slip, devised to illustrate in one diagram the wide conditions covered by his experiments. In the screws now under consideration, the values of the $\frac{\text{pitch}}{\text{diameter}}$ vary only from 1.2 to 1.34, and for these the abscissa values for the same slips do not differ much. Taking the mean value, and bringing the slips to a common scale, Fig. 5 is obtained, which would approximately represent the relation between the efficiency of any one of these screws and its true slip, if this curve were applicable to full sized screws propelling actual ships. The slips in Fig. 5 being real or true, are not the slips of commerce, which are the apparent slips, such as those given in the table. Let us endeavor to split up these real slips into the apparent slips and another item, the speed of the wake. We then at once meet with the difficulty that the wake in which the screw works has not a uniform motion. Complex, however, as are the motions of the wake, the screw may be assumed to work in a cylinder of water having such a uniform forward velocity as will produce the same effect as the actual wake on the thrust of the screw. It is then readily seen that the real slip is the sum of the apparent slip and the speed of the hypothetical wake. To make this clear, let V be the speed of the ship, V_s the speed of the screw, $i. e.$, revolutions $\times$ pitch, and V_w the speed of the wake; then—

Apparent slip = $V_s - V$.

Real slip = $V_s - \text{speed of ship with respect to the wake.}$

" = $V_s - (V - V_w) = (V_s - V) + V_w$.

" = Apparent slip + speed of the wake.

If the apparent slip be zero, the real slip is the speed of the wake, and if the apparent slip be negative, the real slip is less than the speed of the wake. The real slip is greater than the apparent slip, and can never be a negative quantity. From Mr. Froude's model experiments, it appears that this speed of wake for the A class of ship amounts to about 10 per cent. of the speed of the A screw. If this value is correct, then the real slip is $(10 + 17.6)$ per cent., or 27.6 per cent. This is shown in Fig. 6, where O is the point of no slip, being

Fig. 5.

Fig. 6.

17.64 from the point of real slip. Slips to the right of O are positive apparent slips, slips to the left are negative apparent slips. The vessel F would certainly have a wake with a speed considerably less than that of A's wake. From the model experiments, the wake for F is about one-half that for the A class, or, roughly, 5 per cent. of the speed of the screw. For the ship F, O is the point of no apparent slip, and the real slip is $(5 + 17.6)$ or 22.6 per cent. For E, the point of real slip is approximately the same as for F. For B and D, the positions on the curve would be about the same. The ship B has a higher speed of wake than D, but the screw D has the greater apparent slip. The influence of the number of blades on the scale for the slip has been neglected. If this efficiency curve were applicable to full sized screws propelling actual ships, and if the determination of the wakes were beyond question, then we should have a proof that our screws were at or near the maximum efficiency. But, as we know, from the total propulsive efficiencies, that the screws have high and not widely different efficiencies on these ships, we may argue the other way, and say that there is good reason to consider that at least the upper part of the curve agrees with experience obtained from actual ships. Now take Fig. 6 and consider the general laws there represented. Take the speed of the wake as 10 per cent. of the speed of the screw, which is probably an average of widely different conditions, including many single as well as twin screw ships. Then this curve shows that considerable negative slips mean inefficient screws; that screws may have very different positive slips without any appreciable difference in their efficiencies; and that very large positive slips and inefficient screws may be companions. For instance, a screw with a large positive slip in smooth water is frequently inefficient at sea against a head wind, which increases the resistance, and necessitates an increase of slip. I venture to say that these statements, taken in a general manner, are not at variance with experience obtained from the performances of screw ships. Before it is possible to satisfactorily decide if this curve applies in a general manner to full sized screws propelling ships, we require the results of trials of various ships where the screws are working about the region of no slip. Model experiments teach that the scale for the slip varies with the design of the screw, and that with a given screw the speed of the wake (which decides the point of no apparent slip) varies with the type of ship and with the position of the screw with respect to the hull. Remembering these disturbances, it is not improbable that it may be possible to account for or explain what at first sight may appear departures from the curve. The diameters of the screws in the table are not compared with the diameters given by the method explained by Mr. Froude in his paper last year, for there are differences in the slips, the proportions of blade area to disk, and, to some extent, in the shapes of the blades, which are not taken into account in that method. Assuming, however, as Mr. Froude does, a constant proportion of blade area to disk, and a uniform pattern of blade, the determination of the diam-

ter for a given set of conditions may, as a rule, be a complete solution of the problem of the design of a screw, but these assumptions do not cover all the necessities of actual practice, which make it extremely desirable to know something about the influence or efficiency of various proportions of blade area to disk, and of the form or distribution of a given area.

During the discussion which followed, Mr. John said that, both as regarded the mercantile marine and the Royal Navy, there were few data to work upon, but few ships having been built with twin screws. Mr. Linnington's proportions of pitch to diameter of 1.2 to 1.34 was not invariably adhered to. He mentioned a couple of small twin screw vessels where the proportion of pitch to diameter came nearly to 1.5, and he remembered a few years ago the propellers in one of these vessels being changed and the pitch increased, the result being a very considerable improvement. He believed they might go with quick running twin screw engines to a larger proportion of pitch to diameter than they could with a single screw. He might instance the change in the Iris. She was first engaged with the pitch equal to the diameter, and she gained two knots or thereabout when the diameter was reduced 2 ft. and the pitch increased 2 ft.

Admiral De Horsey said that he tried experiments with the single screw in the Aurora. She had a feathering screw, and when the sails were used to assist, they commonly altered the pitch of the screw according to the strength of the wind. The screw could be altered while it was revolving, and as the wind freshened they coarsened the pitch, and when they wanted to stop the engines they coarsened the pitch so as to bring the screw right fore and aft, so that they never altered the way of the ship in changing from steam to sail alone. The reason why twin screws had been adopted in the navy was that if one was damaged there was the other still available. But it gave them a still further advantage, as it enabled them to have a fore and aft bulkhead, which with a single screw was difficult. The mercantile marine had not as yet looked favorably on twin screws. Their finest and fastest ships were single screws, probably because, in very bad weather, the single screw was better.

Mr. Spyer said that in designing propellers for ships of war, they were obliged to attempt to obtain the highest possible speed, and that was not necessarily coincident with a propeller of maximum efficiency. On the other hand, for mercantile purposes, coal consumption was obviously of paramount importance, and the speed of any particular vessel must be obtained with the smallest possible amount of indicated horse power, and a propeller of maximum efficiency. Regarding the position of the propellers in a small pinnae, the propellers were shifted six or seven inches further out, and with about ten per cent. less indicated horse power she obtained three tenths of a knot more speed.

Mr. Barnaby asked Mr. Linnington whether, in designing twin screws for a vessel of 8,000 i. h. p., he would make each screw, which would have to take 4,000 i. h. p., of the same diameter as a screw for a single ship of 4,000 i. h. p., of the same speed. Unfortunately in high speed vessels, from one point of view, the faster they went for a given power the smaller the diameter of the screw had to be, and the larger the pitch, so that in very high speed twin screw vessels the ratio of pitch to diameter would be found to come out very great indeed. In a twin screw torpedo boat, to be tried shortly, they had a ratio as high as 1.64. In the case of the Inflexible it was found, owing possibly to the position of the screw, that the whole of the plates immediately over the screws were damaged. Mr. Beckett Hill had been using, during the past three or four years, the twin screw steamers the Ludgate Hill, Richmond Hill, and Tower Hill. These were all over 4,000 tons register, and indicated, when at work at full speed, 2,500 h. p. Before he and his friends built these steamers, they built some very large tug boats on the twin screw principle. At the present moment, four of the fastest steamers building for the Atlantic service were to have twin screws. The great obstacle to the extension of the twin screw in the mercantile navy had been the fear that the projection of these screws would make the vessels very difficult to handle, but he had found no such difficulties. He had found it an advantage to put the point of the propeller as near the deadwood as he could, without actually touching it, and in the large steamers, as well as in the tugs, the distance was a few inches. As to the point of safety, he thought it a great advantage to have twin screws, and on two occasions twin screw vessels had met with accidents which, but for the twin screws, would have necessitated their putting back to New York for repairs. The Richmond Hill, on one occasion, met with an accident to her machinery two days after leaving New York; but she was able to come on with the second set of engines, and was only one day late in the passage. No difficulty had been found in the docking and undocking of these vessels, either in London or Liverpool, and while with single screw vessels they had sometimes to employ one or two dock boats to dock and undock them, they never had to do so with the twin screw vessels. These vessels were 400 ft. long, with 48 ft. breadth of beam—a very large size to handle in a river like the Thames. He noticed in the paper a propeller with a diameter of 15 ft. 6 in. to indicate 11,110 h. p., so that a great Atlantic steamer, which should indicate 11,000 or 12,000 h. p., and have a beam of about 65 ft., would have her screws very well protected.

Mr. White said that as soon as it was found that with twin screws they lost nothing in efficiency, ship owners generally were contemplating their adoption, an admirable example of which had been set in the vessels of the Hill line. In adopting twin screws, the question whether they should overlap was one that deserved very serious consideration, and it was interesting to know, from experience gained by the vessels of the Hill line, that there was no difficulty in the way of the projection of the screws. With a moderate power, and with vessels of considerable size, the screws were well sheltered; but in the large ships which were contemplated, where there must necessarily be larger screws, this might be different, and become a difficulty.

Mr. Linnington, in reply, said there was no reason to think that the twin screw at sea might not be as satisfactory, in comparison with the single screw, as it appeared in smooth water. As a matter of fact, one of the great advantages of twin screws was that at sea the condition of weather which would bring the single screw out of the water, and make it extremely in-

efficient, would have no appreciable effect on the twin screws. In vessels of deep draught especially, they were well immersed, and they were really more efficient at sea than in smooth water. In ships of full form, the longitudinal position of the screws was of importance; but in the ships referred to in this table the run was very fine, and the screws were well covered by the hull. He did not think, in such a case, any small difference in longitudinal position would affect the performance. If any alteration were made, it would probably be better to put the screws farther off. When the rudder was hard over, the blades of the screw should be about a foot clear of the rudder.—Industries.

RECENT ADVANCES IN SEWING MACHINERY.*

By JOHN W. URQUHART.

THE distinct improvements in sewing machinery to which I would invite your attention this evening have reference more particularly to the results of inventive effort within the past ten years. But although marked development in the machines has occurred in so short a time, it may be taken for granted that those advances are but the accumulated results of many years' prior invention and experience of stitching appliances.

The history of the sewing machine, and the decision of the great question, Who invented an apparatus that would unite fabrics by stitches? do not at present concern us. Many sources of information are open to those who would decide that extremely involved problem. But whether the production of the first device of this kind be claimed for England or for America, it is quite certain that no one man invented the perfect machine, and that those fine specimens of sewing apparatus shown here to-night embody the labors of many earnest workers, both in Europe and America.

Most of us are familiar with the arrangements of an ordinary lock stitch machine, and an able paper by Mr. Edwin P. Alexander, embracing not only a good account of its history, but most of the elements of the earlier machines, has already (April 5, 1863), been read before you. This, and sundry descriptions of such apparatus in the engineering papers, confine my remarks to the more recent improvements in three great classes of machines. These are, briefly, plain sewing machines; sewing machines as used in factories, where they are moved by steam power; and special sewing machines, embracing many interesting forms, only recently introduced. We have thus to consider, in the first place, the general efficiency of the machine as a plain stitcher. Secondly, its adaptability to high rates of speed, and the provision that has been made to withstand such velocities for a reasonable time. And, thirdly, the apparatus and means employed to effect the controlling of the motive power when applied to the machines.

To deal with the subject in this way must, I fear, involve a good deal of technical description; and I hope to be pardoned if in attempting to elucidate the more important devices, use must be made of words but seldom heard outside of a machinist's workshop.

It appears scarcely necessary to premise that the sewing machine of twenty years ago has almost faded away, save, perhaps, in general exterior appearance; that the bell crank arms, the heart cams, the weaver's shuttles, the spring "take ups," rectangular needle bars, and gear wheels, have developed into very different devices for performing the various functions of those several parts.

The shuttle is perhaps the most important part of a lock stitch machine. But what is a shuttle? So many devices for performing the functions of the early weaver's shuttle have been introduced of late, that the word shuttle, if it be used at all, must not be accepted as meaning "to shoot." We have vibrating shuttles, which are, strictly speaking, the only surviving representatives of the weaver's shuttle in these new orders of machines; and stationary shuttles, oscillating shuttles, and revolving shuttles, besides the earlier rotating hook, in several new forms, difficult to name. But the general acceptance of the word shuttle, as indicating those devices that pass bodily through the loop of upper thread, is, I venture to think, sufficiently correct.

Many changes have been effected in the form, size, and movements of the shuttle, and we may profitably inquire into the causes that have induced manufacturers to abandon the earlier forms. The long, weaver's kind of shuttle, originally used by Howe and Singer, had many drawbacks. Mr. A. B. Wilson's ingenious device, the lock stitch rotating hook, was not free from corresponding faults. The removal of these in both has led to the adoption of an entirely new class of both shuttles and revolving hooks. It is well known that the lock stitch is formed by the crossing of two threads, one of which lies over, and the other under, the cloth to be sewn. This crossing point, to insure integrity of the stitch, must occur as nearly as possible in the middle of the thickness of the fabric. The crossing must also be effected while a certain strain, called tension, is imposed upon both threads. If the tension of one thread should outweigh that of the other, the locking point becomes displaced. If the tension be insignificant, the stitches will be loose. If the tension should vary, as in the long shuttle, there will occur faulty points in the seam.

In the earlier rotating hook the tension depended upon the friction developed between the spool and the hook. This tension, therefore, varied in proportion to the speed of the latter, and could never be constant. This was quite apart from the frictional resistance offered to the upper thread in passing over the cavity of the hook.

In the shuttle the tension was obtained by threading through holes in the shell, or beneath a tension plate, as in Howe's machine. This tension, so long as the reel ran between spring centers, was never constant. The variation was chiefly due to the angular strain set up when unwinding from the reel. This strain varied according to the point of unwinding. It was light in the middle of the reel and heavy at either extremity. These drawbacks caused immense anxiety to the first makers of sewing machines, and numerous attempts to overcome them led to little improvement. With reference to high rates of speed, the older shuttle, requiring a long and noisy reciprocation, had its disadvantages.

* A recent lecture before the Society of Arts, London.

The only effective remedy for these drawbacks was a radical one. It was necessary to substitute depth of reel for length. Hence, several attempts have been made to construct disk or ring shuttles. Many forms of those have been tried. They all depend upon the principle of coiling up the thread in a vertical plane, rather than in horizontal spirals. Some makers placed the disk in a horizontal plane, and caused it to revolve. Nothing could be worse, as will be seen, if we follow the course the enveloping loop must take in encircling such a shuttle. But a complete solution of the difficulty of employing a ring shuttle has been achieved in the oscillating form, invented by Mr. Phil. Diehl, and known as Singer's (Fig. 1). A short examination of it

FIG. 1.

may profitably engage your attention. The shuttle itself is sufficiently well known, but certain features of it, and to which it owes its efficiency, appear to call for some explanation. Its introduction dates back some years, during which time it has undergone certain modifications.

It consists of a thick disk bobbin of thread, *b*, fitting loosely in a case constructed in the form of a bivalve, *a* and *d*. This case is furnished with a long beak, usually forming a continuation of the periphery. The beak is intended to enter and detain the loops of upper thread, and lead them so that they ultimately envelop the shuttle, a motion of the thread which is chiefly due to the oscillation of the shuttle in a vertical plane. The oscillating movement is to the extent of 180 degs. of the circle, which suffices to cast the loops freely over the shuttle. The center of oscillation is not coincident with the center of the shuttle; but it is nearly so with the periphery of the thread reel, and exactly coincides with the point where the under thread is drawn from the shuttle, *g*. The shuttle thread is thus entirely freed from any tendency to twist, an objection frequently urged against circular or revolving shuttles. It will be observed, also, that the body of the shuttle is extremely narrow. Bulging of the thread loops to one side or the other is thus obviated.

But the long beak in this description of shuttle serves an important purpose other than that of seizing the upper thread loops, otherwise a very short beak would be preferable. It adds so much to the efficiency of the machine that a little further explanation of it appears essential. In the old fashioned machines the thread required to envelop the shuttle was dragged downward through the cloth, while the needle still remained in the fabric. This necessitated the use of large needles with deep side channels, to enable the thread to run freely, and as a consequence the punctures that had to be made in the fabric were unnecessarily large, and could not in any case be entirely filled by the thread, a condition which is now recognized as essential in linen stitching and for waterproof boots.

The long beak in both shuttles and hooks offers an immediate solution of the old difficulty experienced with long shuttles. When the needle begins to rise, the shuttle commences to oscillate, through the loop, the motions so coinciding that the long beak, *c*, merely detains the loop until the eye of the needle has ascended above the cloth; then, and then only, does the envelopment of the shuttle commence, and the thread required for it flows downward through the puncture. The envelopment is completed before the needle has attained its highest point, and the consequent loose thread is immediately pulled up by a lever, called a positive take-up, before the needle begins to descend for a fresh stitch. In this way little or no movement of the thread is required in the cloth while the puncture made is occupied by the needle. The result is the capability of such apparatus to work with an incredibly fine needle—indeed, so fine as to be no thicker than the uncompressed thread itself. This would have been considered quite impossible of accomplishment by our earlier machine makers. The advantage thereby gained in stitching linen goods, and in sewing leather, where every puncture of the needle should be quite filled by the thread, is at once apparent. Indeed, a rubber or leather sack, stitched in this way, will contain water without leakage—a very extreme test.

Revolving Shuttles.—The class of shuttles known as revolving or rotating, and which really consist of a combination of the disk shuttle and the earlier rotating hook of Wilson, have been under trial by several makers for many years. If, for example, the oscillating shuttle we have just examined were to complete its circular movement, it would constitute a revolving shuttle, but would not be quite similar to those devices now known as such. The most remarkable device of this kind yet introduced is to be found in Wheeler & Wilson's machine known as No. 10 D, and invented by Mr. Dials last year. It consists, in fact, of a detached hook, and its inventor declines to class it with shuttles at all, styling it a detached hook. It consists of an exterior shell or skeleton of steel, capable of rotation in an annular raceway. Its detachment from the axis forms a striking exception to the general construction of interlocking apparatus in this company's machines. Under the beak of this curious device is found an oblong recess, into which fits loosely a carrier or driver, rotating with a differential or variable motion. The space between the carrier and the sides of the recess is sufficient to permit the free passage of the thread in encircling the shuttle, and the differential movement ingeniously releases the contact between the hook and carrier. The skeleton of this device is only one-sided, and does not really carry its bobbin in the course of its revolution. The bobbin is placed in a cup-like holder, which lies within the shuttle or hook body, and is retained in position by a latch hinged to the bed of the

machine. The cup and bobbin are prevented from partaking of the rotatory movement by a steel spur projecting from the cup, and fitting loosely into a notch in the latch. Tension upon the under thread is obtained by passing it under a tension plate upon the bobbin cup. Twisting of the thread is by these means entirely obviated. In this apparatus, the disk-like appearance of the bobbin is partially lost in its consider-

FIG. 2.

able breadth, and there is thus a distinct departure from the lines of the ring shuttles before mentioned. The diagrams exhibit the hook in several positions during its revolution, and the position of the threads corresponding thereto.

Fixed Rotating Hooks.—Wilson's rotating hook for lock stitch machines, and Gibbs' hook for single thread machines, are both well known. In the year 1872, the Wheeler & Wilson company introduced a new hook, forming an improvement upon Wilson's original device (Fig. 3). Its chief peculiarity consists in the extension

FIG. 3.

of the termination of the periphery, forming a long tail piece, quite overlapping the point, and serving as a guard, both to keep off the bobbin thread and to prevent collision between bobbin and needle.

This improved class of hooks are provided with a much deeper cavity than those first introduced, an arrangement permitting of the employment of a more commodious bobbin, which is generally covered by a cap, as in the revolving shuttle, but free to revolve. In some cases the cap carries a tension plate preventing its revolution with the hook. But beyond these improvements on Wilson's original device, the utility of the hook mainly depends upon two things quite apart from the hook itself. These are the dispensing with the old fashioned check brush and the use of a positive take-up.

Thus, in the original machine, the stitch was pulled up by the succeeding revolution of the hook. For while one revolution sufficed to cast it over the spool, a second turn was requisite to complete the stitch. In this way, to make a first stitch with such an apparatus required two turns of the rotating hook. The improvements mentioned enable the machine to complete a stitch with one turn of the hook—an important step in advance, when we consider that by the old method each length of slack thread must be tightened up solely through the fabric and the needle eye. But this particular arrangement bears so much upon the introduction of the positive take-up itself that further reference to it must be reserved until that device has been described.

Simple Thread Hooks.—The best known of these is Willcox & Gibbs. It has been so often described, that no further reference to it may be made. It continues to make the same excellent twisted stitch as it produced twenty-five years ago.

Of Vibrating Shuttles.—These are shuttles of the long description, moving in a segment of a circle. There are several varieties. The most novel machine of this kind is the vibrating shuttle machine just produced by the Singer Manufacturing Company. In this case the shuttle itself consists of a steel tube, into the open end of which the wound reel is dropped, and is free to revolve quite loosely. Variation of tension is thus obviated in a very simple manner. The chief point of interest in the machine is undoubtedly the means employed in transferring the motion from the main shaft to the underneath parts, an arrangement as ingenious and effective as any device ever introduced into stitching mechanism. It is the invention of Mr. Robert Whitehill, and consists of a vertical rocking shaft situated in the arm of the machine. Motion is imparted to it by means of an elbow formed upon the main shaft acting upon two arms, called wipers, projecting from the rocking shaft, the angle formed by the arms exactly coinciding with that of the elbow in its revolution. This admirable motion will no doubt attract much attention from mechanists and engineers.

The Lock Stitch from Two Reels.—In the early days of the sewing machine, the makers of it often met with the question, "Why do you use a shuttle at all? Can you not invent a method of working from a reel direct?" The questioner generally means a reel placed upon a pin, just as the upper reel is placed. The reply to such a query is, of course, that to produce the lock stitch in that way is impossible—as indeed it is.

But many ingenious mechanists have pondered long over the problem, and several clever contrivances have been invented with a view to its solution. It may

scarcely be necessary to say that the best manufacturers of sewing machines have conducted experiments with the same object in view, and the result has always been a return to the shuttle, with its steel bobbins.

Why is this, and how is it that a very big shuttle cannot be used, large enough, indeed, to accommodate any bobbin within itself? The answer is very simple. It has been done over and over again.

Since the whole bulk of the under thread must pass through the loop of the upper one, it is quite clear that the size of that loop must be proportioned to the bulk of the shuttle. Thus, a small shuttle would, perhaps, be covered by an inch of thread, while our supposed mammoth shuttle might require ten times that amount. Now, let us consider that to sew an inch of thread into lock stitches frequently involves its being drawn up and down through both needle and fabric twenty times. This means considerable chafing, and possible injury to the thread.

But if we were to sanction the use of capacious shuttles, ten inches of thread must undergo this chafing and seesaw treatment, and under the above conditions every part of the ten inches must pass up and down two hundred times—treatment that might reasonably be expected to leave little "life" in the thread. But in spite of this tremendous drawback, there are machines offered for sale made with such shuttles.

For reasons that I have now pointed out, it is quite clear that a large shuttle or bobbin is by no means an unmixed advantage. Indeed, the very best makers of sewing machines have always striven to keep down the bulk of the shuttle, and in those splendid machines shown here to-night the use of the small shuttles is conspicuous. It may be contended that small bobbins frequently require refilling, which is quite true, but the saving of the thread effected thereby, not to mention that of the machine itself, amply compensates for the use of small shuttles. Apart from this, however, it is no longer necessary to wind bobbins at all. Dewhurst & Sons, of Skipton, and Clark & Co., of Paisley, have produced ready wound "cops" or bobbins of thread for placing direct into shuttles. Thus no winding of bobbins is necessary, and indeed the bobbins themselves are dispensed with. I believe that the slightly increased cost of the thread thus wound is the only present bar to the extensive introduction of ready wound "cops."

Of Thread Controllers.—One of the earliest difficulties encountered by the maker of a sewing machine was that of effectually controlling the loose thread after it had been cast off the shuttle. In some machines this slack thread amounts to six, in others to one or two inches. Howe got over the difficulty by passing his thread, on its way to the needle, over the upper extremity of the needle bar—the ascent of the bar, then, sufficed to pull up the slack. Singer improved upon this by furnishing his machine with a spring take-up lever, partially controlled by the needle bar.

Wilson, in the Wheeler-Wilson machine, had neither of those arrangements, but depended upon the succeeding revolution of the hook to draw up the slack of the preceding stitch. These devices were all far from perfect in their operation, chiefly because they commenced to act too soon. In each case the pulling up commenced with the rise of the needle, and the tightening opera-

FIG. 4.

tion subjected the thread to all the friction of rubbing its way through both needle eye and fabric. Now, an ideal take-up should not commence to act until the needle has ascended above the fabric, and one of the most important steps toward perfection in sewing machines was undoubtedly attained when such a device was actually invented. In effecting this, the means employed consists of a differential or variable cam, rotating with the main shaft. This controls the movements of a lever called the take-up, pivoted to the

machine (Fig. 4). Not only has it been possible by these means to control the tightening of the stitch, but the paying out of the thread for enveloping the shuttle also, and both the paying out and pulling up are actually effected after the needle has ascended above the cloth. The introduction of the positive take-up, the first forms of which appeared in 1872, not only simplifies the movements of the shuttle or hook, but for the first time renders the making of the lock stitch possible, while the needle has a direct up and down motion. Thus, we find that in most of the swiftest sewing machines, the needle bar is actuated by a simple crank pin or eccentric, there being no loop dip or pause in its motion.

The diagram shows a positive take-up in three positions—at the commencement of the needle's descent, during the detention of the loop by the beak, and during the casting off of the loop. The dotted lines indicate the path of the cam to produce these positions. The intermittent movements of the take-up have thus led to the abandonment of variable motions in both needle and shuttle, and particularly so in oscillating shuttle machines.

Wheeler & Wilson's Variable Motion.—But while the simple and direct movement is now preferred for shuttles, both oscillating and rotary, the revolving hooks of Wheeler & Wilson are provided with a differential motion, and the way it is effected appears sufficiently interesting to call for a short description. When the rotating hook has seized the loop of thread, it makes half a revolution with great rapidity; its speed then slackens, and becomes very slow for the remaining half a revolution. In the first machines introduced, this was effected by means of a revolving disk, having slots in which worked pins attached to the main shaft and hook shaft respectively.

In the later and more improved machines, the variable device is much simplified (Fig. 5). The main

FIG. 5.

shaft, leading to the rotating hook, is separated into two portions, the axis of one portion being placed above that of the other. A crank pin is attached to each, and these pins are connected together by a simple link. An examination of the device itself shows that, while the motion of the main shaft portion is uniform, that of the hook shaft is alternately accelerated and retarded.

The picture on the screen gives a general view of the No. 10 D machine, in which these motions are embodied, and showing the position of the positive take-up affected by those motions, a position which is preferred for very high speeds in this machine, especially for threads possessing little elasticity.

Motions of the Feeder.—The speed attained by the fastest sewing machines is due more to the reduction and simplification of the movements than to any other improvement. Heavy concessions and reactions have been replaced by direct motions, and cams have been excluded as much as possible. Mr. A. B. Wilson's famous invention of the four motion feeder depended upon both gravity and a reacting spring for two motions. Singer improved upon it by making three of the motions positive, a spring being used for the drop. But a really positive four motion feeder was long sought by inventors.

Hitherto the reaction of the feeder—that is, its descent and recession—was generally attained by means of a spring. The drop and ascent are now effected by means of a separate eccentric in Singer's machine. Uncertainty of action in the feed, once a cause of much inconvenience, may now be said to be overcome. A peculiarity of the four motion feeder in Wheeler & Wilson's machine is an arrangement enabling the operator to feed in either direction at will.

Not less worthy of note are improvements that have been made in wheel feeders. The wheel feed was originally much used for cloth sewing machines, especially in Singer's system. But in recent years the drop or four motion feeder has entirely superseded it for such purposes. The wheel feed still holds its own, however, for sewing leather, especially in the "closing" of boot uppers, in this country. Singer's original wheel feeder was actuated by a friction shoe riding upon the flange of the wheel. The friction grip, however, had certain faults, owing to the tendency of the shoe to slip when the surfaces became covered with oil.

A later form of Howe's machine used a pair of angu-

FIG. 6.

lar clutches, embracing the flange of the wheel. In both Singer's and Wheeler & Wilson's latest styles of machines this arrangement is simplified and improved by the use of a single angle clutch, which is found to work even when the surfaces are freely oiled (Fig. 6).

Any motion of the free extremity of the lever upon which the biting clutch is formed binds the latter upon the flange of the wheel, which then advances so long as the lever continues to move in that direction. When the stitch is completed, the clutch is allowed to recede, and is pulled back by a reacting spring. The bite of the clutch is given by the two opposite corners.

The feed wheel itself is free to revolve in a forward direction, but is prevented from rocking backward in Singer's machine by an ingenious little device, recently introduced. It consists of a small steel roller, situated within the angle formed by an inclined plane and the flange of the wheel, and constantly pulled into the angle by a spiral spring. Any backward tendency of the wheel binds the roller more firmly in the angle and stops the wheel. Former feed wheels were checked by a brake spring or block, which retarded the motion of the whole machine when heavily adjusted.

Feeders for Button Hole Sewing Machines are almost invariably of the wheel type, but in this case the cloth is usually carried by a clamping device, and moved in a pear-shaped path by means of a cam cut in the feed wheel, as shown in the samples of this wonderful kind of mechanism exhibited here to-night.

The Compensating System of Construction.—Compensation for wear is a part of the mechanist's art that appears just as essential to him as compensation for variation of temperature is to a maker of chronometers. In the construction of sewing machines to be run in factories by power at their utmost speed, such a system is of the greatest importance. An effective system of compensation has been eagerly sought by the best machine makers ever since the introduction of fast speed sewing.

Compensation has been attempted here and there in the machines for many years, but no sewing apparatus could be said to be so compensated until the cone compensator came into use, a device which has been taken advantage of by various makers. Save in the shuttle race itself there is not a part of the oscillating shuttle machine subject to serious wear that cannot be instantly adjusted to full motion by the turning of a screw, while wear in the shuttle race can be compensated for in the usual way. This effective system depends upon the union of two mathematical forms, long used in mechanism—the cone and the screw. In screw cones we possess a perfect compensator, and it is surprising that parts of mechanism so hung appear subject to very little wear. Another advantage, too, is gained by the introduction of screw cone bearings; the friction is always greatly reduced by their use. In every case the fine adjustment of the cones is securely maintained by locknuts (Fig. 7).

FIG. 7.

But the screw cone system is not the only compensator used in sewing machinery; where it cannot be easily introduced, other devices have been employed.

The well known tapering needle bars of former years have been superseded by cylindrical needle bars. The Wheeler & Wilson Company appear to be the first who utilized the engineer's shifting box as an anti-friction device for round needle bars. They packed their bars round with felt rings, and compressed the whole by a screw cap.

In the Singer machines the same excellent device has been adopted, hemp packing and screw bushes being used (Fig. 8); *f* and *g* show the direct action on the

FIG. 8.

needle bar. This method of forming needle bar bearings, partially of metal and partially of felt or hemp, has afforded the most surprising results.

When the bars are of hard or finely polished steel, no perceptible wear can be detected in them, even after they have been in daily use in factories for twelve months, whereas bars not so bushed might show considerable wear in that space of time. The packing, to be effective, should be sufficiently close to prevent as much as possible friction of the steel with the cast iron needle bar ways. Lubrication of the steel is insured by keeping the hemp packing moistened with oil.

Cylindrical needle bars, when combined with an effective system of brushing, have proved themselves superior to every other form of slide for lock stitch machines. But their introduction is by no means a thing of yesterday. They were used freely in sewing machines as far back as 1860, but were never very suc-

cessful until united with the lubricating brush. Some makers go a step further, and elaborate the system by the introduction of steel brushes, easily renewable.

Every effort is now made to reduce, as much as possible, not only the extent of movement of the parts in high speed machines, but the weight of the parts themselves. Indeed, so far has this been carried that, in some of the Wheeler & Wilson machines now shown, the needle bars consist really of steel tubes. Small moving parts are made as light as possible, but rigidity is secured by the free use of strengthening ribs. Many of the parts are of cast iron, rendered malleable by annealing, and finally casehardened. Such parts are found to be quite as durable as if made of forged steel, and are, of course, less costly. As to the automatic tools now used in the construction of the machines, it may be said that scarcely a file, hammer, or chisel touches the frame or parts while they are being assembled to work together. The interchangeable system of construction is, of course, the only one possible for the accurate production of the millions of sewing machines now manufactured annually.

High Arm Construction.—Sewing machines, as now constructed, exhibit a rather short and very high arm, a form of framework that has been found to contribute in no small degree to the light running capabilities of fast speed machines. While it reduces the length of the various parts concerned in the transference of the motive power, it adds to their rigidity and diminishes their weight, maintaining at the same time the capacity of the machine to accommodate the largest garments beneath the arm.

But the specific improvements in plain sewing machines, to which I have had the honor of drawing your attention, do not exhaust the list, and, time permitting, it might be considerably augmented. Nor must it be inferred that advancement has taken place exclusively in those systems of sewing machinery now before us.

Accessories to Sewing Machines.—The number of special attachments that have been successfully adapted to plain sewing machines has multiplied so rapidly of late, that only one or two of the more notable can be spoken of on this occasion. Perhaps the most generally useful of these is the trimmer, an arrangement consisting of a vibrating knife, which trims off the superfluous edge of a seam as the machine stitches it. These are in extensive use in the factories at Leicester, Nottingham, and elsewhere, while Northampton and Norwich use the same device for paring the seams in boot upper manufacture. The chisel-like knife is usually actuated by a cam rotating with the main shaft, and one or two of the usual forms of this attachment are to be seen here this evening on both lock and loop stitch machines.

When machines are moved by the foot, there are many objections to running the whole machine while winding the shuttle reels. We have, therefore, several useful devices for releasing the balance wheel of the machine from the main shaft, while winding. These are to be found both on Wheeler & Wilson's manufacturing machine and upon Singer's highly finished "Family" machine, which also carries a most ingenious automatic reel winder, capable of doing all the work itself, and ceasing to act as soon as the bobbin is filled.

The setting of the needle in a sewing machine was once quite a task. Ofttimes it had to be adjusted by chance, in other instances by certain guiding marks upon the needle bar. It is gratifying to know that all this has been done away with, and that the needle has only to be inserted into the bar, and fastened by turning a small screw. These are styled self-setting needles, and are usually so arranged that they cannot be adjusted wrongly as to the position of the eye.

In the Willcox & Gibbs machine, and in Singer's single thread machine, shown here, we have an intermittent tension arrangement, which clamps the thread at the right moment, and differs from ordinary tension devices, inasmuch as it may be said to be automatic. The feeder, too, on these machines is of excellent design, while the arrangements that have been introduced into the Willcox & Gibbs straw hat sewing machine are surprisingly effective in spinning up a hat from a loose roll of braid. Speaking of straw hat machines, mention should be made of Wiseman's hand stitch apparatus, as improved by Messrs. Willcox & Gibbs, and shown here this evening. This machine employs two needles, and makes a stitch resembling hand work at intervals, producing a short stitch at the center of the hat, and automatically widening the space between the stitches as the distance from the center increases. The machine itself is of wonderful ingenuity, and must be examined to be understood.

The stitch making itself is, I believe, quite new, and is also of much interest. A pair of needles, the width of a stitch apart, rise from beneath through the material. One of these is an ordinary machine needle, threaded; the other is a barbed needle. After rising above the surface, the loop of the threaded needle is seized by a "threader," and thrown into the barb of the barbed needle. The needles then descend, and the feed occurs, being the length between stitches. Upon the ascent of the needles again against the material, the loop is both given off the barb and is entered by the threaded needle, completing the stitch.

Of Button Hole Machines.—The mechanism of button hole machines is so intricate, that I can only attempt on this occasion to partially elucidate the construction of one of them, recently introduced, namely, Singer's, which automatically cuts, guides, and stitches the work.

Fig. 9 exhibits the stitching made by this machine

FIG. 9.

upon the edge of the button hole. Fig. 10 represents the right and left hand loopers and loop spreaders, and for the stitch making. They rock from right to left with an intermittent motion obtained from a cam. The left hand looper carries the under thread and interweaves it with the upper, forming the stitch, originally invented, I believe, by Mr. George Fisher, of Nottingham, and reinvented for the button holing ma-

chine by D. W. G. Humphreys, of Massachusetts, U. S. A., in 1862. The loop spreaders are moved by a roller carried upon the looper frame. Fig. 11 exhibits the feeding arrangement, both sides of the feed wheel, the driving lever, and the shape of the path given to the carrying clamp by the heart cam cut in the upper

FIG. 10.

FIG. 11.

surface of the feed wheel. The picture on the screen represents the upper portions of the machine, exhibiting the conveying clamp, the to and fro dipping motions of the needle bar, and the parts conveying motion to the arrangements beneath the bed plate. These are shown in Fig. 12, and represent the feed and looper

FIG. 12.

cams, the feeding and looper levers, and the stitch forming mechanism already shown. A most ingenious device in this machine is the arrangement for automatically lengthening the throw of the feed while stitching around the eye of the button hole. It is effected by means of a cam, which imparts more or less leverage to the feed arm by the intervention of a "shipper" lever, hinged to the feed lever itself. The space of time at my disposal obliges me to recommend a personal examination of the machine itself, to fully understand its various motions and its action in working a button hole.

Mention may be made of Singer's special button hole machine for making the straight holes used in linen work, and in which a shuttle is employed. Of Wheeler & Wilson's ingenious button hole machine for the same purpose, I am enabled to show a diagram, in which it will be observed that the feeding arrangements are placed above the bed plate, and are no doubt thereby rendered easily accessible.

Application of Power to Sewing Machines.—There was a time when a cry arose to the effect that the introduction of mechanical sewing would lead to divers calamities, physical and mental. The ladies were to become crooked in the spine, and regular operators were to become regular cripples. It is scarcely necessary to ask, Has this been so? The operators of to-day are, I think, superior in physical attainments to their sisters of the needle and thread fifty years ago.

Within the past few years a revolution has taken place in the moving of sewing machines. Domestic machines will probably always be driven by foot power, spring, electric, and water motors notwithstanding. But the age of treadles in the great manufacturing trades is a thing of the past. It was not necessary for Parliament to step in and protect the workers, as was frequently suggested by alarmists. The commercial interests of manufacturers themselves were at stake. Machines driven by power could do 25 per cent. more work than those moved by foot. The operators, relieved of the treadling, maintained a much better working condition; and altogether the introduction of power driving, once well tested, became a necessity. Power sewing machinery was speedily devised and introduced by several of the first manufacturers, controllers of the speed of the machines followed, and two or three

splendid systems of stitching by steam power were soon widely known.

By the kindness of three of the best manufacturers of power sewing machinery, I am enabled to show to you, this evening, the best known systems, arranged just as they are fitted in many large factories, as also a sketch of the arrangements of Wheeler & Wilson's system. We have in the first place a light shafting carrying a band wheel opposite to each machine. By the use of a powerful electromotor, the shafting is caused to rotate at the rate of 400 revolutions per minute by electricity. The current is generated by the Society's dynamo machine, and is conveyed here by copper cable. I do not know of any instance of sewing machinery in a factory being driven by an electromotor, but such means of conveying motive power appears admirably adapted for that purpose, when the stitching room happens to be far removed from the main shafting or engine. But with regard to motors for sewing machines, when special power has to be fitted down for that purpose, my own experience leads me to speak in favor of the admirably governed "Otto" gas engines made by Crossley Bros. These are especially steady, a feature of no small moment in moving stitching machinery of various kinds.

Much attention has been devoted to the invention of controllers of the motive power supplied to sewing machines. The principle of the friction disk has found most favor. In many cases two of these plates, fast and loose, are placed upon the main shaft, and their separation and contact controlled by the treadle. The great sensitiveness of the friction attachment employed by the Singer company is due chiefly to the transference of the friction plates to the axis of the machine itself (Fig. 13). Their contact and separation are controlled by a

FIG. 13.

lever worked by a very slight movement of the treadle. But the chief point of interest in this device lies in the combination with the lever of a brake, enabling the operator, by a simple reversal of the treadle's motion, to instantly suspend the rotation of the machine. The forked lever, in fact, acts simultaneously in throwing off the motion and applying the brake. The speed is always in direct proportion to the pressure exerted upon the treadle, and a single stitch can be made at will.

FIG. 14.

Fig. 14 shows the friction wheel separated, the portion *a* being fast, and *e* loose.

The Wheeler & Wilson company do not confine themselves to any particular controller, but prefer the form shown here this evening (Fig. 15), in which two bands and an intermediate pulley are employed. The first band is left rather loose, and the machine is set in motion by the tightening of this band through the depression of the treadle. The speed varies in proportion

FIG. 15.

to the pressure applied, and the sensitiveness of the arrangement is increased by a brake device coming into play by the reversal of the treadle as before.

Messrs. Willcox & Gibbs depend upon a similar device shown in three varieties to-night.

Speed of Power Sewing Machines.—The fastest practicable speed of a machine worked by the foot appears to be 1,000 stitches per minute. Most operators can guide the work at a much higher rate, especially in tailoring or on long seams. The average speed upon such work is 1,200 stitches per minute; but many lock-stitch machines are run at 1,500 and 1,800 per minute, and even at much higher rates. There is always a limit

to be imposed upon speed by the guiding powers of hand and eye; it is this limit, and not the capability of the machine, that confines the rate of driving. Willcox & Gibbs' single thread machines are run in many instances at 3,500 stitches per minute. We have before us a single thread Singer machine (appropriately named the "Lightning Sewer") and a Willcox machine, moving at the enormous rate of 4,500 stitches per minute, and producing good work. But it is doubtful whether such very great velocities can ever be advantageously employed. Upon collar work, and in sewing boot uppers, the rate seldom rises above 1,200 with advantage. If the machines be speeded too high in any trade, the operator never uses the excess, and it only proves a drawback. I seen the heaviest and hardest kind of navy boots stitched at 1,500 to the minute upon Singer's lock-stitch machines. Wheeler & Wilson's No. 10 D machine has been run by them, I am informed, as high as 2,500 to the minute. Loop-stitch machines, when well made, can be actually run as high as 6,000, but 4,500 is, I believe, the maximum yet used for this class of machine, even experimentally. There can be no doubt that lock-stitch machines can be run as high as 3,000. The actual speeds of the lock-stitch machines shown here upon the power stand average 1,300; those of the chain stitch machines vary from 1,200 for the sack sewing machine to 4,500 for the small or single chain stitchers. Any of the latest styles of either lock stitch or single thread machines can be run far faster than any known expert operator can possibly guide the work under it.

It is very improbable that such speeds will ever be exceeded. The limit has no doubt been reached. Very high speed is generally a delusion, and either results in indifferent work, or actually retards its progress. Some idea of the speed of the single thread machines now shown may be gathered from the fact that, running at 4,500, and making eight stitches to the inch, they accomplish over fourteen yards of sewing every minute. Of special machines of interest, and which are too unwieldy to be shown here, I am enabled to exhibit a few photographs.

One of the most novel of these is the "Twin" machine, designed by the Singer company for the connecting together of the Jacquard cards used in lace machines. The operation was formerly performed by hand. It is now done by machine at less cost. The cards are placed upon a feeding drum, and fed beneath a pair of needles. The laces forming the connection between the cards are fed above and beneath, in line with the needles, and the whole is easily stitched together. An extension of the same device is the multiple machine, in which four needles and shuttles are used, sewing all the four seams at one operation. This method of linking the cards is considered better than similar work done by hand.

Of Wheeler & Wilson's new factory, at Bridgeport, and of the Singer company's great new factory near Glasgow, I am enabled to exhibit photographic views.

Before drawing my remarks to a close, I would briefly indicate the nature of the various machines shown upon the power benching. Of the Singer system, there are four. A drop-feed oscillating shuttle machine for manufacturing purposes; a wheel-feed oscillating shuttle machine, furnished with a trimmer, used chiefly in stitching leather and boot uppers; double chain-stitch machine, used for sack making, now shown for the first time; and a single thread "Lightning Sewer," fitted with a trimmer for hosiery work. Of Wheeler & Wilson's system, there is a drop-feed manufacturing machine with the new detached hook and latest improvements; a No. 10 machine with the usual hook, a wheel feed and trimmer, and a smaller machine of the same type with drop feed. Of Willcox & Gibbs' system, there is the ordinary single-thread machine for manufacturing, a single-thread machine, with a trimmer, as used in the hosiery trades, and a machine specially used for straw hat making.

We have here a small Singer machine, riding upon the edge of two pieces of carpet, a carpet machine weighing ten pounds. When the handle is turned, it stitches and travels over the edges, uniting them faster and more securely than six hand sewers; and several others, representative of the family type of sewing machine, besides Wheeler & Wilson's hemstitch machine, the working of which is of much interest.

I would now invite those of you who seek a better acquaintance with those curious and novel machines to freely examine and test the various types to be found upon the power benching and upon stands. One or two operators will come forward and show some of the capabilities of the machines upon actual work, in which the making of a straw hat will perhaps show what can be done in a few minutes by quick speed and expert fingers; but these performances must not be regarded in the light of competitive tests between the manufacturers showing them, and are intended merely to show the utility of motive power driving.

In conclusion, I desire to thank those gentlemen at the head of the leading firms of sewing machine manufacturers for the trouble they have taken to arrange for your inspection specimens of their excellent systems, and I have much satisfaction in expressing my obligations to them for ready assistance in the preparation of my paper.

Power machines and treadle machines were exhibited by Messrs. Willcox & Gibbs, Messrs. Wheeler & Wilson, and the Singer Manufacturing Company. The motive power was provided by an electrical motor, supplied by Mr. Moritz Imish. The Howe Machine Company exhibited a model of the first machine made by Elias Howe, and also one of the most recent Howe machines. Mr. Newton Wilson showed a model of the Saint sewing machines, constructed from Thomas Saint's patent specification, 1790, and Mr. Carver showed the Standard sewing machine.

THE NEW KRUPP GUNS.

NOTHING is being talked about at present in Germany but the guns of great caliber that are manufacturing at the celebrated works on the banks of the Ruhr. As our neighbors appear to be elated over this wonderful work, it is expedient to examine the subject, in order to see whether their applause is legitimate.

We have known for a long time that the artillery materiel devoted to the defense of the German coasts consists of a long, stationary 5½ inch gun; of long 7½