

## DOUBLE-CUTTING AND HIGH-SPEED PLANING MACHINES.

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BY MR. J. HARTLEY WICKSTEED, *Past-President*, OF LEEDS.

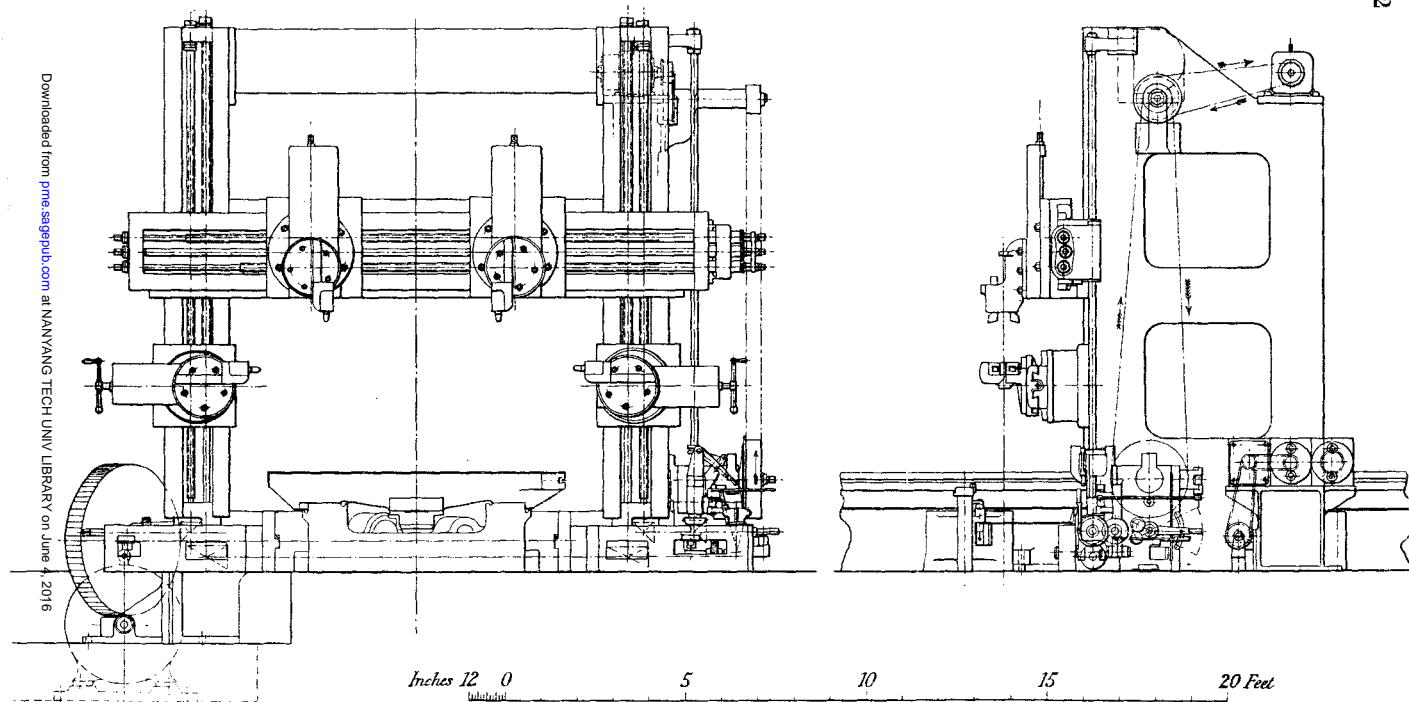
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The Planing Machine with its idle return-stroke is necessarily inferior in principle, for the economical removal of material, to a Lathe with its continuous-cutting action. Nevertheless, plain surfaces are best done on planing machines, and this being so, the problem of minimizing the time spent on the idle return-stroke has naturally received great attention, with the result that, in some cases, it has been reduced to one-tenth of the whole time spent on the complete cycle of the table. But, why do we not eliminate the idle stroke altogether by making the machine cut equally on both the forward and the backward strokes, and thus make its cutting action very nearly continuous?

It is hoped that, in the following Paper, the conditions will be explained under which this is undoubtedly the most economical method, and also the conditions under which single-stroke cutting should be preferred.

The recent development of change-speed reversing motors has overcome the chief objection previously existing to the extended use of the double-cutting principle. The previous objection to the use of a double-cutting tool-box was that, with an equal speed to the planing-machine table on both the forward and backward cut, it followed that, when the work did not permit of the use of both

FIG. 1.—Double-Cutting Planing Machine, 30 ft.  $\times$  10 ft.  $\times$  10 ft. (Buckton). Driven by 30 h.p. Reversing Motor (Vickers).



tools for want of clearance at the end of the stroke, as, for instance, when planing in a steam-chest, and when therefore only one tool could be used, the absence of a quick return-motion on the idle stroke discounted the advantages gained on other work where double cutting could be employed. The variable-speed reversing motor removes this objection, because this drive can be set either to reverse at equal speeds for double cutting or to drive slowly on one stroke, and quickly on the other, whenever it is convenient to plane only in one direction. Thus, in the machine illustrated in Fig. 1, which is a Buckton Double-Cutting Planing Machine to plane 10 feet square by 30 feet long, driven by a 30-h.p. Vickers Reversing Motor, with an auxiliary 3-h.p. motor for raising the cross-slide and side tool-boxes, and for feeding and traversing all the tool-boxes, the table is driven at speeds varying between 20 and 60 feet per minute, on either stroke. The motor is regulated by varying the field strength, and will stand heavier intermittent loading at the lower speeds than at the higher. Hence, this motor will exert its full horse-power at all speeds, as the torque on the motor-shaft is approximately inversely proportional to the speed. The result of this is that the slower the speed the table is driven, the heavier is the cut that can be taken. In general, the machine cuts on both strokes, but the double-cutting tool-holder can be removed and a strong single tool-holder substituted, capable of carrying a long projecting toolstock for heavy cuts on steel, in any case where the work does not lend itself to double cutting.

In planing cast-iron the advantages of double cutting are twofold; for, besides having two feeds to the tool-box on each cycle of the table, the back-to-back tools mutually assist each other by chipping away the scale in front of them in either direction, so that each tool has clean metal to enter at all the edges of the casting with which it comes in contact. The tools are thus saved from so much wear that, instead of two tools requiring more fixing, they require, on the whole, less fixing than a single tool, for the reason that the back-to-back tools so save each other from wear that they do not need to be removed and re-fixed during the

progress of the work, for the purpose of being reground. Also, the first roughing cut is more uniform if made with two tools than with one tool, because they get so much less worn between the first cut and the last, partly because each tool only takes alternate cuts, thus reducing the wear to half what a single tool would be subjected to on one job and with one setting; and further, because of the assistance which each tool has rendered to its companion in preparing clean metal at all the edges where the single tool would have had to face hard scale. It has accordingly been found that turbine casings, for example, could be planed true in less time by double than by single cutting, even if the time taken by the idle return-stroke were eliminated altogether. The reverse position of the back tool also makes it particularly advantageous for taking broad finishing cuts; it does not require cranking back to prevent making chatter marks, because it has no tendency to dig into the work. For the same reason it can be advantageously used for cutting grooves with a parting tool. In these cases, although the double-cutting tool-holders are not changed, the back tool only is inserted and the back stroke can be driven at 20 feet per minute, with an idle stroke, on the usual forward stroke, of 60 feet per minute. There are also occasions where it saves turning the work round end for end to have a tool available for planing up to an obstruction in either direction.

The feed of the tool-boxes is effected by a continuous running belt-pulley and a friction-clutch, which is thrown in at each reversal of the machine, and permits the belt-pulley to take one, two, or four complete revolutions before it is thrown out. Further changes of feed are provided in a gear-box. If one tool alone is in action, the tappet at one end of the table is turned back so that the feed does not operate on that reversal.

The manner of double cutting is to fix both tools precisely back to back; in fact, the second tool is adjusted by simply dropping it into the furrow made by the first tool. The back tool follows in this furrow till the end of the stroke when it receives a feed motion; it then cuts a further furrow in which its companion follows free, and thus, on a single cycle of the table, two furrows

have been cut of equal width and equal depth. Thus, assuming a feed of  $\frac{1}{8}$  inch at each reversal, then at the completion of the cycle  $\frac{1}{4}$  inch would have been traversed.

Fig. 2, Plate 62, shows a Constant-Speed Double-Cutting Planer driven from a line-shaft. It planes 36 feet long by 8 feet square.

It is astonishing to the author to see any machines put down for the express purpose of planing engine base-plates, machine-beds, table, or tank-plates, with an idle return-stroke, even if provided with gang tools, when two back-to-back tools would do all such work with much greater economy in the wear of the cutting tools, the wear and tear of the machine, cost of driving power, the time of doing the work, and the quality of the work done.

It must be conceded, however, that for work of great variety, and in some cases for special work, the bulk of it may only lend itself conveniently for cutting in one direction, and therefore the saving of as much time as possible on the idle stroke is very advantageous. For instance, in planing railway switches, with heavy cuts on very hard steel, it would be dangerous to enter a tool in the direction of facing the point, and consequently this special work is done cutting on one stroke, and the quickest possible idle-return. Also, in miscellaneous work fixed to the table by cramps and bolts which often project above the work and would interfere with the 6-inch over-run of the back-to-back tools, there are advantages in cutting in one direction only. The consequence is, that on machines of moderate size, where it is practicable to get a quick return of about 8 to 1, it is hardly worth while to have a double equipment of tools and tool-holders, especially as on short jobs requiring right and left-hand tools for planing down vertical faces, or for undercutting, or for rounding the corners of the work, the single-cutting tool-box would be almost constantly in use.

Fig. 3, Plate 62, shows a machine with tandem tables, each of which will separately plane 16 feet long by 5 feet wide by 5 feet high. It will cut at any speed from 17 feet per minute to 60 feet per minute, and return at 136 feet per minute. It is driven by a 50-b.h.p. electrical set as made by the Lancashire Dynamo and Motor Co., Ltd.; the motor generator is placed upon the top of the

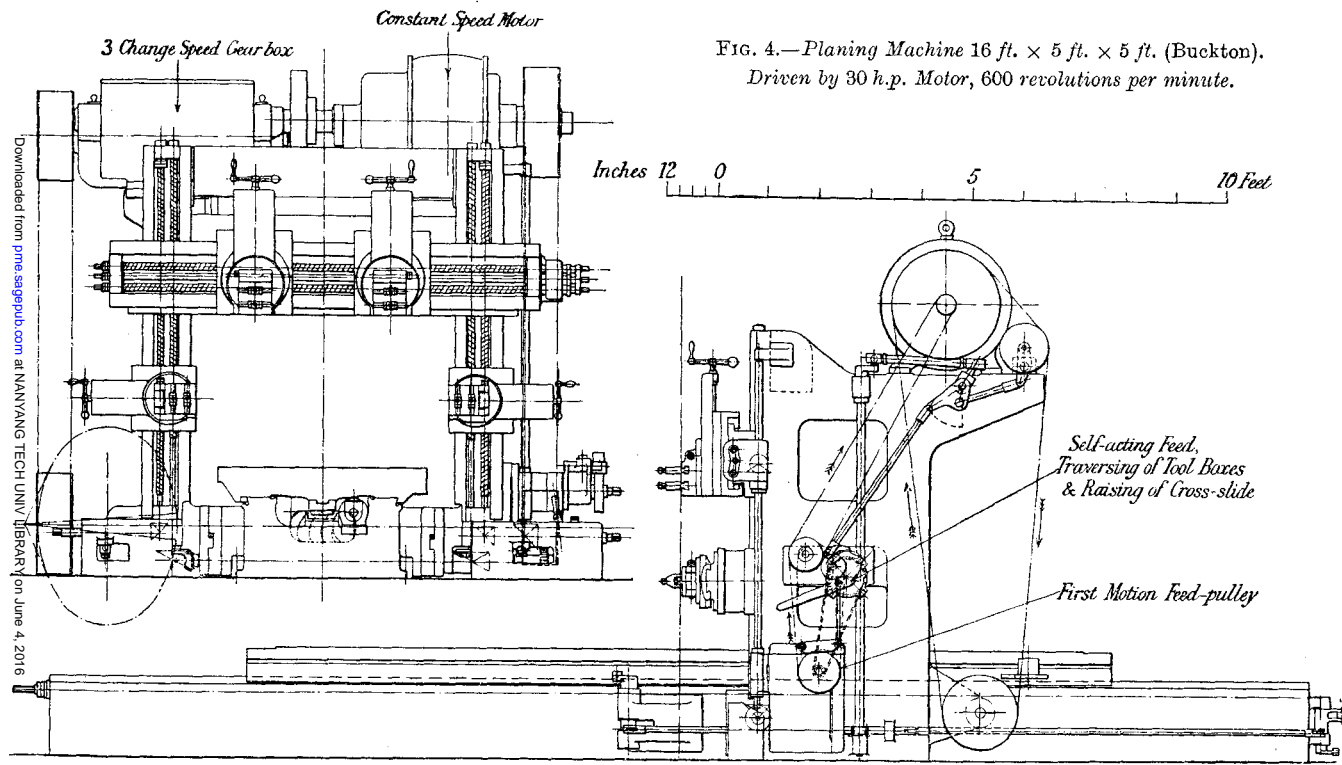


FIG. 4.—Planing Machine 16 ft.  $\times$  5 ft.  $\times$  5 ft. (Buckton).  
Driven by 30 h.p. Motor, 600 revolutions per minute.

machine and runs at a constant speed. The motor is driven from the mains and can be either alternating or direct current. The generator supplies current to the planer motor, the voltage of which is varied, thus giving changes of speed on the machine over a total range of 8 to 1. The machine will take the same strength of cuts at any speed from 17 feet to 60 feet per minute, the horsepower given out by the planer motor being directly proportional to the cutting speed.

The next machine to be described is of exactly the same strength as the foregoing, and it gives the same weight of cut at slow speeds and has the same ratio of quick return; but, instead of being driven and reversed by a reversing motor, it is driven either by a belt from the line-shaft or by a continuous-running motor.

Fig. 4 shows the machine to plane 16 feet by 5 feet by 5 feet driven by a 30-h.p. motor running at 600 revolutions per minute, whose power is delivered through belts to the machine. The belts do not shift on fast-and-loose pulleys but are themselves tightened and loosened alternatively, and when at half stroke of the jockey-pulleys each runs loosely in a loop under its respective pulley without touching it. The cutting speeds are 17, 35, and 60 feet per minute, and the return speed 136 feet per minute. The machine has a self-contained countershaft, which may be belt- or motor-driven, and two open belts, as has been said, to convey the reverse motions to the cutting and return strokes. One belt for the quick return is driven from the countershaft or motor-spindle, the other belt for the variable cutting-stroke is driven through a three-speed gear-box. The gear-wheels run in oil and only one pair is in mesh at a time, namely, the pair giving the speed required for the cut in use. On account of the drum of this belt being driven through single-purchase gearing it runs in a contrary direction to the quick-speed belt, and therefore it reverses the machine without being crossed, which enables it to drop plumb round its pulley. Each belt encloses a jockey-pulley. The pedestals for the jockey-pulleys are adjustable so that a good endless belt never requires taking up and joining. Both jockey-pulleys are thrown from the same rocking shaft, and when the reversing-gear rocks this shaft in one direction the driving-belt

is tightened by its jockey-pulley, and when it rocks in the contrary direction the driving-belt is loosened and the quick-return belt is tightened. The belts are endless belts from the makers' works without any laced joints or metallic joints, and any stretch that ensues in a new belt is taken up by moving the position of the jockey-pulley. The grip of these open belts is so smooth upon their pulleys that there is not the slightest knocking on the gearing, at the reversals, of the machine. They themselves form a most perfect friction brake-drive, and no cushioning device or friction-coupling is required to prevent knock at reversal. The belts are 8 inches wide, and as they are not subject to contrary flexure round the jockey-pulleys, and encounter no edge friction from belt striking forks, they are exempt from the elements of self-destruction usually found in heavy planing-machine belts.

It is perhaps needless to say that the chief inertia in stopping or starting a belt-driven planer resides in the rim of the driving pulley. During the quick return-stroke the shaft of this pulley makes about 800 revolutions per minute, and it is obvious that if this shaft be driven by a pulley 24 inches diameter with 8 inches face, instead of a pulley 48 inches diameter with 4 inches face, the weights of the pulley-rims would be about the same, but the peripheral speed of the one would be twice that of the other, and the inertia to contend with in the larger-diameter pulley would be four times that in the smaller-diameter pulley, although the belt driving power would be the same. Therefore, by using broad belts of low velocity instead of narrow belts of high velocity to deliver the power of the motor on to the cut, the chief inertia has already been reduced enough to enable the return speed to be double without increasing the inertia of the pulley-rim. Incidentally, the broad slow belt is a better brake than the quick narrow belt on account of its broad surface and low velocity.

The author does not claim to have discovered the advantages of the broad slow belt for reversing pulleys. That principle was first introduced by Mr. W. C. Mitchell, and has been applied by him to many heavy planing machines. His system is that of tightening and loosening belts by jockey-pulleys acting upon the outside of the



belts, and the chief difference in the author's system is that the jockey-pulleys act upon the inside of the belts and that the rocking shaft which works them is rocked from a crank-pin semi-revolving, so as to reach opposite dead-centres at each reversal. The same system of a loose belt tightened from the inside is also applied to the feed-motion.\* When the handle, Plate 63, of its jockey-pulley frame is lifted, the feed-motion runs continuously for traversing the tool-boxes and for raising the cross-slide. When the handle is dropped the continuous motion ceases, but when the machine is running, a lever from the rocking shaft, which throws the main jockey-pulleys, pulls a pawl lever engaging into the frame of the feed-motion jockey-pulley, and thereby tightens the feed-belt, just at the end of the quick-return stroke; but as soon as this tightened belt has driven the first motion of the feed gear one revolution, it has also turned a stripping disc  $\frac{1}{4}$  of a revolution, stripped the pawl out of engagement, and allowed the handle to drop, loosening the belt, and, at the same time, pressing a brake upon the feed-pulley to prevent over-run and has given a feed of  $\frac{1}{3\frac{1}{2}}$  inch. The stripping disc has four wipers, which, when all are in operation, strip the jockey-pulley after the first motion feed-wheel has made one revolution.

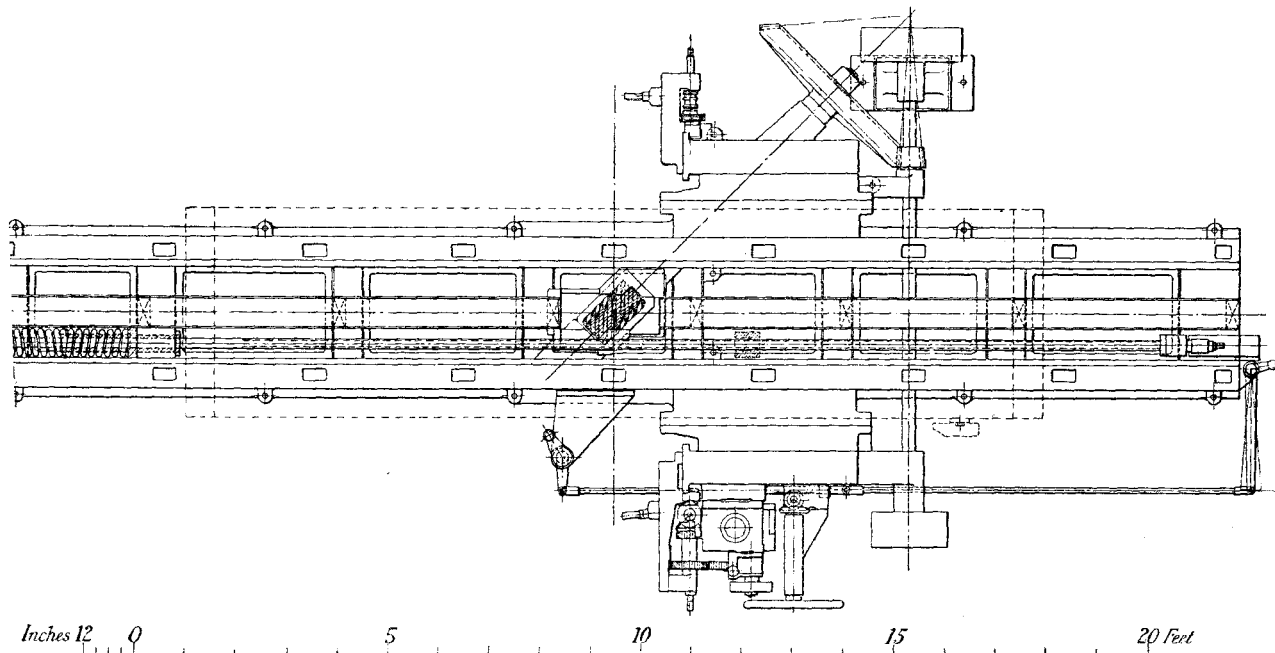
The wipers can be turned down, and, when only two are left in action, the feed-pulley receives two revolutions before the pawl is lifted and the feed becomes  $\frac{1}{1\frac{1}{8}}$  inch; and when only one is left the feed-pulley receives four revolutions before the pawl is lifted and the feed becomes  $\frac{1}{3}$  inch. But the first motion feed-pulley drives through two change-gearings, and when the quicker gear is thrown in, the feeds obtained from the stripper plate become  $\frac{1}{4}$  inch,  $\frac{1}{2}$  inch, and 1 inch. By this simple automatic gear, therefore, six rates of feed are obtained varying from  $\frac{1}{3\frac{1}{2}}$  inch to 1 inch. The tool-boxes can be traversed without altering any clutches.

For example, assuming that a feed is operating upon one of the tool-boxes and that, to pass over a part that does not require

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\* A full description of this feed-gear may be found in Patent Specification No. 1586. A.D. 1911.

FIG. 5.—*Planing Machine, 16 ft.  $\times$  5 ft.  $\times$  5 ft. (Buckten). Showing reaction spring for high-speed return stroke.*



planing, it has to be traversed 12 inches to come up to its fresh cut, then, without making any change in the feed-gear, but by simply holding the jockey-pulley into the belt by its hand-lever, the motion becomes continuous instead of intermittent; but the moment the hand-lever is dropped, the intermittent feed-motion is resumed. The direction of traverse is reversible by a handle. All the feed-motions and the traversing motions of the tool-boxes and the raising and lowering of the cross-slide are effected by power from this same continuous-running belt. The table is driven through a rack by Sellers' spiral gearing. The guides of the table and bed are flat horizontally and slightly undercut at the sides. The table therefore cannot lift under any circumstances.

The plan view of this machine, Fig. 5, shows the arrangement of a reaction spring placed in the bed of the planing machine, which enables it to attain the speed named without distress upon the return belt or overload upon the prime mover. It will be seen from the drawing that there is a boss cast on the second cross-bar at the front end of the bed, and abutting against this boss is a spiral spring about 2 feet long. Through this spring a screw-shaft is passed carrying a collar to press against the outer end of the spring, and also carrying a heavy nut against which a lug, cast solid under the table, impinges.

By turning the screw-shaft, the nut can be traversed over a length of 16 feet into any position desired for the reversal of stroke. When the lug under the table impinges upon its nut, it moves the screw-shaft endways, and by the collar at one end compresses its spring. On one end of the screw-shaft a cam-plate is carried on a crosshead, and the end movement of the screw carrying the cam-plate with it moves the lever of the belt striking gear, and thus the same movement of the screw-shaft compresses the reaction spring and reverses the drive. The synchronism of these two operations is not disturbed by turning the screw round and altering the position of the nut to adjust the length of stroke, and this can be done even while the machine is in motion. The place at which the table ends the cutting stroke always corresponds with the position of the nut, namely, anywhere over

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the 16-feet range of the screw-shaft. The screw is 1 inch pitch, which is convenient when the operator is setting the stroke for exact clearance, as each full revolution of the screw alters it a known inch. The screws can be turned by hand so rapidly that an adjustment over a range of 10 feet can be effected in 1 minute. At the end of the screw-shaft, passing through the spring where the cam-plate is placed for reversing the table from the cutting to the idle stroke, it will be seen that there is a little space between the cam-plate and the belt striking lever. This is to give a late cut-off to the belt striking gear so as to prevent the driving belt being loosened before the spring is sufficiently compressed. While the cam-plate is passing through this space on the 60-feet cutting stroke it is compressing the spring, wholly by the residual energy of the moving masses, and when the space is covered and the lever kicked the spring has made a dead beat of 4 inches. The scale of this spring is 1 ton per inch, giving a terminal pressure of 4 tons.

Thus, at the end of each cutting stroke, the spring being compressed 4 inches, there is, at the moment of the table reversing, such a thrust upon it as will help to start it on its quick-return journey. The quick-return belt is thereby greatly relieved, as it is not called upon first to take out the kinetic energy of the table and the revolving pulleys in one direction, and then to supply a further amount of energy to accelerate them in a contrary direction, but, instead of this, the whole of the residual energies of the revolving parts and of the moving table at the end of the cutting stroke are stored up in the spring and are immediately returned, by its reaction, to assist in starting up the quick-return stroke.

When the speed of cutting stroke is 60 feet per minute, more than the necessary amount of work is supplied to compress the spring by the kinetic energy of the moving parts, but when the table is driven at its slowest speed of 17 feet per minute a little assistance is required from the drive at the end of the cutting stroke to complete the compression of the spring. Seeing, however, that the drive is from a constant-speed motor and acts through  $3\frac{1}{2}$  times the multiplying

power of gear when the cutting speed is at its slowest, it happens that at the very time when there is a deficiency of energy in the moving parts for the complete compression of this spring, there is a surplus of power in the drive, beyond what is required to complete the maximum cut, without putting any overload upon the motor. By the reaction of the spring described, the table has a good send-off at the beginning of the quick return-stroke, and no dwell is perceptible at the point of reversal; there is no shock on the gearing, and the curve of the power diagram does not rise above the full-load line. In starting up the quick-return motion the short spring delivers 0.66 foot-ton of energy in 0.26 of a second, which is at the rate of 150 foot-tons per minute, which is at the rate of 10 h.p. during the period of acceleration.

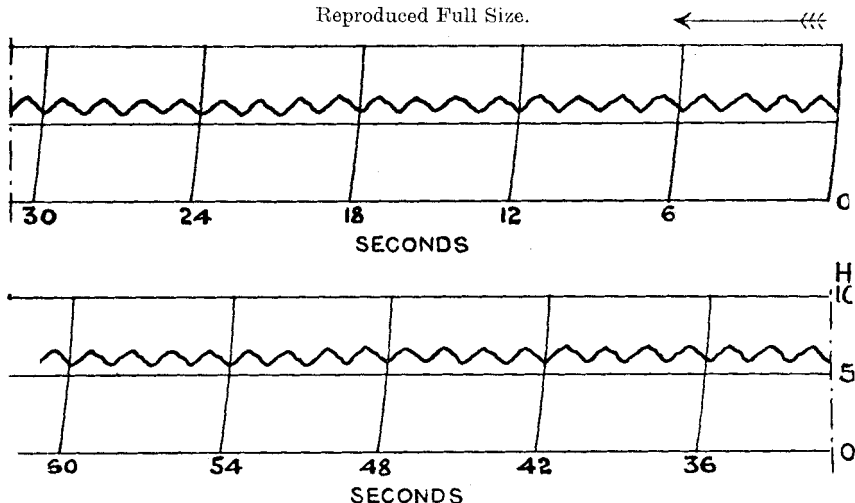
The following detailed description will explain the action of the spring. Picture then, the table ready for starting its return stroke under the influence of a spring compressed to a load of 4 tons and stored with 8 inch-tons of potential energy, which, being regulated by the speed of the return belt, it delivers to the table in 4 inches of travel. The 30-h.p. quick belt with this assistance is able to accelerate the table, and keep the speed up throughout the stroke, without heating the pulley. The machine will at all times work dead beat between two walls, and plane up to  $\frac{1}{8}$ -inch landing.

The reversal at the end of the quick-return stroke is dealt with quite satisfactorily by the broad belt on the 24-inch driving pulley, and this belt motion is struck from the usual form of knocker on the table.

The machine will work with certainty at full speed and let the tool drop without marking the work between landings of  $\frac{3}{8}$  inch for the start and  $\frac{1}{8}$  inch for the finish, Fig. 6, Plate 62. The reduction in idle clearance-spaces and the command of good feed-traverses, ranging from  $\frac{1}{32}$  inch to 1 inch, contribute greatly to the large output of work which has been realized with this machine. By this system of drive with continuous-running prime-mover, the full power of the drive is available at all speeds, and the heaviest chips can be taken at the slowest speed.

The power of the machine, as described, is equal to a 10-ton pull upon the table at the middle speed, and a 15-ton pull at the slow speed. The speeds given are such as could be worked continuously without heating or irregularity down to 12 inches length of stroke, and if made without a reaction spring, the return speed, instead of being 136 feet per minute, would be 110 feet per minute, but if it were driven by shifting belts and without reaction spring, 90 feet per minute.

FIG. 8.—*Power Diagram from Planing Machine, 10 ft.  $\times$  4 ft.  $\times$  4 ft. (Buckton).  
40 Cycles per minute.  
Reproduced Full Size.*



It will be readily understood that in proportion as machines are made for lighter cuts, they can be returned at quicker speeds, because, as has been said before, the chief inertia lies in the rim of the driving pulley, and this rim must needs be made in proportion to the weight of the cut required. Thus, in a 4-foot-square machine, with a 5-ton pull on the table, fitted with a reaction spring, the quick return of 160 feet per minute can be given, or in a quite simple machine for light cuts, with about 1-ton pull on the table, a return speed of 240 feet per minute is attained without the

assistance of any springs. On the other hand, it should be borne in mind that, in a machine for extra heavy cuts requiring a 20-ton pull upon the table, the judicious return speed would be less than those quoted in proportion as the power might be greater.

Reverting finally to the 4-foot-square machine just mentioned as returning at 160 feet per minute, Fig. 7, Plate 62, shows photographs of work done with this machine on a 6-inch stroke, making 80 reversals per minute, and Fig. 8 is the power diagram taken at the time.

In this machine there were two reaction springs, one of which was compressed by the table at the end of the cutting stroke, and the other similarly compressed at the end of the return stroke, so the table ran in almost complete balance, as shown by the almost horizontal line on the power diagram. Each hump on that line shows a cycle of the table, 40 of these cycles being completed per minute, involving 80 reversals.

The Paper is illustrated by Plates 62 and 63 and 4 Figs. in the letterpress.

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*Friday, 17th November 1911.*

The PRESIDENT, in asking the members to accord a hearty vote of thanks to the author for his very interesting account of modern planing machines, said that those machines were responsible for part of the revolution in all engineering shops that had been taking place during the last comparatively few years.

The resolution was carried with acclamation.

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*Discussion on Friday, 15th December 1911.*

The PRESIDENT stated that, before the Discussion was commenced, the author desired to make a few remarks for the purpose of bringing the salient points of the Paper to the recollection of the members.

Mr. WICKSTEED, having given a brief description of the machines described in his Paper, said that he had brought for the inspection of the members some shavings obtained by the use of the machine in order that they might realize the meaning of a 10- or 15-ton pull upon the table. It would be observed that they were rather heavy shavings cut from 40-ton steel. There was nothing exceptional about them; the only object in showing them was that they gave an idea of what he meant to convey by the pull upon the table. To cut one of those shavings had required a pull upon the table of about 12 tons, and the pull was put upon the table at the rate of 20 feet a minute by a 20-h.p. constant-speed motor.

Taking 1 h.p. as equal to 15 ft.-tons per minute, then 20 h.p. would give 300 ft.-tons per minute, and the shavings he had exhibited would require about 250 ft.-tons per minute to remove them, which gave an ample margin without overloading the motor, for friction and other things such as inertia resistance.

Mr. WILLIAM H. PATCHELL inquired what was the weight of steel removed per minute.

Mr. WICKSTEED replied that the cross section of the shavings was the tenth part of a square in section, which, multiplied by a length of 20 feet, gave 24 cubic inches, the weight of which was 6.6 lb.

Mr. L. PENDRED, in opening the Discussion, said all the members of the Institution knew perfectly well the great interest that the author had always shown in double cutting, and the sturdy advocacy he had always devoted to it. It was not the author's



fault if double cutting had not been generally adopted in British workshops. He, the speaker, thought it must be the general opinion of all who were in the habit of visiting workshops that double cutting was very rarely used. Nearly all the machines that he saw in use were single cutting, that is, cutting in one direction only was employed. He imagined that the only reason why double cutting was not adopted was that managers as a rule were opposed to the slightly extra complexity which was involved in its use. He had said that the author was not responsible if double cutting was not more used, but, on second thoughts, he was not sure that the author himself had not been his own greatest enemy, because it was due to Mr. Hartley Wicksteed's improvements in the planing machine that double cutting was not more largely employed. The author, in conjunction with the electrician, who had done a great deal to bring the reversing motor up to a high point of perfection, had so improved planing machines, and so increased the rate of return, that it was not nearly so essential to cut on the return stroke as it was in the old days. When the return stroke was only twice the cutting stroke, then a great deal of time was saved by cutting on the return stroke. Now that the return stroke was three or four times as fast as the cutting stroke—and he believed Mr. Wicksteed even went to a higher speed than four times—there was not so much necessity as there was in the old days to cut on the return. But the author had gone a step further. One of the great difficulties that the planing machine had to meet was the enormous load that was put on at the moment of reversal.

In 1900 Captain Tresidder made some experiments at John Brown and Co.'s Works from which a number of very valuable diagrams were obtained, and which had since been published. He found from the figures that were given that in one case, where Captain Tresidder was cutting an armour plate at  $9\frac{1}{2}$  feet a minute, and returning at 19 feet, with a very small feed, only  $\frac{1}{32}$  inch, the cutting power and the power for return were both about equal, between 7 to 8 h.p. The reverse at the beginning of the cutting went up to  $14\frac{1}{2}$  h.p., and the reverse at the beginning

(Mr. L. Pendred.)

of the return rose to no less than 29 h.p. Those tests were made with an electrical drive. The improvements which had been introduced in the way of regenerative control, of which the device made by Messrs. Buckton was one of the best, had done a great deal to reduce the enormous power that was required at the beginning and the end of the strokes, and he thought it had done a great deal also to check the introduction of double cutting.

There was one small mechanical point the author had not touched on in his Paper which he would be very glad if Mr. Wicksteed would enlighten them further upon in his reply. If any planing machine were put before, say, an engineer from Mars, who had never seen a planing machine before in his life, he would have no difficulty at all in stating in which direction the cut should go. The whole machine was designed to take thrust in one direction. Referring to the sketch, Fig. 10, Plate 64, if one imagined the tool cutting in the normal direction, then the whole pressure of the saddle was taken upon the flat face of the shear A where there was plenty of area. If, on the other hand, the tool were reversed, or if two tools were put back to back, then during the backward cut the whole tendency was to lift the saddle off the shears, and the whole of the pressure of the cut had to be taken on the inclined face B behind the cross-slide. The sweep of the casting which supported the whole of the thrust of the machine was designed to take a thrust and not a pull, and if double cutting were used there seemed to be a certain amount of tendency to use the machine in the wrong direction, in fact pulling the machine where one ought to be pushing it. He hoped the author would be able to state whether that had had any influence on the little favour that double-cutting machines had been shown.

He thought one of the most important points in the Paper was the modification of Mitchell's drive which the author had adopted. He would be very much obliged if the author could give a comparison between the machine fitted with the belt-drive, such as was described, and the purely electrical machine, that is, a machine with electrical reversing and a variable-speed motor. It seemed to him that nearly all that was required could be obtained

from the belt-driven machine; that it might be possible to avoid altogether the use of the electrical machine, which with its reversing motors and so on was rather a complicated thing, and was probably far more costly than the belt-driven machine. The belt-driven machine with the modification of Mitchell's drive to which he had called attention was an extremely pretty device. It gave a low-speed small-diameter pulley with a low-speed belt, and anybody who had calculated the waste of power that was caused by the sudden stoppage of a high-speed pulley of a large diameter which was generally used in planing machines would appreciate the fact that what was wanted was a low-velocity belt and a small diameter pulley. That had been gained by the device which Messrs. Buckton had taken up.

Mr. JAMES E. DARBISHIRE said there was one point in reference to the author's planing machine which he wished to emphasize, namely, the adoption of Sellers' system of driving the table. He was fortunate enough in his early days to be connected with the old firm of Sharp, Stewart and Co., of the Atlas Works, Manchester, and it was probably known to most of the members—it was at all events to the older ones—that the firm mentioned were the lineal successors to Sharp, Roberts and Co., Roberts being the celebrated Richard Roberts who invented so many good things, amongst them one of the planing machines. When the speaker went to the Atlas Works there were in active use two planing machines made by Richard Roberts, in which the table was moved by a chain. Those machines were actually in service up to somewhere about the year 1880, but of course they were then kept more from sentiment than anything else. The firm also had rack machines with a plain rack, and rack machines with a step-rack; and they had some screw-driven machines made by Whitworth, which had the "Jim Crow" motion, the reversing tool-box, which turned round at the end of each stroke and cut in both directions. But as Mr. Pendred had dealt with the question of double cutting, he did not think it was necessary for him to say much upon that point. They abandoned the "Jim Crow" tool-box,

(Mr. James E. Darbshire.)

he thought chiefly for the reason that Mr. Pendred had called attention to, namely, that it gave a pull upon the cross-slide which was very difficult to take up and which produced irregular work. The rack-machines and the Whitworth screw-machines were all driven by single belts, and the screech of the belt at the time of the reversal of the table was something to remember.

About the year 1864 or 1865 William Sellers, of Philadelphia, produced his planing machine, and Sharp, Stewart and Co. took a licence for the manufacture of those machines in this country. They imported a small machine in which the table was driven by the "spiral pinion," as Mr. Sellers called it, which was a quick thread-worm running in a rack under the table. The motion was very quiet, very free from back-lash, and in fact nothing could have been better. The firm took the machine up, and from that time onwards all their planing machines were made with the Sellers' drive. Some of the first machines were made for the Barrow Shipbuilding Company, and were installed at the shipyard at Barrow and worked there many years. After some twelve years or more a fire occurred in the shipyard in which a lot of the tools were very seriously damaged, amongst them these planing machines. Eventually they were all returned to the Atlas Works to be repaired. The machines were rebuilt and improved in some respects, but he wished to say that from his own personal knowledge they put back into those machines the very same pinions and the very same racks without recutting or doing anything to them, and they were almost absolutely free from back-lash. He never saw any gears which wore so well as the Sellers' pinions and the racks in those machines. The firm made a great many of those machines, and during the whole of the time he had been connected with the business he had never heard a complaint of the Sellers' drive. One advantage gained from that drive was that the machine was at once speeded up by something like 20 per cent. Even with the tool steel available at that time, the Sellers' planer could be run at a cutting speed of something like 22 feet a minute, which was a very high speed indeed at that period. During the period that Sharp, Stewart and Co. held the

licence to manufacture the Sellers' planer nobody else adopted the system, simply because that firm had the monopoly. Subsequently, after the patent ran out, one of the very first people to see the merits of the Sellers' drive and to adopt it in his planing machine was his friend the author.

Mr. RICHARD W. ALLEN said the author had divided his remarks into two headings, "double cutting" and "high-speed planing machines." It had been mentioned by Mr. Pendred that some managers of works were opposed to double cutting. Personally he did not think that was really the case. He believed there was almost as much fashion in engineering as in ladies' hats. For instance, it has been fashionable for years past to cut in one direction; but he ventured to believe that, if the author and others who devoted their time and attention to planing machines would bring out a double-cutting machine which was efficient, it would have a very large sale. The suitability of the double-cutting machine depended very largely upon the nature of the work that had to be cut and its shape. It was quite obvious that if the articles to be planed were small and varied in shape, there was no particular advantage in double cutting. On the other hand, if the work was such that the double-cutting machine could be used for planing every day and every week, then there was something in it. During a recent visit to Newcastle he saw a machine which was specially constructed for planing the steel plates for forming the drums of a Yarrow boiler. As the members were aware, the drums of the Yarrow boiler were made either in halves or in three pieces, and the steel plates were planed to a sharp edge in order to obtain a true diameter. The particular machine in question was a double-cutting machine, and he was informed by the manager of the works that it worked exceedingly well, a great saving in time being effected. Workmen as a rule liked to do the work in the quickest time and with the least possible change.

The author had mentioned in the Paper various drives and planing machines. He (Mr. Allen) had watched for several years the Vickers' drive, which he remembered was supplied to a very large

(Mr. Richard W. Allen.)

planing machine of 8 ft. square with a 16-ft. table built by Messrs. Armstrong, Whitworth and Co. The machine was originally supplied with belts, and as his friend Mr. Darbishire had mentioned, the machine squeaked very badly every time it reversed, showing the loss of power in the belts. The belts however were removed, and the Vickers' drive was added to the machine about five or six years ago, and that drive had certainly been a great improvement, although in his (Mr. Allen's) opinion there were still a few defects in this apparatus. The principal of these defects was that the electrical switches were operated by a bicycle chain which in time stretched; the result of this was that the switches did not operate at the right time, and consequently the table occasionally ran off, which was not altogether desirable. In all electrical devices with high-speed planing machines, the designers should really think of one thing in particular, namely, simplicity. After all, engineers were human, and the man who worked the machine liked to have an apparatus which had the least possible parts and was free from breakdown. He had seen one machine at work which the author had mentioned in the Paper, and it seemed to him to be a very excellent piece of apparatus, but rather complicated. It would be more advantageous, he thought, if electrically-driven planing machines were simplified, and built with a less number of parts on account of the possibility of a breakdown.

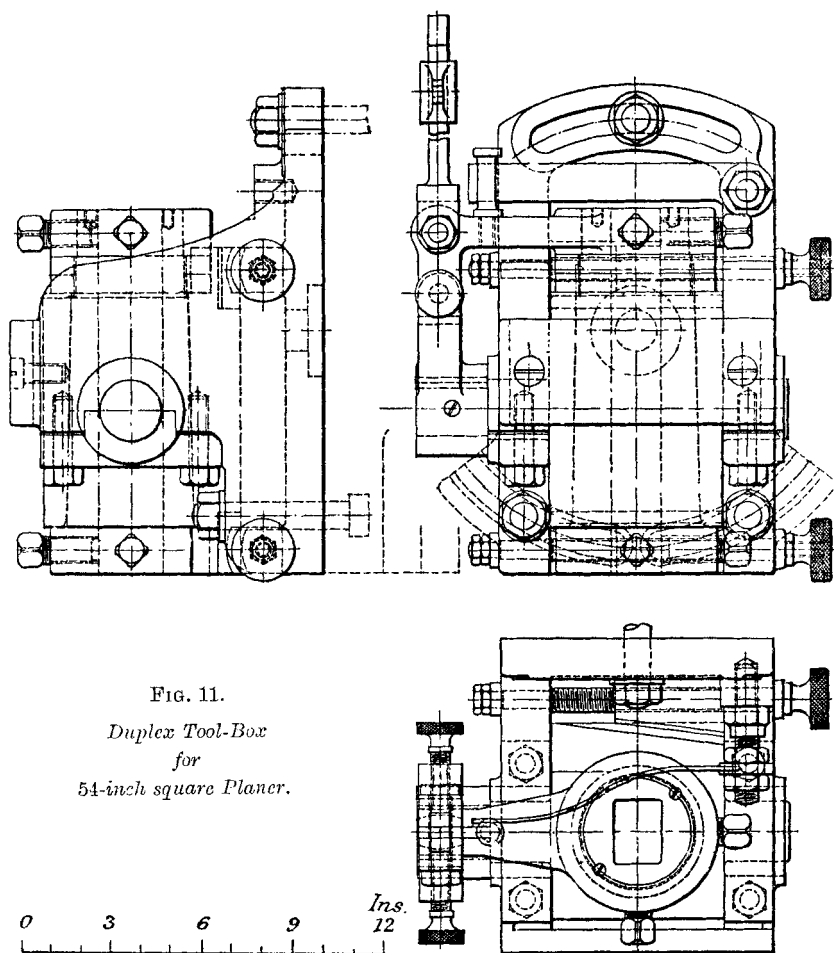
The author had mentioned the Sellers' drive. He happened to be at Messrs. Sellers' Works in Philadelphia in the early part of the present year, and he spoke to one of the managers on the question of high-speed planing machines, and ascertained that the Sellers Co. were not altogether in favour of the so-called electrical drive. They preferred to drive the planing machine through reversing clutches operated by compressed air. He was shown several machines at work, and they certainly worked exceedingly well. The machine was entirely dependent upon the air supply of the works, and, if the compressor failed, the machine was at once put out of action. The planing machine was one of the most difficult pieces of machinery to drive, and thanks were therefore due to the author for the work he had done on the subject.

Mr. WALTER DEAKIN said he was not a maker of planing machines, but was very much interested in them, and thought he could safely say that he was a proselyte of the author's efforts with reference to the value of double-cutting planing machines. There was a great prejudice against them, but he thought it was due to a want of consideration of the subject in a fair and square manner. For instance, a previous speaker had stated that there were jobs which were unsuitable for double cutting; personally he wished to say that about 75 per cent. of the jobs in many engine works were eminently suitable for double cutting. As engineers were specializing more and more in their manufactures, it would and ought to be possible to select suitable work for suitable machines, and in an engineering works of any size there was ample room to keep a double-cutting planing machine constantly in operation. One of the objections to the system had no doubt been the limited manner in which it had been possible to employ double cutting, generally only for roughing out purposes on plain surfaces.

He thought it would be interesting in connection with the discussion to introduce to the members a device which overcame many of the obstacles which had hitherto existed. Fig. 11 (page 1004) showed the chief principles of the device. This consisted of a pivoted tool-box with a semi-rotary motion, both vertically and horizontally. The Whitworth "Jim Crow" tool-box turned the tool all the way round. The complete revolution of the tool was objectionable on account of the considerable space necessary in which to circle the tool. With this new device the work could be done effectively without revolving the tools, and with one tool having a cutting edge on each side, instead of two tools as employed by other methods. The action of the device for cutting plain surfaces was shown in Fig. 12. The horizontal line represented the surface to be planed. When the tool was cutting in what he might call the ordinary form of cutting, it was inclined slightly at an angle as at A. In the reverse the opposite condition was brought about. The alteration of the angle was really only very slight, because all that was necessary was to give the angle of relief for each direction of the cutting tool; that

(Mr. Walter Deakin.)

was effected by rotating the tool-box on the horizontal axis. The alteration of the angle was effected by means of an additional shaft



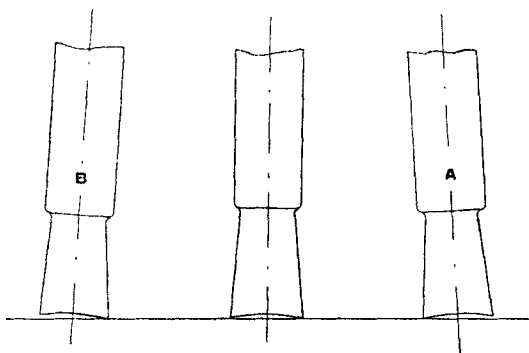
above the cross-slide of the machine; this moved at each end of the stroke like the ordinary feed-motion, and effected the alteration in the cutting angle of the tool. One of the advantages of the system



was that it was possible to do not only ordinary surface, but side and under cuts. In his own works it had been found that it was possible in that way to beat the milling-machine in undercutting slots of milling-machine tables, which were formerly milled on a horizontal milling-machine, with ordinary milling cutters, and then undercut on a vertical milling-machine.

With the form of tool-box described, the slots could be planed quickly by using the horizontal semi-rotary motion for surface-cutting the slots, and the vertical semi-rotary motion for undercutting. It was therefore unnecessary, as in the ordinary single-cutting planing

FIG. 12.



machine, to lift the tool out of the slot on the return stroke, and consequently considerable economy was effected. Side cuts and angle cuts could be done in the same manner, and with equally good results. Another important point about the device, which he thought would appeal to all engineers, was the facility it afforded for easy adjustment of the relative position of the cutting edges of the tool. He was not quite sure as to the method employed by the author of the Paper, but he believed he had to set down the tools to a level surface, and then fasten them with the set-screws provided for that purpose.

Mr. HARTLEY WICKSTEED stated that that was the case.

Mr. DEAKIN continuing said that not only was that so, but they were not capable of any further adjustment apart from unscrewing them and then fastening them again. In the arrangement which he was illustrating this was effectively accomplished by two tapered wedge pieces, which were seen in position behind the rectangular tool-block. These tapered wedges were at the bottom and the top of the tool-box, and held the tool, and were operated by a screw with a milled knob at the end, projecting from the outside of the tool-box; the amount of oscillation could thus be easily and quickly determined. A similar device was fitted for the semi-rotary vertical motion. When the box was being used for vertical cutting, both the wedges were fixed up against the back of the block to prevent any movement in a horizontal direction. A lever connected with the shaft above the cross-slide of the planing machine and operated by the table movement of the machine was connected with the tool-box and vibrated, thus giving the angle of inclination necessary to cut on the forward and return stroke of the tool. He thought a device of that kind overcame many of the objections that existed at the present time to double cutting. He also thought that if more attention were given by engineers to the subject they would find that they had tapped a new source of revenue.

There was another point to which he wished to refer in connection with the subject, which he thought touched upon an element of prejudice that existed in connection with double cutting, the point already referred to by Mr. Pendred, namely, the pulling of the slide off the front on the return stroke. If that question were considered calmly, he thought it would be found there was not quite such a formidable objection to the idea as appeared at first sight. What really happened, when cutting was being done in the ordinary manner on a planing machine, was that great pressure was applied at the lower edge of the cross-slide, but the tendency was to relieve the pressure at the top edge of the cross-slide, so that the absolutely solid cutting which it might be imagined they were getting was not obtained. The reverse of that was that they pressed it on the top edge, and pulled it off the bottom edge. In

cutting in either direction the action resulted in severe torsional strain on the cross-slide of the planing machine, and on the reverse stroke in double cutting there was little practical difference. If some alteration were made in stiffening up the cross-slide generally, any serious objection to double-cutting planing machines on that account would be eliminated. He was able to state that from actual experience he had obtained some excellent results from such a device, and had experienced none of the objections that had been urged in the course of the discussion.

The greatest objection to the whole scheme was the prejudice that existed among engineers. It was very foolish indeed to make so much as was generally made of the unsuitability of some jobs for double-cutting planing machines. This was quite obvious to all intelligent people, and wise men would get a double-planing machine at work on as many jobs as possible. If that was done, money would be saved, and engineers would in that matter, as in others, show that they were getting rid of prejudice, and going a little more solidly for facts. He was very much obliged to the author for the Paper he had contributed; personally, he was a believer in the planing machine. The planing machine, like most other machines, had its function in the shop. Milling machines were very good for particular classes of work, but he believed that the planing machine had a long career before it now that it was rejuvenated with the improvements to which attention had been called in the Paper; and if in addition the author took advantage of some of the other improvements which he (Mr. Deakin) had drawn attention to, he thought Mr. Wicksteed would do a better business in the future in supplying double-cutting planing machines than he had done in the past.

Mr. CHARLES WICKSTEED thought it was a mistake, when an endeavour was being made to ascertain why the double-cutting planing machine had not come into vogue, in spite of its apparent advantages and in spite of the indefatigable work that his brother had done in connection with it for the last fifteen years, to try and

(Mr. Charles Wicksteed.)

look at it entirely or even principally from the point of view of its mechanical defects. In his opinion the real reason of its non-adoption was the intense conservatism of the engineering profession and the extremely slow pace that most engineering works altered or improved their systems. It was quite true that if a visit were made to works, new works especially, the manager would be able to show a number of new machines and new processes that had been installed, but he would not state the years it had taken the inventor of these machines and processes to get any concerns of importance to recognize their merits or take them into serious consideration. Neither would he say that he was not the man who first recognized the advantages, but that he had simply followed others when the advantages were fully established and recognized and when it became the fashion to do the work in the new way. The principal aim of the management in too many engineering concerns was to save trouble; anything that gave the manager personal trouble and entailed a necessity of looking after the new process, and impressing the foremen with the fact that they had got to make the machine work, was shunned.

In the double-cutting planing machine there was nothing very attractive, nothing that appealed to the imagination, but there was the fear of trouble. For that reason its adoption was put off year after year, and this in spite of keen competition and the necessity for speedy and cheap production and economy of space. That the double-cutter would affect the savings in a large proportion of work, especially heavy work, there was no doubt, and that advantage should not have been taken of the double-cutter long ago for work that it was apparently suited for would appear to him to be impossible; and had he not known by painful experience the intense conservatism of so many English engineers! Granted that his brother had improved the single-cutting machine to the extent that had been mentioned by a previous speaker, and that, with the aid of spring buffers and a jockey-pulley, he had made it possible for a heavy machine to take its backward stroke at three times the pace of its forward. Even then the double-cutter showed a great advantage. If, for instance, the machine

took three minutes to make the cutting-stroke and one to return when converted into a machine to take the cutting-strokes both ways, it followed that in six minutes the machine would do double the work that with a single cutter it would do in four minutes. Or, in other words, the output would be increased one-third.

Mr. WILLIAM H. PATCHELL (Member of Council) asked the author to supplement the information he had already given in his Paper by giving a few particulars in his reply as to the size and depth of cut and the weight of material removed. All engineers were now very keen indeed on speeding up, but if a machine was speeded up and more material was not removed per unit of time, not much had been gained. When there was only an engine at the end of a long shaft in a shop, it was very difficult to tell what power was being put into any particular machine, but now that electrical driving was becoming more popular, it was very easy indeed to check the power against the work done, and to see what was the actual efficiency of the operation. He thought therefore if the author would give some of those particulars they would be very interesting.

He noticed that the author was very keen on the use of jockey-pulleys, but many members, including himself, had had very unhappy experiences of their use. The late Dr. John Hopkinson in particular he remembered introduced jockey-pulleys in various installations in this country. He introduced them in the electric station he put down for the Manchester Corporation, and also in the power-station of the City and South London Railway; but those engineers who had to work the jockey-pulleys were generally anything but sympathetic in regard to their use. To get any sort of a life at all, the belts had to be link-belts, and link-belts were an abomination. They were very heavy, and for a given width of pulley there was only half a belt, as there were so many holes in them and it was impossible to get a proper grip, although the makers said that a much better driving surface was obtained. Personally, he would rather have more width of belt and less air, because in that way he thought a more satisfactory belt would be

(Mr. William H. Patchell.)

obtained. He was surprised during a recent visit to the Continent to see some 400 h.p. motors running air-compressors with a jockey-pulley. He endeavoured to convey to the engineer in charge, by means of the broken German at his command, his sympathy with him, but in reply the German engineer simply beamed on him and said he would not wish to have any better drive than the jockey-pulley; he was absolutely satisfied with it.

Mr. WICKSTEED enquired whether a laminated belt was being used.

Mr. PATCHELL replied in the negative; so far as he knew it was a plain belt. He did not see the machine at rest, but as far as he could see, it was not a laminated stitched belt, but a plain belt with a long sewn joint. It was impossible, however, to tell very well when a belt was travelling fast, exactly how it was made, or of what it was composed. He was very much struck, however, with the work done by the French firm which supplied into Germany the machine to which he was referring; they, at any rate, had made a jockey-pulley run much more satisfactorily than was the case in this country.

Mr. A. W. MARSHALL said that the tilting tool-holder built on the principle referred to by a previous speaker was a very old device. The author would no doubt know that it was adopted years ago by Colyer on his planing machine. If a double tool was used, it seemed to him that it permitted the tool to be shaped to the correct form which used at any rate to be recognized for planing machine-tools, that is, in which the point of cutting took place, not at the front edge of the shank of the tool, but at the back, so that when the stress came on the tool, and the tool tended to give, it relieved itself from the cut. Modern practice seemed to be going away from that idea, and shaped tools were used which were apparently formed on the old North Country idea of knocking the lumps off rather than of effecting a proper cutting action. He thought that was a point worthy of

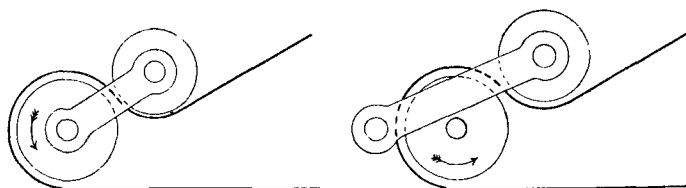
consideration. It seemed to him to be extremely difficult to get two cuts alike when any device for double cutting was introduced, in which the cutting angle of the tool was changed; and if a machine was required to give very accurate work, the introduction of such a double-cutting arrangement must, he thought, tend to impair the accuracy.

With regard to Mr. Patchell's remarks (page 1010), the jockey-pulley belt-drive to which he referred was known as the "Lenix" drive, which had been extremely successful. In that case the jockey-pulley was pivoted generally concentrically with the driven pulley, Fig. 13, so that, as the belt came round in the direction shown, the

*Diagrams illustrating the Driven Pulley in the "Lenix" Jockey-Pulley Drive.*

FIG. 13.

FIG. 14.



tendency of the jockey-pulley was to wrap the belt right round the driven pulley; and a weight was applied on to the jockey-pulley, so that the action was automatic, and adjusted itself to the drive. In certain cases where it had been impossible to do that, the supporting lever was pivoted so near that the action, although not strictly concentric, was very nearly concentric, Fig. 14, and that drive he believed had been very successful with dynamos and similar machinery. The general construction and arrangement was modified according to the circumstances of the drive.

Dr. H. S. HELE-SHAW (Member of Council) said that he wished to make a few remarks concerning the forces to which Mr. Deakin had just referred (page 1003). It must not be assumed that the reversal of stress alluded to by Mr. Deakin did not matter, because in the ordinary way, although there was *pressure* at the

(Dr. H. S. Hele-Shaw.)

lower end and *pull* at the upper end, and it was true these forces were reversed in direction when the tool was reversed, yet there was a considerable difference in the magnitude of these forces. Fig. 15, Plate 64, might be considered to represent the vertical distances of the tool-box and holder and position of the tool in Mr. Wicksteed's planing machine. The speaker thought he was right in saying that the extreme distances might be divided as shown into the three equal parts. The tool was, if anything, usually shorter, therefore the proportions might be considered well within the mark. According to this diagram, if the pressure  $R_1$  is the reaction on the upper end, and  $R_2$  on the lower, then we have the equation

$$R_1 \times AC = R_2 \times BC \text{ and since } AC = 3 BC,$$

$$\text{then } R_1 = \frac{1}{3} R_2 ;$$

also, if  $F$  = the reaction at the cutting edge of tool,

$$R_1 = \frac{1}{2} F.$$

It was thus easy to see that it did make a good deal of difference if the direction of the pull was reversed, because what was the push on the face of the guide in the ordinary direction was changed to a pull on the V groove when the direction was reversed; that is to say, assuming the weak part of the contrivance to be the pull on the V groove, the load on the weak part was three times as great in the reversed position as it was in the forward position. Of course it was possible to meet this by proper design, which he had not the slightest doubt Mr. Wicksteed always took care to do, but he raised the point as he fancied, from some remarks which had been made, that this great difference in the stresses upon reversal might be sometimes overlooked.

Professor ROBERT H. SMITH desired to make one remark about the form of tool illustrated on the board with special reference to what had been said by Mr. Marshall (page 1010). That gentleman advocated the use of two tools instead of the form of tool described by Mr. Deakin, because a springy tool was obtained in the other



form which he had sketched on the black board. In the first place, everyone knew that nowadays spring tools had almost been given up, except for special work; they were not useful for accurate cutting work, except under special conditions. But he wished to point out one very good reason why the use of two separate tools was better than the use of a single tool tipped backwards and forwards. When the single double-edged tool was used, the two cutting actions in the one direction and in the reverse direction could not always be exactly equal; one of the points would be worn before the other, and it would be necessary to grind one side of the tool to set up its edge earlier than it would be desired to perform the same operation upon the other side of the tool. Supposing the right-hand tool had its edge blunted first, it followed that that being a little more worn stood higher and would not cut quite so deep as the other one which was not worn. It was necessary, however, to have the two tool-edges cutting equally deep, and it would be necessary therefore to grind the tool that it was not desirable should be ground, the one that was still sharp. The user would be forced to grind off the metal upon the edge which was still in good condition. That, he thought, was a very solid objection to the use of the single double-edged tool instead of two separate single-edged tools.

Mr. WALTER DEAKIN said that the objection to which Professor Smith referred did not exist, as there was an adjustment in the tool-holder by which the relative wear could be adjusted most carefully and quickly, and the ease of grinding that tool was the same as that of an ordinary tool.

Mr. J. HARTLEY WICKSTEED, in reply, said he could truly say he was most gratified at the discussion which had taken place on the Paper. The discussion, however, had not taken the line that he thought it would have done. For instance, he expected questions to be raised as to the power of the transmission in the tightening and loosening belts; the amount of cut that could be obtained with 20 h.p. on different material, or the pull that could be put upon a

(Mr. J. Hartley Wicksteed.)

table at 60 ft. per min., with 30 h.p., and so on. He was prepared with his results to answer any such questions, but they had not been asked. At the same time he was interested to find there was a revival of the good old dispute about double cutting. He had had a good deal to do with double cutting, and knew all the arguments that were used against it, which were so fixed in tradition that it took time and patience to dispel them. In that connection he would like to mention that some years ago he had sold a large quick-return single-cutting planing machine to a leading firm of turbine makers. He had, however, taken care that its design was such that it might later on be converted to double cutting. After a few years' time the work overtook the capacity of the machine, and he was called in to consult with the firm about it. He advised the conversion prepared for, and on the idea being adopted, it was found possible to deal with all the work, and to dispense with the night shift.

He did not think the remarks which had been made about the conservatism and prejudice of engineers explained quite fairly the whole difficulty. The fact was that, to get the full advantage of a double-cutting tool-holder, there must also be a double-acting feed-motion. If there was a feed at each reversal of the table, then when the machine had made one cycle, it had done double work. If there was not a double-acting feed, but only the existing feed at one end, and this feed was split between the two tools, the tools would be troublesome to adjust, and it was also probable that the old feed-motion would not prove good enough to give a double feed that was worth splitting. The old feed-motions of planing machines were often the worst part about them. This was one of the troubles which checked the application of double-cutting boxes to existing machines.

The development of high-speed cutting had compelled makers to make the machines a better job all through, and to remodel the feed-gear entirely. Therefore the output of planing machines had been increased, not only so far as the increased speed of the table contributed to that result, but also by the greater amount of work that was done due to the improved feed. He had touched

upon those points in the Paper. Square slips on the cross-slide, as shown on Fig. 16, Plate 64, were preferable to V slips, whether a machine were made for double cutting or not; and by the time a planing machine has been made strong enough to take a cut one way without sensible spring, it meant it was strong enough to take the cut both ways.

In a well-built machine there was absolutely no objection from the structural point of view to cutting on both strokes, and if the work were suitable for the purpose, that is, if it were plain work, it was an unmixed advantage. For instance, in planing engine-beds there was less changing of the tools, not more, because the tools did not require changing until they had finished the job. The tools eased each other so much in cutting cast-iron that they took off a true roughing cut across much more surface than if only one tool were employed. The tool, on the backward stroke, cut just as well as the one on the forward stroke, and a little better. The backward cutting tool did not require to be cranked to give smooth cutting; it would cut more sweetly of its own accord, because whatever spring there might be in the torsion of the cross-slide, being of the same amount in each direction, went to make the tool dig in on the forward cut, but to ease it on the backward cut.

The double-cutting tool-box, described by Mr. Deakin (page 1003), was a repetition in most respects of Angus's device, only that it had something quite new about it in the movement on a vertical axis that enabled it to use the double-cutting principle for the under-cutting of T slots, which he thought was very clever, and had afforded a striking instance of the advantage of cutting on both strokes.

The first speaker, Mr. Pendred (page 998), asked him to say what difference he found between the reversing motor-drive and the jockey-belt reversal. He thought the chief difference disclosed itself on short strokes. The armature of a motor possessed considerable mass and if rotating at a good speed represented a fair amount of kinetic energy, and it had to be reversed. On the other hand, a driving-pulley of wood or aluminium would

(Mr. J. Hartley Wicksteed.)

have a mass of only about one-tenth of that of the armature, and therefore only about one-tenth of the kinetic energy at the same speed.

The effect of this difference was most noticeable on short strokes, say those of about one foot, and with such a stroke at a given speed he had found that 30 cycles of the table could be taken with a reversing-pulley against 20 cycles of the table with a reversing armature. But there were a great many people who did not care about this; their work was perhaps not short work; they did not care whether they took a little longer or not, so long as they were clear of belts and clutches. They had had experience with overworked belts shifted on fast-and-loose pulleys, and did not want to have anything more to do with them. Moreover, many people had not yet had experience of the particular method of belt reversal now published in his Paper; they had not had belts well above their work that were tightened by jockey-pulleys from within.

Mr. Patchell (page 1009) had made some remarks in connection with jockey-pulleys. He quite agreed with Mr. Patchell that if an engineer adopted a link-belt he was likely to meet with difficulties, first, because a link-belt could not do duty in proportion to its nominal width, owing to there being a link and a space and then another link and a space. To get the same surface of contact as a solid belt, the link-belt must be twice as wide, besides that with equal width it had only half the strength, for it was necessary to take into consideration the wear and tear that took place upon the soft eyes of the leather. Every link was perforated by a hole for the hinge-pin to go through, and the part round that hole was of reduced section. The belt required to be double the width not only to have the same surface of adhesion on the pulley but to have the same strength across the eyelets. A solid belt should be able to give a pull of about 1 cwt. to the inch of face; and if more than half that pull per inch was used with a link-belt, the eyelets would be strained and the belt would wear out before long; also during the process it would require frequent taking up, and always by two links at a time. It would appear with a jockey-pulley applied from the outside that the temptation to use a link-belt was that it

would make no difference to such a belt whether it was given contrary flexure or not; but he thought it was more possible that good work might be done with an outside jockey-pulley by using a laminated-belt which had no transverse joints at all, and was only sewn together through what might be called its neutral axis; such a belt would take a convex or a concave bend, without stretching the stitching. But, even so, the leather would stretch faster if it was first put round a curve in one direction, and then in a contrary one; the leather would be chewed about, and that was bound to make the belt stretch faster than if the flexure were always in the same direction. The first of his heavy rail-planing machines driven by inside jockey-pulley had now been working hard day and night for  $2\frac{1}{4}$  years and the belts were in as perfect condition as when they started.

Before coming up to the previous Meeting he had stopped on his way to London and inspected another of the Buckton machines with his system of jockey-pulleys, which was taking off cuts similar to those exhibited on the table. He enquired how long a time had elapsed since any adjustment of the jockey-pulleys had been made, and was told that they had not been touched since August, so that it had been working for four months without the slightest adjustment. But whenever that machine might be found to shirk the full weight of cut, it would only be necessary to take a screw-key and tighten the jockey-pulley  $\frac{1}{2}$  inch. It would not be necessary, as is the case with belts running straight on to fast-and-loose pulleys, to send for a belt-sewer who would proceed to cut the laces and tighten up the belt at least 1 inch to the next punched holes, and to put the belt on again with a joint which had the elements of self-destruction in it from the very start. There was no destructive action from the inside jockey-pulley on his machine. The belt had no laced joints, and all that was necessary to keep it right was to adjust the jockey-pulley till the belt gave the pull that was required—no more and no less. No doubt the motive of previous inventors in applying their jockey-pulleys to the outside of the belt has been to increase the angular contact of the belt when tightening it; but a belt reversed a planing machine more

(Mr. J. Hartley Wicksteed.)

smoothly if it was rather opened than closed upon the driving drum. Owing to the weight of the belt and other causes, the driving drum was not the place where it was first to slip even though its angular contact was somewhat less there than it was upon the driven pulley. The net effect of the arrangement was to make the belts give no trouble. The storekeeper did not know that there were such things in the shop; he never heard about them.

He was much interested in Mr. Darbshire's remarks about the Sellers' drive, which he could quite confirm. The wear of the Sellers' spiral pinion into a rack, when both were well made and self-lubricated, left nothing to be desired.

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### *Communications.*

Mr. LEWIS H. MORGAN wrote that he remembered the double-cutting planer of thirty years ago, in which a revolving head held the tool. Up to the present time, one reason for planing only one way was that, to resist the heavy thrust of deep or heavy cutting, the entire upper structure was designed to carry this thrust on wide or extended surfaces, bringing all parts more or less into compression; whereas, if this method were reversed, the cut on the return stroke would be carried by parts in tension. Therefore to limit the cut in favour of the return stroke would also so reduce the value of the forward one that no material benefit would accrue. In other words, for heavy work, was not one cut of, say,  $\frac{1}{4}$ -inch feed equal to two cuts of  $\frac{1}{8}$  inch? It would appear, however, that the ten feet square planer shown in Fig. 1 (page 982) was not intended for very heavy duty, for the 30-h.p. motor fixed its limits, and therefore a return cut would have its advantage.

Referring to Fig. 3, Plate 62, he thought the drive for this machine was in the wrong place. The noise, vibration, and escaping oils were a constant source of annoyance, not only to the workman alone, but to others. The trend was in the right direction, but the motor should be on the ground, and the reverse motion obtained similarly to that of the Sellers' drive.

Referring to Fig. 4 (page 986), the writer had had considerable experience with the broad slow belt, first introduced by Mr. W. C. Mitchell, and considered this was one of the best forms of drive. It was not necessary that there should be jockey-pulleys for tightening the belts, for this could be accomplished by putting the drive and reversing shaft into a rocking frame, the motion of which would tighten the desired belt, leaving still greater clearance for the other. Fig. 17, Plate 64, showed this drive.

With regard to the speed of shafts on the return stroke, this he thought was really the crux of the whole matter. No belt in a vertical position could do effective work running over, say, 3,500 feet per minute. Yet Mr. Wicksteed gave as an example of a shaft running 800 revolutions per minute on which there was a pulley 48 inches in diameter; to reduce the inertia of this large pulley he proposed to replace it with a 24-inch pulley of wider face. Now, while this would reduce the inertia of the cutting pulley, there was still the problem of trying to get 800 revolutions of the shaft for the return stroke, through the return pulley, a pulley that could not be much less than 24 inches. This would mean an excessive belt-speed and loss of power.

With regard to Fig. 5 (page 990), showing arrangement of reaction spring, he presumed this was only intended for light and high-speed planers, for the residual energy in a moving table of the heavy type, under ordinary speed, was so small in compressing a spring that its value would be but very little. This could be easily proved by observing how far the table over-ran the driving gear, if allowed to run off. And often in belt-driven planers the writer had seen the table start in towards a cut, carrying with it the full peripheral energy of the driving pulleys, brought almost to a standstill under heavy loads before the end of the cut was reached.

(Mr. Lewis H. Morgan.)

To add a spring in this case would but add to the difficulty. It was a mistaken idea that the table and its load cut much figure one way or the other, for by actual experiment much the same power was required to reverse the mechanism whether the table was on or off. This applied of course to planers whose prime movers were of high velocity. This brought the writer, therefore, to this conclusion, that large and heavy duty planers should have direct connected, slow, but variable-speed motors of wide range; much of the gear power should be taken out of the machine, and its equivalent put into the torque of a slow-speed motor. By thus displacing the inertia of the rapid running parts, the matter of reversing the table would be rendered much easier.

Mr. J. HARTLEY WICKSTEED wrote that in the foregoing communication reference was made to the Whitworth double-cutting planer in which a semi-revolving head held the tool, which Mr. Morgan remembered thirty years ago. It might interest him to know that this principle was still in vogue for planing plate-edges, in which there was always a clear over-run to admit of turning the tool round, and in which there was no transverse feed to the tool. For general work, however, the separately adjustable back-to-back tools, with a flapper relief-motion to each tool, as introduced by the author, had such advantages as to give the double-cutting principle a largely extended range of application. There was no objection to its use through want of stability in the structure of the machine, for so long as it was designed to carry stresses well within elastic limit in compression it would equally carry similar stresses in tension. The real limiting factor in the backward-cutting tool was the strength of the tool-box itself and its attachments, and experience had developed the use of such material and design as gave the required strength to these parts.

To the question—"for heavy work, was not one cut of, say,  $\frac{1}{4}$ -inch feed equal to two cuts of  $\frac{1}{8}$  inch?" Besides other considerations, it might be pointed out in answer that a  $\frac{1}{4}$ -inch feed, *ceteris paribus*, would demand a 60-h.p. motor to drive the machine, whereas the two cuts of  $\frac{1}{8}$  inch taken on alternate strokes would only require a 30 h.p. motor.



As to the objection of placing the drive of the planing machine overhead, the author had found no objection to this on the score of vibration. There was neither noise nor vibration with properly balanced revolving parts, and there was no escaping oil from a properly constructed gear-box and bearings.

To the remark that "it was not necessary that there should be jockey-pulleys for tightening the belts, for this could be accomplished by putting the drive and reversing shaft into a rocking frame, the motion of which would tighten the desired belt," the answer was that, in this case, both sides of the belt had to be forced tight, whereas with the jockey-pulley it was only the tail-belt which required tightening, and this had only one-third the tension upon it of the driving side; whereas, when both sides were tightened together, the force required was double that of the tension on the driving side, hence the rocking frame required to exert six times as much pressure to tighten the belt as was required by the jockey-pulley.

With regard to belt speeds, allusion was made to a hypothetical case of a pulley 4 feet diameter running at 800 revolutions per minute. This, however, so far from being a description of the machine shown in Fig. 4 (page 986), was the very antithesis of what was there recommended, which was a broad pulley 2 feet diameter; and it must be borne in mind that the 800 revolutions made by this pulley were not set up by its own belt, but by the return belt which drove a smaller-diameter pulley. As a matter of fact the driving belt described in the Paper did its heaviest work at 900 feet per minute, and neither it, nor the return belt, ever exceeded the 3,500 feet per minute which Mr. Morgan postulated as the limit of high efficiency with vertical belts.

Referring to the assumption in regard to Fig. 6 (page 990) that the reaction spring was only intended for light and high-speed planers. This was not so, for in proportion as a machine was geared for heavier cutting, so was there more residual energy in the revolving parts available for the compression of the reaction spring. A very conspicuous instance of this was found in the author's rail-planing machines, where two cuts  $1\frac{1}{2}$  inches deep were

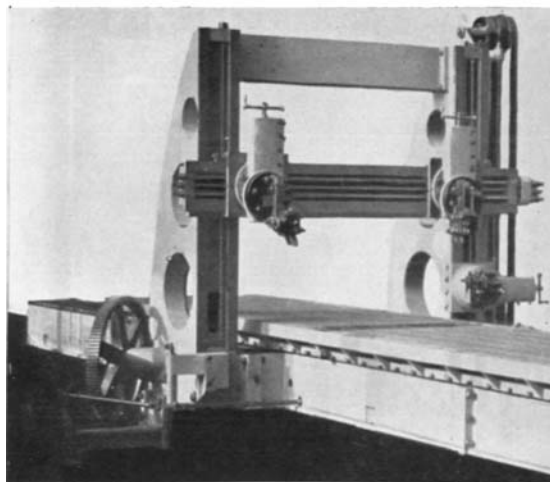
(Mr. J. Hartley Wicksteed.)

taken in rails of 0·8 per cent. carbon, and where the speed of cutting was only 20 feet per minute. In machines for this duty, although the full depth of cut increased towards the end of the rail, and was at its fullest depth at the very end, the stroke of the machine was not set to travel more than  $\frac{1}{2}$  inch past the end of the cut. The drive, besides completing the cut, compressed the reaction spring by the aid of residual energy without any difficulty. Just at the last moment, when the belts had been struck, the moving parts were overbalanced by the spring, and so started up the very quick return stroke without the slightest hesitation. All that was needed was that the driving-belt should have sufficient power not only to take off cuts representing 15 tons pressure, but also to deliver its own kinetic energy, and that of the continuous running countershaft to overcome a momentary excess of pressure just before it was released.

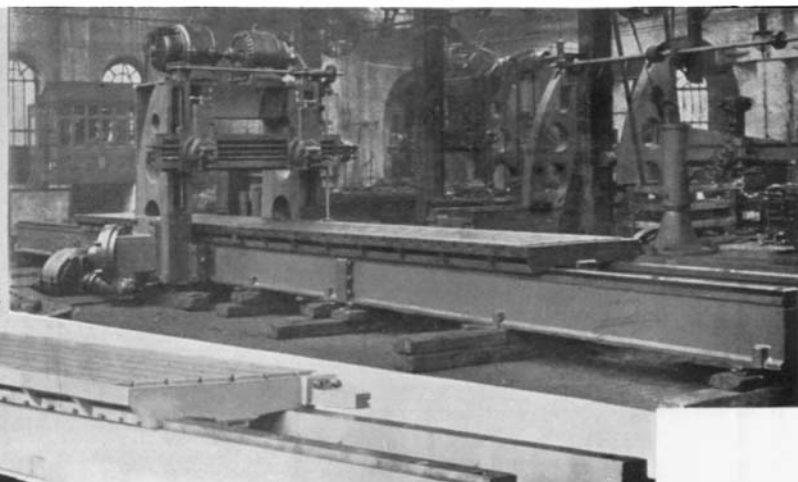
To the instance quoted of a machine that started "in towards a cut, carrying with it the full peripheral energy of the driving-pulleys, brought almost to a standstill under heavy loads before the end of the cut was reached," the reply was that this simply showed that the machine had not sufficiently powerful drive to overcome the resistance of the cut, and also to keep up the speed of the moving parts. But if the drive were sufficient to keep up the full speed of cutting to the end, the same energy of the moving parts would be there and available for the compression of the spring, which Mr. Morgan instanced as enabling the beginning of the cut to be made more rapidly than the insufficient power of the belts which he mentioned was able to keep it up.

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**Fig. 2. Constant-Speed Double-Cutting Planer (Buckton). Driven from a line-shaft.**

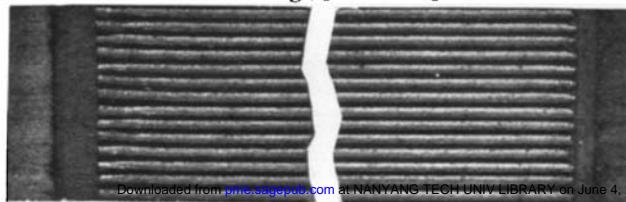


**Fig. 3. Variable-Speed Planer with Tandem Tables (Buckton). Driven by 50 B.H.P. Electrical Set.**



*Specimens of Work from Spring Balanced Planers (Buckton).*

**Fig. 6. Length of Stroke, 12 inches.  
Between Landings,  $\frac{1}{8}$  inch and  $\frac{1}{4}$  inch wide.**



**Fig. 7. 40 Cutting Cycles per min., with table reversing 80 times per min. Length of Stroke, 6 inches.  
Between Landings,  $\frac{1}{8}$  inch and  $\frac{1}{4}$  inch wide.**

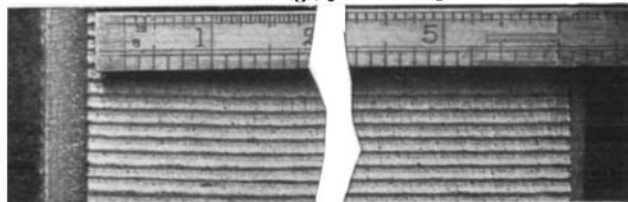
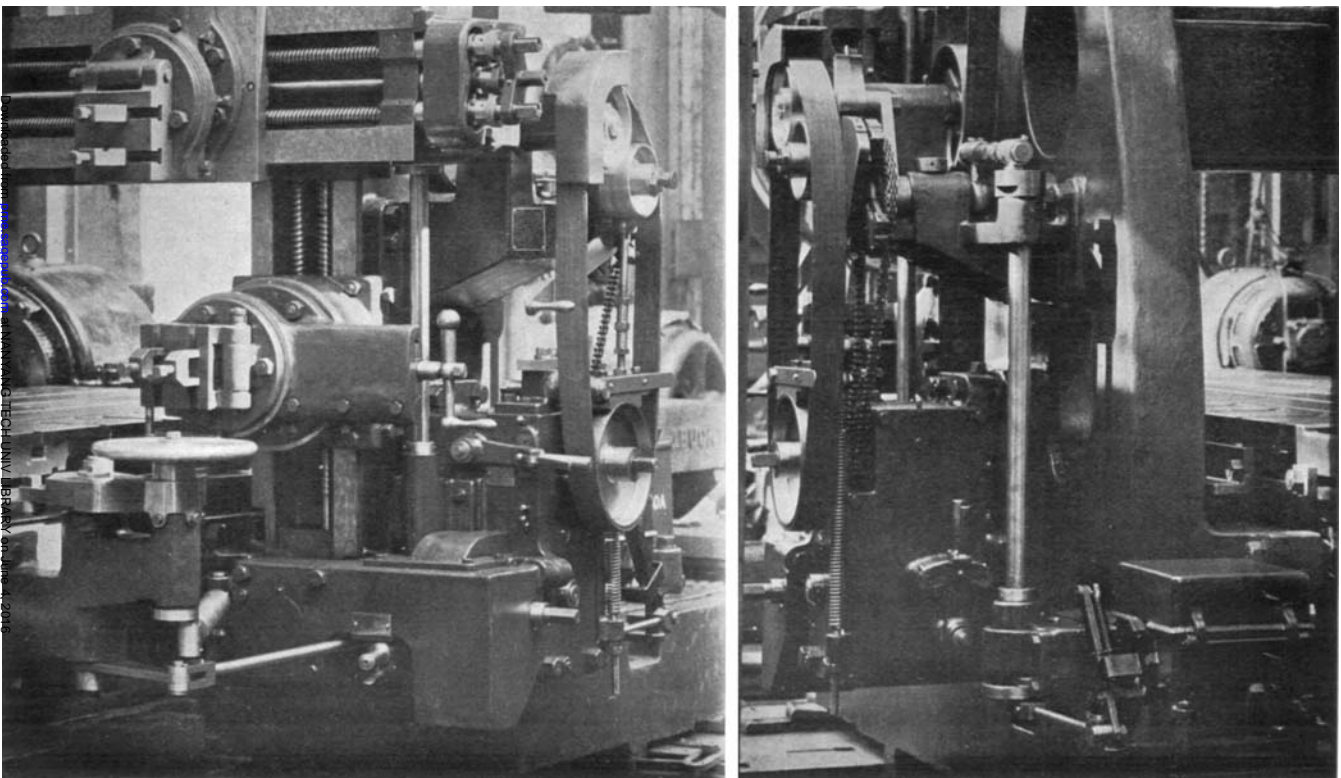


Fig. 9. Mechanism for Feeding and Traversing the Tool Boxes and for Raising the Cross-slide for large Planing Machine (Buckton). Plate 63.



(Mr. L. Pendred's remarks.)

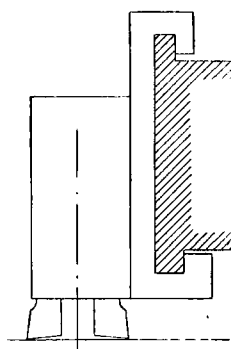
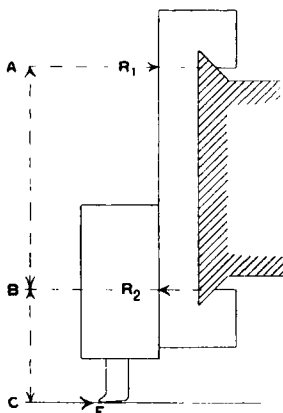
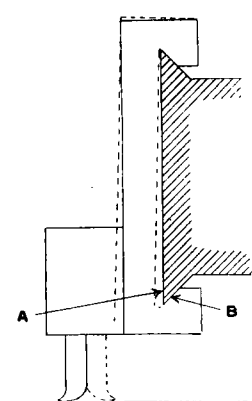
(Dr. H. S. Hele-Shaw's remarks.)

(Author's reply.)

Fig. 10.

Fig. 15.

Fig. 16.



(Mr. Lewis H. Morgan's communication.)

Fig. 17. Two views of 96" Planer. Bells tightened by a Rocking-frame.  
(Francis B. Cockburn.)

