aimed at was to have a quick-working press, and one so arranged as to permit of the power being applied as nearly as possible in the same increasing ratio as the resistance arising from the compression of the bale. For that purpose the best pumping arrangement in his own experience had most certainly been found to be that in which there had been a considerable number of pumps, which could be easily thrown in and out of action, so that, in consequence of their number and of the facilities that they offered for adapting themselves to the varying resistance in the press, they could be combined together at

the beginning of the stroke for running the press up rapidly at first, and then their number could be reduced towards the end of the stroke, until at last there would be the minimum number of small pumps working at a high pressure against the resistance encountered by the top rams of the press in finishing the bale. The problem consisted in fact in supplying a great body of water to begin with at low pressure, and a very small body of water to finish with at high pressure. If the pumps were driven direct from the steam cylinder of the engine, it seemed to him—not as a matter of opinion merely, but simply as the result of the large experience already gained, particularly in India—that there must always be the same pressure of steam in the cylinder throughout the entire stroke, and it would be impracticable to work the engine at all economically by expansion, because there was a dead resistance on the pump rams which could not therefore be overcome by a varying power in the steam cylinder. It certainly did seem therefore that the proper and reasonable plan to adopt was not to put the pumps in a direct line with the cylinder, but to work the pumps from a crank-shaft driven by a connecting-rod and provided with a flywheel, which would take up the extra power at the beginning of the stroke and give it out again when it was wanted. That the practice of the writer of the present paper did assimilate to this view was shown by the fact that he had gone on increasing the number of the pumps from four to twelve. That pointed to the advantage of a large number of pumps; and as the result of practice with these pumps driven from a shaft he had found the best number of pumps for working a series of presses to be eighteen or twenty: the most recent number was eighteen, of which about half were 3 in. and the rest 2 in. diameter. The whole of the 3 in. pumps and part of the 2 in. pumps worked into the small cylinders of the press throughout their long stroke, and only two or three of the smaller pumps were worked at the end of the stroke of the press. The actual commercial result of this mode of working had been that, whereas with direct-acting pumps the average cost in fuel of pressing each bale was about 2*d.*, with pumps driven from a flywheel shaft in the way he had described the cost had been reduced to about $\frac{3}{4}$ *d.* per bale. Not much of this saving could be due to the engine

itself, because it was a direct-acting non-condensing engine, water for condensation not being very available. Therefore so far as experience went he thought it was decidedly against direct-acting pumps; and it was desirable that this should be recognised, because the direct-acting plan was always preferred, wherever practicable, on account of being a simple and straightforward way of doing the work; but certainly so far as his experience had gone it was not the best plan in this case. He had no doubt about these results, because so many of these pressing companies in India, being limited companies, were required to publish their balance sheets; so that the figures for several years running could be obtained, and an average arrived at.

In the press which he had described, Plate 68, as soon as the bottom follower had got up to the top of its stroke the movable grid was thrown into its place and locked, for finishing the compression of the bale by the top rams, and then packing it by means of wrought-iron hoops put round: at the same time the bottom follower was descending again, and the attendants were beginning to fill the box for the next stroke. That was a considerable improvement, it seemed to him, over such an arrangement as had been described in the paper, where the bottom follower was locked at the top of its stroke, and had to wait there until the bale was completely finished by the top rams, which seemed to him a very serious drawback, losing the great advantage that a compound press should afford, of finishing the bale at the top of the press while the lower part of the press was being filled in readiness for the next stroke: that was the main point of difference between the two presses.

In reference to the number of bales per hour that could be packed, that was rather a difficult question to answer: it depended upon the power of the press and the rapidity with which the men could manage the lashing of the bales; no doubt the author of the paper had had the same experience as himself in that respect. The most authentic record of a day's work that he had ever received from India was in an instance where the inventor of the press under trial was by, and everyone was working well, and as many as 30 bales of jute were done per hour. But for regular work he thought it

would be fairer to take the rate at 20 bales per hour for jute, and for cotton not more than 18. It would be thought be very good work indeed for a press to continue to do 18 bales of cotton per hour; but the rate of progress depended upon the rapidity with which the men could lash the bales; that was what limited the speed.

As to the horizontal press described in the paper, which he thought extremely ingenious, he was only sorry that such ingenuity should have been thrown away so far as regarded cotton, because, as had been explained in the paper, the press was found to cross-pack the cotton, and cross-packed cotton would not do; and therefore so far as cotton was concerned the press might as well not have been constructed. So far as jute was concerned, he thought it was possible the difficulties of the press would be found even greater than with cotton, because jute was a material that required to be very carefully packed; it had to be packed in hanks, and the ends of the hanks had all to be in a certain position, namely at the end of the box; and if it were attempted to pack jute in two directions at right angles, such a tangled mass was produced that there was no means of dealing with it. For jute-roots it was different, and cross-packing would be of no consequence in that case; but for jute and for cotton, which were the two great staples of the work that had to be dealt with by the packing presses in India, the horizontal press he thought would be altogether inapplicable. No doubt one great object that was sought to be attained with the horizontal press was to get rid of the foundations: in any system of vertical press long cylinders at the bottom were a necessity of the economical action of the press; and it was natural therefore that it should be sought by placing the press horizontal to get rid of the difficulty of foundations, which entailed some outlay where there was a great quantity of water to be dealt with in the foundations; and although practically the difficulty was not usually a great one even where water was met with, still it was one that appeared desirable to be done away with, as would be accomplished by the introduction of the horizontal press. In the pressing of cotton and jute into bales however, even apart from the question of cross-packing, it certainly was not his own experience that horizontal pressure in itself was so good as vertical pressure,

because it was so difficult in pressing horizontally to get uniform density throughout the bale, which was apt to be pressed in lumps. He did not say that that objection could not be got rid of; but at present horizontal pressing was not desirable on that ground. In the compound vertical press that he had described the filling was all done from a pair of doors DD, Fig. 16, Plate 68, at the level of the stage on which the attendant stood, and the easing doors EE were just above. One man was thus in charge of everything, and there was no possibility of accident. Even if he were to turn on the pressure, for instance, at the time when it ought to be turned off, then the regulators which were attached to the pumps in a simple way would merely lift the suction valve of the pump off its seat, so that the pump would work no more; but this provision was hardly necessary, because the whole of the operations were entirely within the man's control, and the regulators were only put there as a matter of precaution.

Mr. B. WALKER enquired whether the use of the accumulator had been tried in connection with the presses described in the paper, and what had been the result. If a large accumulator were used for a very low pressure, and a smaller accumulator for a higher pressure, and the pumps were going steadily on, it was known exactly what was the amount of pressure produced in the press, and the press could be made to go up at any speed desired. Many years ago he had made experiments in pressing rape-seed, and had found that with a steady pressure the quantity of oil got out of the seed was much more uniform than with the ordinary mode of applying the pressure suddenly. He was well aware that a certain amount of coal was thrown away by using the accumulator; but he should like to know whether it had been tried, and what loss took place. The action he was satisfied would be simpler by having one accumulator with the high pressure and the other with the low pressure, and turning either of them on so as to get any speed desired; in this way he had frequently lifted 150 tons 24 ft. in two minutes, and he did not see any difficulty in regard to speed: it was only a question as to what was the desirable speed to make the press travel at. In seed pressing,

if the seed were bruised too violently, and a high pressure were put on at once, the oil was not yielded to the same amount : it did not flow quite so easily as if the pressing began gradually and a higher pressure were put on afterwards.

Mr. WILSON replied that in cases where only one press was used he considered the accumulator was essential, and it had been applied in such cases ; but where there were as many presses as would keep the pumps constantly going, the accumulator was then thrown out : there was no use for it where the engines were already going constantly. That principle he had followed out as much as possible, in cases where at first presses had been used with two cylinders which required high and low-pressure pumps. With such presses arranged in sets of six, the low-pressure pumps were first applied to run up one press as far as they could, and then the high-pressure pumps were applied to finish the bale, thereby running up one press with a low pressure while the bale in another press was being finished with high pressure. As long as there were plenty of presses to keep the pumps constantly going, he had never considered that any advantage was gained from the accumulator ; but in cases where only one press was employed he had considered that it was essential to have an accumulator, so as to utilise the power of the pumps during the time that the bale was being lashed and the press got ready for starting to work again.

Mr. CHRISTOPHER JAMES mentioned that a few years ago he had tried the use of a small accumulator in connection with half a dozen presses for pressing stearine and lard oil, &c., and it acted very well indeed. The pressure employed was 2 to $2\frac{1}{2}$ tons per sq. in. at first, running up the presses very quickly ; but to his surprise it was found that the long-continued action of the accumulator with a pressure of only 16 or 17 cwt. per sq. in. did the work very much better.

With regard to the use of horizontal direct-acting engines, it appeared to him that was a very neat arrangement, and it must not be forgotten that there was a good flywheel combined with it, as represented in Fig. 1, which acted as an equaliser ; so that the difficulty

which seemed to be apprehended by a previous speaker did not exist in practice. He enquired whether for the packing of the rams in the presses described in the paper the ordinary cup-leathers were used, or any other packing of that kind. In the case of an accumulator working rapidly up and down, he had found from time to time great difficulty with the ordinary cup-leather; and he should like to know what pressure could be worked at with a packing of hemp or flax or anything of that sort; it seemed to him if that kind of packing could be used, it was a much simpler mode of packing than the cup-leather, as the ram need not be taken out for packing. With regard to the difficulty that had been mentioned as to the cost of the foundations with vertical presses, it seemed to him that, the whole strain being entirely self-contained in the presses, the question of whether they were put upright or horizontally did not signify. If there were a vibratory action or anything of that kind, it would be different; but the whole strain in the press being self-contained, its mere weight of 50 tons was no very great amount to be carried upon the foundations.

Mr. WILSON replied that he had found a great error had been introduced and seemingly perpetuated by long practice, through the cup-leather being made too broad, which caused a great amount of friction against the ram; and moreover when the leather was so very broad, the friction of the leather on the ram tended to carry it along with the ram and crush it, and it was very apt to crack; in fact the broad leathers lasted only a very short time. But if the leather was made very narrow, and supported by the curved groove in which it rested, it might last for an indefinite period; there seemed to be no limit to its durability, provided there was nothing detrimental in the kind of water used. Cup-leathers he always used above a certain pressure; up to 600 or 700 lb. per sq. in. hemp or cotton packing could be used, but beyond that pressure cup-leathers seemed to be the best packing for standing the pressure.

As to the use of direct-acting engines for working the pumps employed to supply the hydraulic presses, it was seen from the drawing that there were twelve pumps worked by a pair of direct-acting engines coupled at right angles, with a heavy flywheel to turn

the centres. In first starting a press the whole of the twelve pumps were employed, and as long as the pressure was light these twelve pumps delivered almost a constant flow into the press; when the pressure increased, four of the pumps were thrown off, not by any mechanical disconnection, but simply by opening a valve to allow the water to escape from them into the supply cistern, so that there was no time lost and no jarring took place in throwing them off, the opening of the valve simply relieving the pressure and allowing the water to escape through the distribution box. Again, if it was necessary to have the pumps so arranged as to throw off another four when the pressure was further increased, that was also done by another valve opening from the delivery pipe of the next four pumps to the supply cistern. By that means a pressure was obtained sufficient to overcome the resistance of the cotton until the bale was finished, and it was found in many cases that in this way from 60 to 70 lb. weight of cotton could be compressed into a cubic foot. That was more than sufficient, because if the cotton were made as heavy as water it was quite enough. Indeed 40 cub. ft. to the ton was what was allowed by the Suez Canal, so that if the pressing was carried beyond 56 lb. weight per cub. ft. no advantage would be gained thereby. That extent of compression could be accomplished quite easily by the presses described in the paper with a water pressure of 2 or $2\frac{1}{2}$ tons per sq. in. According to his own experience he had not found a disadvantage from the use of direct-acting engines, but the reverse; the direct-acting plan was attended with simplicity of action, and there were no joints or joint-pins to wear and get slack, so that with valves and pumps made in the proper proportions the wear and tear was very small. He had never found any advantage from using eccentrics to work the pumps from the crank-shaft; with a great number of pumps it increased the complication, and was no advantage over direct action; so that he preferred the direct-acting arrangement, which was much simpler in every way.

Mr. E. A. COWPER observed that the deep foundation which had been spoken of as required by the compound vertical press described in the paper would not be needed if the press were constructed with

the smaller ram at the top, inverting in fact the arrangement shown in the drawing. Many years ago he had made a press having a 7 in. ram with 7 ft. 6 in. stroke at the top, to come down and give a light pressure upon the bale, and the compression was then finished by a large ram 16½ in. diameter with 3 ft. 6 in. stroke at the bottom of the press, which worked upwards and gave 400 tons total pressure upon the bale; that press was made to pack cotton in India, and it acted very well. There was no doubt great economy in working first with a small ram and then with a large one; he quite agreed that that was a very excellent arrangement, and a press so constructed might either be used vertically or be laid down horizontally. The plan adopted in the horizontal press described in the paper, of merely dropping a weight upon the box to press the cotton down, seemed at first sight an admirable one; but in consequence of the cross-packing it would not do in practice. The cotton must not be pressed first sideways and then endways, but must be made into one flat pancake (so to speak) by pressing in one direction only; then it was all tied together, and when the bale was hooped it would not burst apart. If that was not attended to, and if there was cross-packing, the bale tended to burst sideways, and the cross-packing injured the cotton besides. Therefore he thought a compound press like that described in the paper, either vertical or horizontal, was the right plan.

Mr. R. H. TWEDDELL, referring to the remark that with a great number of small pumps the varying resistances would be met by varying the number employed, thought that any advantage due to this was to a great extent counterbalanced by the increased complication. He very much preferred the direct-acting pumps described in the paper; but he went even farther, and considered that the number of parts might be still farther reduced and simplified. By this plan certainly a much larger steam cylinder would be involved, but at the same time the number of valves would be materially reduced. Taking an ordinary baling press for pressing goods, such as was in use in Manchester, with a 14 in. ram and a 4 ft. stroke, the pumps must make about 450 double strokes for each single stroke of the press,

and each double stroke of the pump involved raising and lowering two valves, so that for 450 strokes there would be 900 valve beats, which meant, especially at the high pressures, great wear and tear. If the same work in the press could be done with one stroke and one valve beat, it would only be carrying out the direct-action principle advocated in the paper, and was he considered an economical method. The objection which had been raised, that while the resistance varied during the stroke of the press the steam cylinder must be filled with steam at full pressure, could to a very great extent be overcome by using the exhaust steam to work the pumps during the greater part of the press stroke, during which the power required was small.

With regard to the packings employed to stand the heavy pressures, he used hemp packing for accumulators loaded to 2,000 lb. per sq. in., the accumulator making 5,000 or 6,000 and in some cases 7,000 double strokes of 3 ft. each per day of eight hours. Cup-leathers he had found would not stand under conditions of such continuous working, but there was not the slightest difficulty with the hemp. There was a very slight loss, he was aware, through increased friction when hemp packing was used; but it was a question of keeping the apparatus working constantly. The time spent in putting in new cup-leathers was an infinitely greater source of loss than that due to any increase in friction involved by use of hemp.

Mr. H. DAVEY considered the durability of a cup-leather depended entirely on how it was applied. In some experience that he had had in the use of cup-leathers for quick-running hydraulic pumping engines working under considerable pressure, he had found at first that the cup-leathers gave way very soon; and on investigation he found that they gave way from a springing or buckling action which took place in the leather, from its not being properly supported. At first it had been the custom to drop the leather into the recess, as shown full size in Fig. 22, Plate 70, and simply support it underneath with a little ring or filling piece A, sometimes of wood and sometimes of cast-iron or of brass, rounded to fit the inside of the leather. It was found that the leathers invariably gave way about the point B, and it appeared to him that they gave way

there from a buckling action like that occurring in the working of an accordion or of the leather in a pair of bellows: during the upstroke of the ram the leather would be forced hard against it by the pressure until the top of the stroke was reached, and then on the reversal of the stroke until the ram had received a little motion the leather would be stretched in the opposite direction. By simply putting a brass bush or saddle C, Fig. 23, under the leather so as to support it effectually underneath, turning the saddle exactly to fit the leather, he had succeeded in getting the leathers to last three or four times as long. Another point which he had found contributed to the life of the leather was to provide a very long bearing for the ram in the cylinder at D, Fig. 24, immediately below the leather. When thus put in with a more accurate support, the leathers now lasted three or four times as long as they formerly did when not supported accurately enough.

Mr. J. PLATT asked whether any difficulty had been found from the thin edge of the back supporting ring E, Fig. 22, springing against the ram and thereby ultimately breaking across at the point B. He had found this to be the case with a large cast-iron ram with a cup-leather in a recess made to fit it, like the diagram.

Mr. H. DAVEY replied that if the ring E was thinned to a very fine edge it would give way; but there was a point which was found in practice to answer best. The edge of the ring was brought down to a certain distance to support the leather as far as possible, but it must not be tapered to a perfect feather edge; if it were so, it was liable to damage in working.

Mr. E. J. C. WELCH mentioned that during the last few years he had, in conjunction with Mr. R. H. Tweddell, made a number of experiments with packing rings shaped in the same U form as cup-leathers, but made of various kinds of material, including vulcanised india-rubber, gutta-percha, and also leather; and he had found that if a packing ring must be used at all there was nothing like the leather ones. The india-rubber seized on the ram, as he had

expected it would do, and it was torn to pieces in a few minutes. The gutta-percha did not seize, and it lasted fairly well, possibly one-fifth of the time that leather would; but it had this advantage, that when it was worn out it could be remoulded; it was simply necessary to put it into boiling water, add more gutta-percha, and then mould it into a fresh ring. With these gutta-percha rings he had had a very curious experience. The exterior of the ring had at first been moulded with full square corners at F F in Fig. 21, Plate 70, while the interior was shaped so that the edge bearing against the ram was nearly twice as thick as the inner edge. When these rings were put into the hydraulic machines, although they were a good fit they were not "tight"; they leaked, not much, but sufficiently to show that they were not acting on the principle on which lipped rings were supposed to act. These identical rings were then taken out and put in a lathe and rounded at the corners, as shown in the drawing; and as soon as ever that was done they were perfectly tight; showing that for a ring to work at the best advantage it must be free from the ram at those corners. This would also show that the tightness of the ring did not depend upon the direct pressure of the water behind it driving it out laterally against the ram, but upon the pressure acting radially to the curve, and resolved into a direction tending to straighten out the semi-circular curve of the bottom of the ring, and so giving a thrust in the lateral direction against the ram, as further shown by the fact that the wear took place only at the point G next to the ram. A gun-metal liner J had also been made to fit exactly to the shape of the inside of the ring, as shown in the figure; and there were a series of holes drilled right into the root of this liner to admit the water well into the interior of the ring. This however was not found to make a very great difference, because even without these holes the ring would never fit so tight upon the liner J, but that the water would pass in behind it. As to the leather rings, the great defect in many of the sections employed had been found to be that already pointed out by Mr. Wilson, namely that they were made much too deep: it was astonishing how shallow a ring would work with perfect success; and of course the less material there was used the better, so long as it would answer the

purpose effectually. From a large number of experiments he (Mr. Welch) had deduced the following formulæ, which gave what he had found to be the best proportions for leather packing rings:—

$$T = 0.156 R^{0.279} \quad D = 2.5 T \quad W = D$$

in which R = diameter of ram, T = thickness of leather, D = total depth of ring, W = width of ring outside when of U section. It was absolutely necessary that leather rings should not be strained in the moulding; and he had found that it was the straining of them by moulding them too much at one effort which really damaged the leather to such an extent that it was liable to crack soon afterwards, and to have no durability. He had found it necessary to make a series of moulding boxes of successively increasing depth, and to mould the rings by gradual steps; when they passed through the whole series of moulding boxes, much better and more permanent leathers were obtained, and the extra time expended on the moulding was as nothing when compared with the extra duration of the rings. Ultimately however he had entirely done away with the cup-leather rings, and had adopted hemp packing instead; and he used nothing else now. The hemp packing he had used up to a pressure of one ton per sq. in., and it was found to be perfectly tight. He had hemp packing which had been at work for a year without being replenished at all, and there was as yet no sign of leaking.

Mr. E. T. BELLHOUSE said that, having had some experience of packing presses with steel cylinders working up to a pressure of 5 tons per sq. in., he had found very considerable difficulty some years ago, when the steel presses were beginning to be used, in procuring in the then state of the steel manufacture steel cylinders which would stand with any degree of certainty the required pressures; and not having made the cylinders himself he had in some cases sustained considerable loss in consequence of their not having been sound. The steel cylinders however that were now manufactured by Messrs. Whitworth and by Messrs. Nasmyth at Patricroft he believed were eminently successful and very desirable indeed for hydraulic presses. It was now a long time since he had used steel cylinders himself, and he should have used them more,

only that he had not been able with confidence to recommend waiting for steel cylinders to replace broken iron cylinders in hydraulic presses employed in Manchester warehouses. For India he had manufactured two packing presses, which had succeeded admirably, and had a good many advantages. One advantage was that instead of being a considerable height and requiring high buildings, they were about half the height of the presses then in vogue, the pressure being given sideways in the first instance, and then perpendicularly as a finish. An objection was urged against them on the ground that in some unexplained way the fibres of the cotton or other material packed in these presses were so jumbled up together that they broke, and the fibre was destroyed; but that had not been substantiated by the practical working of the presses, and in fact the experience of the bales which were turned out proved that it was an entire fallacy. In those presses the pumps had not been worked upon the direct-acting principle shown in the drawings accompanying the paper, but by shafting and gearing from the steam engine to the pumps, which were worked just in the same manner as the original hand presses used to be supplied by hand power, the more recent presses having been brought to their present state of perfection gradually, as in the case of so many other inventions, through improvements made gradually by a great number of inventors; and he believed there were warehouses in Manchester where the pumps for the presses were worked on the same principle. The pressure was first applied laterally, by two horizontal rams of 7 in. diameter on opposite sides of the press, which were locked at the end of their stroke, and then the finishing pressure was given by a vertical ram of 16 in. diameter; that arrangement saved half the depth of foundations required where the whole of the pressing was done in the vertical direction alone. In a subsequent form of press, which he had designed in conjunction with Mr. W. J. Dorning, it was intended to give the pressure in the vertical direction alone, by means of a large central cylinder with 16 in. ram, and two smaller cylinders, one on each side of the larger. The two smaller rams acting direct upon the table of the press raised it first of all to the extent of their stroke, while the large ram was left behind at the bottom of the press; when they had risen as high as they could

go, a cylindrical block or distance strut, carried by an arm that was centred on one of the press pillars, was swung round and inserted beneath the table of the press upon the top of the large ram, the pressure of which was thus transmitted to the table for finishing the compression of the bale.

With regard to the use of leather packing rings, he had found that the ordinary cup-shaped leather ring, placed in a very shallow groove, was the best plan of packing; that required no supporting rings of metal either outside or inside; and when proper leather was used and the packing well made, it was suitable for any diameter of ram that might be required, and answered the purpose admirably.

Mr. J. G. CHAPMAN wished to draw attention to the difference between the direct-acting pumps employed for working the hydraulic presses described in the paper, and the pumps worked by cranked shafts for the Watson press made by his own firm, which had been described by Mr. Shield. It had been ascertained that, in the packing establishments where the pumps with 6-inch stroke driven by cranked shafts were working, it cost three farthings in fuel to pack a bale of cotton or jute; while in the other establishments with direct-acting pumps having 3-ft. stroke, it cost twopence. That was a great difference, and it was desirable to seek the cause. It was known that this could not lie in the difference of workmanship in the two kinds of pumps, because the work sent out to India must be good, or it could not stand. Granting therefore that the two combinations were equal in workmanship, there must be something in the design of the two sets of pumps to make them so different in the consumption of fuel. Having been personally interested in designing the pumps worked by cranked shafts, he had come to the conclusion that the reason was the difference of speed at which the water was driven before the plungers in the two kinds of pumps. In both cases heavy flywheels were used; and it was therefore clear that at some portion of the stroke the plunger propelling the water when worked direct-acting must go at the rate of the crank-pin; and as this went 50 per cent. faster than the steam piston, it followed that,

if the engine was running at 50 rev. per min. or a piston speed of 300 ft. per min., as all such engines did at times, the crank-pin must be travelling at 450 ft. per min.; so that, if the pump was directly connected to the piston, as those described in the paper were, the highest speed of the water through the valves would be 450 ft. per min., assuming the water-way through the valves to be equal to the area of the plunger. Even at a low pressure that would be an enormous speed; but at high pressures, such as 50 cwt. per sq. in., so great a speed was a very serious matter: whereas in the Watson pumps driven by cranked shafts, as the stroke was only 6 in., the maximum velocity, when running the engine at the same speed of 50 rev. per min. as in the other case, was only 75 ft. per min. instead of 450. The consequence of this difference was found in a four months' comparative trial to be that the coal consumption was small in the one case and large in the other.

With regard to the number of beats made by the pump valves when short-stroke pumps were employed, there were eighteen pumps working of 6 in. stroke to each of the Watson presses; and in order to run the bottom press-rams up through their entire 15 ft. stroke, each valve in each pump made only thirty beats, which he considered was not an excessive number.

Mr. G. LEWIS mentioned that in the Ashcroft packing press, made by Mr. W. Turner of Salford, the pressing was performed by a combination of steam and hydraulic power. From the curve which had been exhibited of the increasing resistance to be encountered in compressing a bale of cotton, it was seen to be necessary that in the first application of the power the speed of the motion should be as rapid as possible, while the pressure was low; then as the press ram rose, the bale became more dense, and it was necessary that the pressure should be increased proportionately. To meet these requirements, in a press that he had previously made on the ordinary plan there were as many as four sets of six pumps, twenty-four pumps in all; and to each of these pumps there was attached a separate and independent apparatus for knocking off, for enabling each pump to work independently of the rest, according to the varying pressures

required, as indicated in the diagram exhibited; and as the pressure rose, the pumps were automatically knocked off in succession. That press had worked with very good results; but as a previous speaker had pointed out, there were in that plan a great number of valves, all of which were liable to get out of repair and required incessant looking after. Now in the design of the compound system upon which the Ashcroft press was constructed, the object aimed at had been to provide for what was very observable in the curve of pressure, namely the rapid rise required in the press ram at starting; and it had been thought that no more rapid rise could be obtained than by the direct employment of steam power itself for the first part of the stroke. This had accordingly been accomplished by placing on the top of the press proper a steam cylinder 45 in. diameter, alongside of which were placed a set of pumps, six in number, arranged in three pairs of different sizes, the steam cylinder and pumps being of the same stroke, namely 9 ft., and the pump plungers being all attached to a crosshead on the top of the piston-rod. From this crosshead were carried down two side-rods coupled to a similar crosshead below the bottom of the press, arranged for lifting the rams proper that carried the table of the press. By this arrangement the first lift of the press, through the full 9 ft. stroke of the steam cylinder, was given direct by the steam: no quicker power could be obtained than by that means; no mode of applying the power to force water could beat that. The press cylinders themselves were filled by a supply of water flowing in by gravity direct from the tank while their rams were being lifted by the upstroke of the steam cylinder. In the return or downstroke of the steam cylinder, with the full steam pressure on the top of the piston, the six pumps came into action, forcing the water into the cylinders of the main press rams; and all six pumps went down as far as they could, that is until they were nearly brought to a stand-still by the resistance of the bale. The attendant, observing this, immediately knocked off the two largest pumps, of 6 in. diameter, and afterwards the two of the next size, leaving at last only the two smallest pumps of $3\frac{1}{4}$ in. diameter to finish the bale with the heaviest pressure: thus there was no power lost, the increasing pressures being successively put on by the

attendant just as required. One press of this kind was doing 45 bales per hour; and a larger press with the same 9 ft. stroke of the steam cylinder had done as many as 50 bales per hour. This seemed almost impossible, because in the ordinary presses with only one box, like those described in the paper, it was necessary to fill that box between the pressing of each bale, and the number of bales that could be turned out was thus limited by the rapidity with which the box could be filled. To overcome that difficulty in the press which he had described three boxes were arranged on a revolving platform centred upon one of the side pillars of the press, and there were three sets of men, two sets for filling and one set for baling; immediately the pressing of the bale was finished in one box, the platform was turned round and the filling of the empty box was begun while the second box was being pressed and the filling of the third was being finished. In that way the press was enabled to do as many as 50 bales per hour; and it would be seen that the whole number of strokes required to finish each bale was only two, one up and one down.

In regard to packing leathers, he could bear out what had been said by Mr. Wilson about their being generally made too deep; and he asked what he had found in his practice was the necessary depth of a packing leather for a ram of 9 in. diameter.

Mr. WILSON remarked, in reference to the idea which had been expressed respecting the difference between what were called direct-acting pumps and those worked by eccentrics, that, although the rams of the pumps described in the paper were worked direct from the steam cylinder, requiring no connecting joints or shafts, still they were guided by exactly the same motion as the pumps worked by eccentrics, inasmuch as their motion was guided by the crank-pin of the engine, and that crank-pin if made large enough would become an eccentric, and would give the same motion as was got with the eccentric, only with much less surface in the crank-pin. Thus the twelve pumps of the engine shown in the drawing might be supposed to be worked with four eccentrics at right angles to one another: they began their stroke slowly and ended it slowly, exactly the same as if actually worked by eccentrics. The real difference between

these pumps and those driven by eccentrics, with which they had been compared by a previous speaker, was that, instead of having only a 6 in. stroke like the pumps worked by eccentrics, these pumps had a 2 ft. stroke; but if a pump with 6 in. stroke had to make as many strokes as would make up the difference in delivery between that and a pump of the same diameter with 2 ft. stroke, the former would have to make four strokes for one of the latter, and the consequence would be that the number of beats of the valves and every other motion in the smaller pump would be increased in the same proportion. In any other respect he could not understand where the difference lay between the direct-acting rams guided by the motion of the crank-pin, and those receiving identically the same motion through the eccentrics: in either case a very heavy flywheel might be employed, for working the steam more expansively; but so far as concerned the effect upon the motion of the water there could be no difference between the pumps worked direct from the piston-rod and those driven by a separate eccentric to each ram. In either plan the motion began at nothing and ended at nothing; and in the larger pumps the maximum speed attained was equal to the circumferential speed of the crank-pin, just as in the small pumps it was equal to that of the eccentrics. Thus he considered that either mode of working would give as satisfactory results as the other; but his experience was that it was desirable to avoid complication as far as practicable, and on that account he thought the simpler the arrangement was, the better.

With regard to the breadth of the packing leathers, he had found a great breadth was so much against the power of the leather to withstand crushing, and the leather was so liable to crack and break wherever it had become at all crushed, that he thought the narrower the leather was, the better, so long as it was water-tight: it could not be too narrow if the water did not escape. A breadth of only 1-8th or 1-4th inch, as shown full size in Fig. 20, Plate 70, he had found would secure the tightness of the leather quite as effectually as if it were an inch broad. The narrower the leather was, the longer it lasted, because the leather was pressed against the ram with the full pressure of the water behind it; so

that the broader the leather was, the greater was the total amount of friction to be overcome, and consequently the force tending to crush the leather longitudinally was proportionately greater, and caused it to be crushed by the friction of the ram. Hence he had had rams covered with gun-metal, whereby less friction was occasioned, because the gun-metal surface was smoother; and by that means economy was obtained in the leather, for where one leather working against a cast-iron ram would be destroyed in a few days, another working on gun-metal would last for months. That was a matter of great importance in the rams: at the bottom for a length of about 3 ft. from the end, where the heavy pressure came on, they were all covered with gun-metal and highly polished, whereby the wear and tear of the leathers was much reduced.

The PRESIDENT proposed a vote of thanks to Mr. Wilson for his paper, which had given rise to a very spirited discussion upon its subject.

The vote of thanks was passed.

The Meeting then terminated.

HYDRAULIC PACKING PRESSES.

Plate 61.

Wilson's Horizontal Direct-Acting Engine and Pumps.

Fig. 1. *Elevation.*

Fig. 2. *Plan of one engine with six pumps.*

(*Proceedings Inst. M.E. 1877.*)

Scale $\frac{1}{40}^{th}$

Ins. 12 6 0 1 2 3 4 5 6 7 8 9 10 Feet.

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Plate 61.

HYDRAULIC PACKING PRESSES.

Wilson's Horizontal Direct-acting Pumping Engine

Fig. 3. Section of Pump and Valves.

Plate 62.

Fig. 4. Plan.

Plate 62.

Fig. 5.
Elevation.

HYDRAULIC PACKING PRESSES.

Plate 64.

Wilson's Finishing Press.

Fig. 6. *Front Elevation.*

Fig. 7. *Vertical Section.*

(Proceedings Inst. M.E. 1877.) Scale 1/50th. Ins. 12 6 9 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 Feet.

Plate 64.

Fig. 11. *Section of one of Top Rams.*

Scale $\frac{1}{12}^{th}$

Fig. 9. *Sectional Plan at XX.*

Fig. 10. *Sectional Plan at YY.*

Fig. 8. *Vertical Section.*

HYDRAULIC PACKING PRESSES. Wilson's Horizontal Press.

Plate 66.

Fig. 12. *Longitudinal Section.*

HYDRAULIC PACKING PRESSES.

Plate 67.

Wilson's Horizontal Press.

Fig 13. *Transverse Section at XX.*

Fig 14.

Transverse Section at YY.

Fig 15. *Half Plan.*

Plate 67.

Fig. 16.

Fig. 17.

Scale $\frac{1}{60}^{th}$
(Proceedings Inst. M. E. 1877.)

HYDRAULIC PACKING PRESSES.

Plate 69.

Fig 18. Diagram showing Pressure upon Bale in Watson Press.

(Proceedings Inst. M. E. 1877.)

HYDRAULIC PACKING PRESSES. Plate 70.

Full-size Sections of Cup-Leathers.

Fig. 19.

*Packing of
Rams in Fig. 6.*

Fig. 20.

*Packing of
Top Rams in Fig. 8.*

Fig. 21.

Fig. 22.

Fig. 23.

Fig. 24.

Scale 1/6th