April 18, 1939. J. MORTON ET AL 2,155,145

KNITTING MACHINERY

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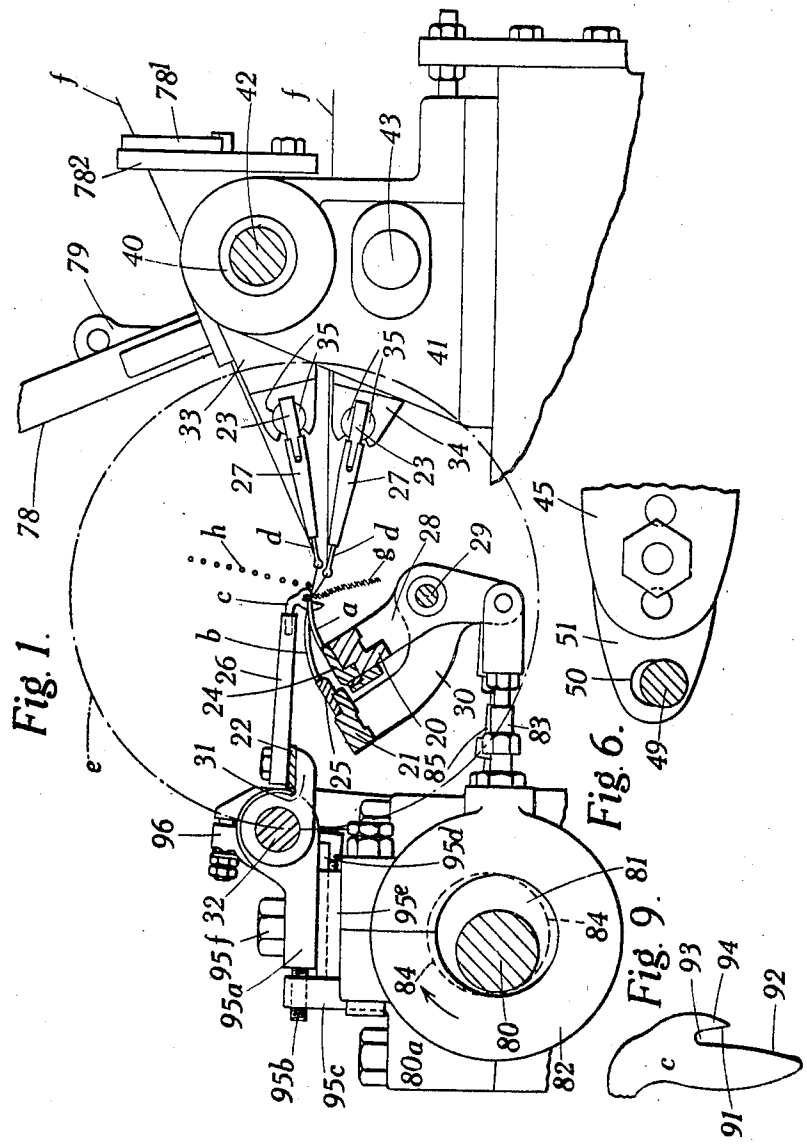

Fig. 1.

Fig. 6.

Fig. 9.

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KNITTING MACHINERY

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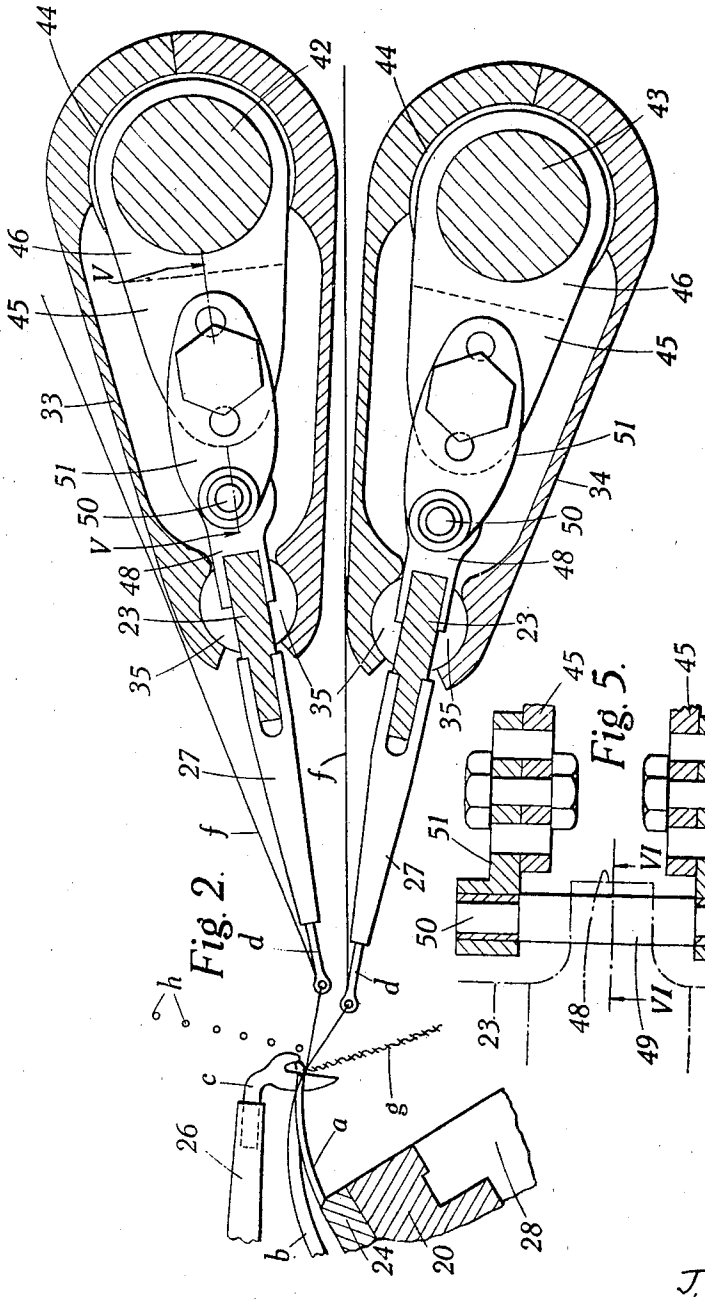

Fig. 2.

Fig. 5.

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KNITTING MACHINERY

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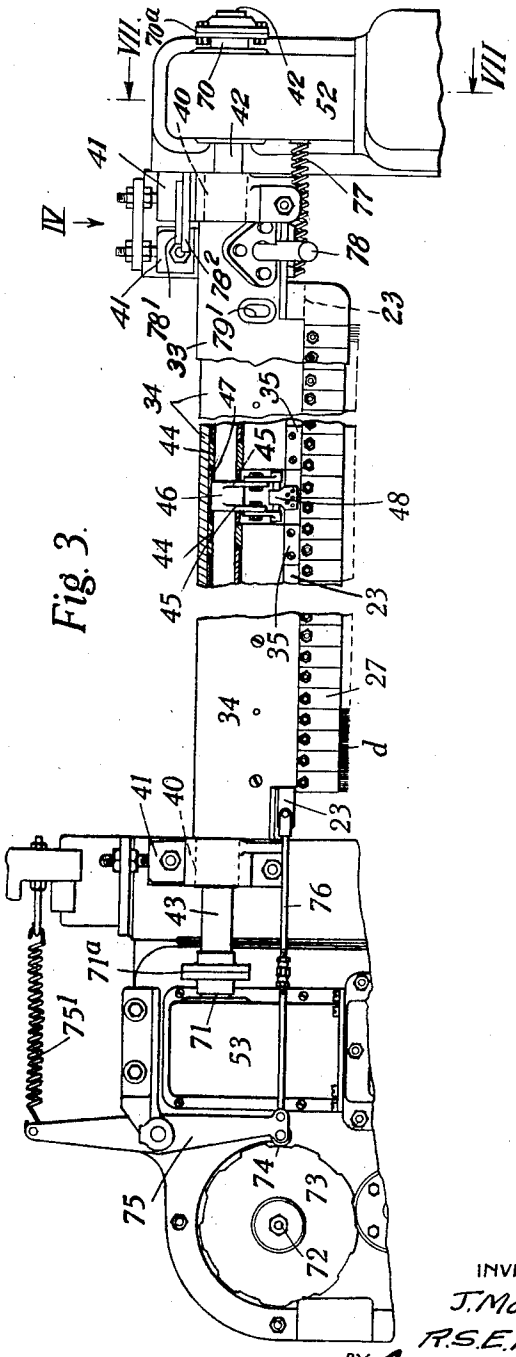

Fig. 3.

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KNITTING MACHINERY

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Fig. 4.

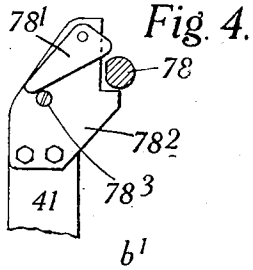


Fig. 14.

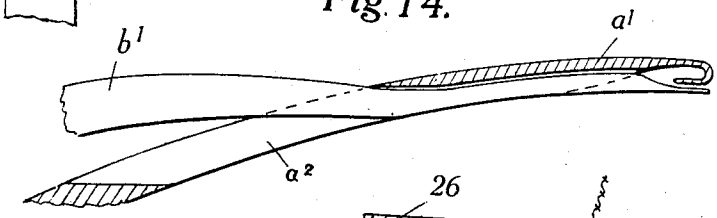
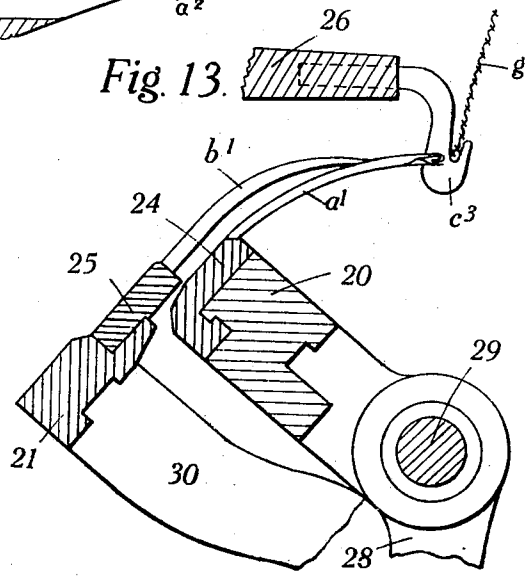


Fig. 13.



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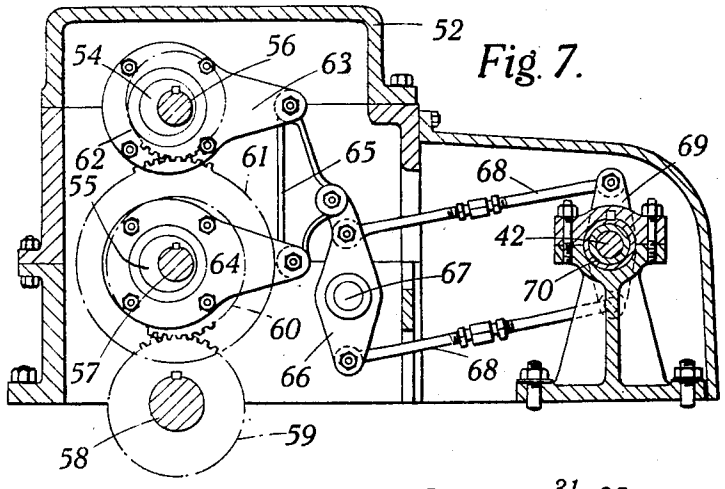

Fig. 7.

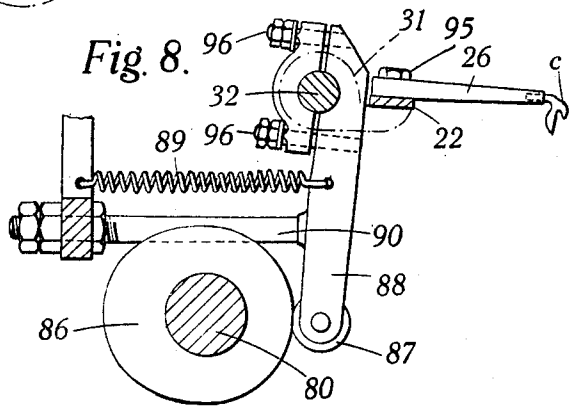

Fig. 8.

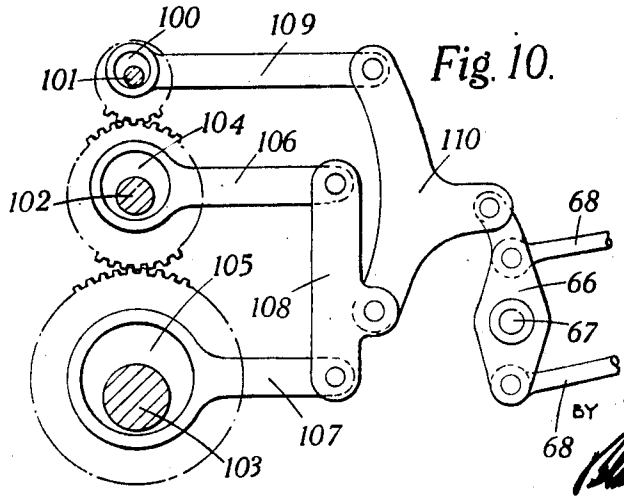

Fig. 10.

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KNITTING MACHINERY

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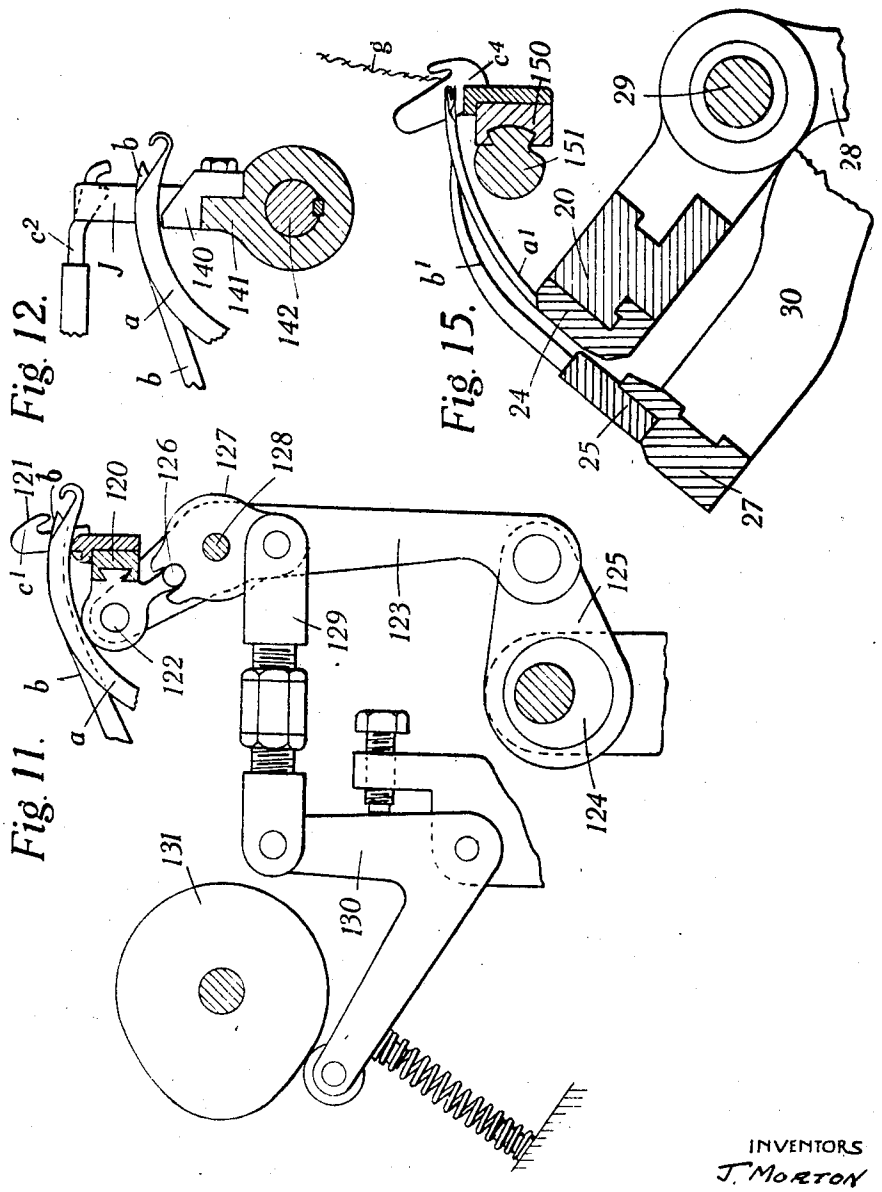

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UNITED STATES PATENT OFFICE

2,155,145

KNITTING MACHINERY

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Application November 12, 1936, Serial No. 110,539
In Great Britain February 21, 1936

17 Claims. (Cl. 66—86)

This invention relates to warp knitting machines and the invention aims at providing warp knitting machines in which the construction and arrangement of the mechanical parts which take part in the knitting operation is such that these parts may be operated at a much higher speed than heretofore, while they perform their various functions with accuracy and precision. The invention, therefore, aims at providing knitting machines which are capable of producing good quality knitted fabrics very rapidly and cheaply.

In warp knitting machines having bearded needles it has been proposed to arrange all the elements which actually perform the knitting operation, namely, the knitting needles or hooks, the warp guides, the sinkers and the presser bars, to oscillate in timed relationship about centres. These knitting elements are usually mounted in heavy metal supports carried in sets by heavy longitudinal bars supported by arms arranged to be rocked to and fro about pivotal axes. In the case of the warp guides, the bar or bars which carry these are arranged to have an endwise patterning or "shogging" reciprocatory motion imparted to them so that the warp guides are moved to and fro laterally as well as being oscillated in planes at right angles to the direction in which the patterning motion takes place.

In these machines the arrangement has hitherto been such that the various elements that act on the warps to perform the knitting operation are oscillated about pivotal axes which are so disposed that the points at which the knitting elements act on the warps have to oscillate in arcs of comparatively large radius. The result of this is that the knitting elements together with the parts that carry them constitute somewhat heavy masses having substantial radii of gyration. Thus, these masses require large forces to move them quickly and the stresses set up prevent the machines from being driven at high speed.

In order that the production of knitted goods may be efficient and economical, it has been found necessary to operate knitting machines at the highest possible speed. Accordingly, in order to reduce the stresses which limit the speeds at which knitting machines can be operated, it has been proposed to make the working parts of light weight material and it has also been proposed to balance the various moving parts. However, these expedients alone are not sufficient because the inertia of the balancing weights and the moment of inertia of parts having substantial radii of gyration necessitate the application of very large driving forces so that speeds of operation have to be considerably lower than the speeds that are desired.

According to one feature of the present invention the various knitting elements are arranged to act on the warps at points which oscillate in arcs of small radii. Thus, one object of the invention consists in a warp knitting machine comprising a plurality of elements arranged, when the machine is working, to take part in the knitting of a plurality of warps into fabric at points approximately located at a knitting centre constituted by an imaginary fixed line, supporting means for said elements arranged to allow said elements to be oscillated about axes grouped closely around said knitting centre, and means for oscillating said elements about said axes, said elements being arranged to act on the warps at points near their ends which are oscillated in arcs of short radii whereby the dynamic forces due to the oscillation of said elements are lessened to such an extent as to facilitate the rapid operation of the machine.

The invention is particularly applicable to warp knitting machines in which the knitting operation is performed by elements including knitting needles and tongues, the latter being separate from the needles and arranged to co-operate with the needles in the drawing of loops in the warps and in the casting off of loops from the needles. The tongues and needles are arranged to be oscillated independently in timed relationship. Accordingly, another object of the invention is a warp knitting machine comprising a plurality of elements arranged, when the machine is working, to take part in the knitting of a plurality of warps into fabric at points approximately located at a knitting centre constituted by an imaginary fixed line, said elements comprising a plurality of knitting needles arranged to draw loops in the warps, a plurality of tongues arranged to take part in the casting off of loops from said needles, a plurality of warp guides arranged to lap the warps over said needles, thereby enabling said needles to draw the loops, and a plurality of sinkers arranged to define the length of the loops drawn by the needles, supporting means for said elements arranged to allow said elements to be oscillated about axes grouped around said knitting centre, and means for oscillating said elements about said axes, said elements being arranged to act on the warps at points near the ends of said elements which are oscillated in arcs of short radii so that, when the machine is working, the dynamic forces due to the oscillation of said elements are lessened to

such an extent as to facilitate the rapid operation of the machine.

In many warp knitting machines having knitting elements arranged to be oscillated about axes, it has been found desirable to impart the necessary oscillatory motion to at least some of the elements through the medium of a cam. In slow running machines such cams work well as the shape of the cams can be formed to give the exact movements required. The cams are sometimes arranged to work in conjunction with counter cams so that the elements associated with the cams are moved positively in both directions of action. However, when very high speeds are required, it has been found to be impossible to design a cam and counter cam motion that will operate over long periods reliably and silently at such high speeds and that will impart the exact forms of oscillatory motion that are required for certain of the knitting elements. The present invention employs means consisting of multi-eccentric mechanism as a substitute for cams and which enables the necessary movements to be imparted to some of the knitting elements without shock and with more precision and reliability than would be the case if cams were used. Thus, a further object of the invention consists in a warp knitting machine for knitting a plurality of warps into fabric, comprising a plurality of elements arranged to act on the warps and thereby take part in the knitting process, supporting means for said elements arranged to allow said elements to be oscillated about an axis, two eccentrics, means for rotating said eccentrics in timed relationship at different speeds, two members operatively associated respectively with said eccentrics to be oscillated by said eccentrics, and link mechanism interconnecting said two members and operatively associated with said elements whereby said elements are oscillated about said axis, the oscillation of said elements being a resultant of the oscillations of said two members. The multi-eccentric mechanism may very conveniently be applied to the operation of the warp guides in a knitting machine.

A warp knitting machine may incorporate one or more guide bars to each of which a plurality of warp guides are attached. Hitherto these assemblies, including guide bars and associated warp guides, have been one of the factors tending to limit the speed of operation of the machines to which they are fitted. The present invention aims at providing guide bar assemblies which are not subject to such dynamic forces that their speed of operation must be unduly limited. Thus, yet another object of the invention is a warp knitting machine arranged to knit warps at points approximately located at a knitting centre constituted by an imaginary fixed line, the machine comprising in combination a guide bar, a plurality of warp guides, each attached to said guide bar at one end and arranged to act on a warp at the other end, a cantilever guide bar support projecting towards said knitting centre and arranged to allow said guide bar to be reciprocated longitudinally and oscillated about an axis, means for reciprocating said guide bar longitudinally and means for oscillating said guide bar about said axis, said guides being of short radius, and said axis being in close proximity to said knitting centre.

The invention further comprises the elements and combinations of parts set forth in the annexed claims.

In order that the invention may be clearly understood and readily carried into effect, some constructions in accordance therewith will now be described, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a sectional elevation of the knitting elements of a warp knitting machine and the supports of said element;

Figure 2 is a view corresponding to a portion of Figure 1, but drawn to a larger scale and showing certain of the parts in greater detail;

Figure 3 is a fragmentary plan showing the middle, ends and supports of the warp guide bars and parts thereon;

Figure 4 shows a constructional detail, as viewed in the direction of the arrow IV in Figure 3;

Figures 5 and 6 are views of another constructional detail, Figure 5 being a section on the line V—V of Figure 2 and Figure 6 being a section on the line VI—VI of Figure 5;

Figure 7 is a sectional elevation of mechanism for rocking a warp guide bar, the section being approximately on the line VII—VII of Figure 3;

Figure 8 is a sectional elevation showing more fully sinker-operating mechanism already shown partially in Figure 1;

Figure 9 is an enlarged view of a sinker;

Figure 10 is a diagrammatic view of a modified form of mechanism for rocking the warp guide bars;

Figure 11 is an elevation of a modified form of sinker and associated mechanism;

Figure 12 is a fragmentary view showing another modified form of sinker and co-operating parts;

Figure 13 is a sectional view of a modified form of arcuate knitting needle, the co-operating tongue and sinker also being shown;

Figure 14 is a detail sectional view, drawn to an enlarged scale, of the needle hook and tongue tip;

Figure 15 is a view corresponding to Figure 13 but showing a modified form of sinker and its supporting parts.

Referring firstly to Figure 1, the knitting elements therein shown consist of hook needles *a*, co-operating tongues *b*, sinkers *c* and two warp guides *d*. Each of these elements constitutes one of a long series carried by a bar, the needle bar being denoted by **20**, the tongue bar by **21**, the sinker bar by **22** and each warp guide bar by **23**. Each series is composed of groups, or "sections", of elements embedded in blocks removably attached side by side to the respective bar, a needle block being denoted by **24**, a tongue block by **25**, a sinker block by **26** and guide blocks by **27**. The manner in which the guide blocks are arranged side by side along a warp guide bar **23** is shown in Figure 3. The various blocks are preferably made of light-weight mouldable material; for example, a synthetic resin such as "Bakelite" or other light-weight organic plastic material, or alternatively a light-weight fusible alloy.

Although two warp guide bars are shown, it is to be understood that only one of such bars or any other practical number thereof may be provided in a machine.

The knitting elements are all oscillatory, and, as shown in Figure 1, their axes of oscillation are grouped closely around the knitting zone, said axes being located within the circle *e* drawn through the axis of the sinkers and about the knitting centre; i. e. the approximate centre of the knitting zone. In the example shown, the radius of the arc in which the needles and their

tongues oscillate is approximately only two-and-a-quarter inches, and the radius of the arc of the guides is or can be made nearly the same, being only slightly greater in the example. The radius of the circle *e* is approximately four-and-a-quarter inches. It will be seen that the knitting centre is approximately midway between the sinkers' axis of oscillation and the warp guides' axes of oscillation.

In the arrangement shown in Figure 1, the axis of oscillation of the sinkers is located outside the arc of movement of the needles yet close to the knitting centre, but it may be located within the arc of movement of the needles and nearer the knitting centre in the manner shown in Figure 11.

The manner in which the knitting elements are supported is briefly as follows:

As regards the needles *a*, the needle bar **20** is carried by several short arms **28**, of which one is shown and these arms, which are suitably spaced apart, are adapted to oscillate about the axis of a supporting shaft **29** arranged, as shown, close to and directly below the knitting centre. As regards the tongues *b*, the tongue bar **21** is carried by several short arms **30**, of which one is shown, and these arms which are likewise spaced apart are also adapted to oscillate about the axis of the shaft **29**. Each tongue is slidably guided in a groove in the arcuate shank of the associated knitting needle. As regards the sinkers *c*, the sinker bar **22** is carried by several short arms **31**, spaced apart, of which one is shown, and these arms are secured to a rock shaft **32**, arranged close to the knitting centre and about whose axis they are adapted to oscillate. As regards the warp guides *d*, they are secured in their guide blocks **27** which are attached to the guide bars **23** and each guide bar **23** has its own combined pivotal and slidable mounting embodying journals **35** carried in one of two normally stationary and superposed longitudinal casings **33, 34**. The casings are arranged to project forward towards the knitting centre and support the pivotal mountings of the guide bars in close proximity to the guides so that the guides can oscillate at short radii with their axes of oscillation close to the knitting centre.

As the axes of oscillation of the knitting elements are close to the knitting centre the elements operate in arcs of short radii and so lessen the dynamic forces set up by the moving masses.

Warp threads *f* are led through the upper and lower guides *d* and looped round the hooks of the knitting needles *a*.

In the operation of the machine, during which all the elements *a, b, c,* and *d* oscillate in timed relationship, the tongues *b* co-operate with the hooks to cast off the loops from the needles and thus form stitches, the sinkers serve to control the formation and length of the stitches, and the warp guides serve to lap the threads *f* round the needles preparatory to each successive stitch-forming operation. The shogging movements of the warp guide bars assist in the needle lapping operation and also serve to produce pattern effects in the knitted fabric, indicated by *g*. If desired, cross wefts as indicated by *h* may be supplied in known manner for incorporation in the fabric.

The manner in which the warp guide bars are supported and operated will now be described in greater detail.

The journals **35** consist of segmental members preferably made of self-lubricating material secured (for example, by screws) in pairs to the respective thin flat bar **23**. The segmental members composing each pair are arranged at opposite sides of the respective bar (see Figure 2) and their surfaces together present portions of the surface of a cylinder. These pairs are arranged at intervals throughout the length of the bar, the arrangement being illustrated at the middle of Figure 3. The members **35** are journalled in part-circular bearings provided in the top and bottom halves of the casings **33, 34**, which are partly hollow and extend from side to side of the machine, each casing being formed with annular ends **40** mounted in supporting brackets **41** on the frame of the machine. In Figure 3, as regards the upper warp guide bar **33**, only the right hand end thereof and the supporting bracket **41** at that end are shown. The casings **33, 34**, constitute normally stationary supports for the guide bars and parts of their operating mechanism.

Each warp guide bar is of comparatively narrow rectangular cross-section, and may be made of a light strong metal or alloy or of metal-reinforced organic plastic material.

The self-lubricating material of which the segmental members **35** are preferably made may be a metal or alloy impregnated with oil or graphite or a light-weight organic plastic material incorporating graphite.

For the purpose of rocking the guide bars **23**, there are provided in the respective casings **33, 34**, two rock shafts **42, 43**, which extend alongside the respective guide bars and are journalled at spaced intervals in bearing bushes **44** fitted into the interiors of the casings. At intervals along each of the rock shafts **42, 43**, the arms **45** are provided in pairs, one pair of these arms being shown in Figure 3 and other views of the arms being given in Figures 2, 5 and 6. As shown, each pair of arms extends from a boss **46** secured to the respective rock-shaft. Distance-pieces **47** are provided on each rock-shaft between the bearing bushes **44** and the bosses **46** and also between successive bushes **44** (Figure 3). Each pair of arms **45** is connected to one of a plurality of spaced eye-pieces **48** on the respective guide bar **23** by an eccentric device, which consists of an eccentric **49** with end trunnions **50** (Figures 5 and 6), the eccentric being a neat turning and sliding fit in extensions **51** rigidly bolted and pinned to the arms **45**. The arrangement is such that, when the rock-shafts **42, 43** are turned in their bearings, the guide bars **23** are also forced to turn in their bearings, the rocking force being transmitted through the eccentric devices **49, 50** which turns relatively to both the eye pieces **48** and the arm-extensions **51** to compensate for variations in the distance between these parts.

It will be manifest that the two warp guide bars described and illustrated are each rockable relatively to the other with the journals **35** arranged at intervals along the middle of the bar itself, the axis of said journals extending through the body of the bar; that rocking forces are applied to each of the guide bars at intervals throughout its length; and that the bearings in which the journals **35** turn constitute also the guideways along which the shogging movements of the bars take place.

Each of the rock-shafts **42, 43** has its own mechanism for rocking it, the mechanism for the respective shafts being substantially similar and

being enclosed in casings 52, 53 at opposite sides of the machine (Figure 3). The rocking-mechanism of the upper rock-shaft 42 is shown in Figure 7, such mechanism involving the use of two eccentrics. As shown, eccentrics 54, 55 are keyed to parallel shafts 56, 57. The eccentric-carrying shafts 56, 57 are driven from the shaft 58 through pairs of gearwheels 59, 60 and 61, 62. The wheels 59 and 60 have the same number of teeth and the wheel 61 has twice as many teeth as the wheel 62, so that the shaft 57 rotates at the same speed as the shaft 58 and the shaft 56 rotates at twice that speed. The shaft 58 is a section of the machine's main-shaft, which is shown also in Figure 1, being indicated therein by 80. The ends of the respective eccentric rods 63, 64 are coupled together by a floating link 65, and this link is coupled between its ends to a lever 66 having a stationary fulcrum 67. The lever 66 is connected at opposite ends by links 68 to a lever 69 secured to a shaft 70 sleeving the rock-shaft and detachably coupled thereto by a coupling 70*a* (Figure 3).

The coupling between the rock-shaft 43 and its mechanism differs from the foregoing in that a shaft 71, rocked by mechanism corresponding to that shown in Figure 7, is coupled at 71*a* to the rock-shaft 43.

If desired, provision may be made for adjusting the axis of connection between the floating link 65 and the lever 66 and/or for adjusting the phase relationship of each eccentric to the other.

The guide bars derive their shogging motions from pattern cams secured one above the other to a rotary cam shaft. In Figure 3, the cam shaft is denoted by 72 and one of the pattern cams by 73. The cam follower consists of a roller 74 on a lever 75 which is attached by an adjustable link 76 to the adjacent end of the respective guide bar. The roller is maintained against the cam by a strong tension spring 75^1 acting on the lever 75 against the pull of a steadying tension spring 77 acting on the far end of the guide bar.

To facilitate the operation of threading the guides *d*, provision is made for pivoting the upper casing 33 about the axis of the rock shaft 42 and its guide bar into a raised position, such being possible by virtue of the nature of the mounting of the annular bar ends 40 in the brackets 41. The aforesaid provision includes a handle 78 (Figures 1, 3 and 4) which can be turned rearwardly and downwardly until it has displaced and has become locked by a self-locking manually releasable catch 78^1 which is pivotally mounted on a plate 78^2 on the adjacent bracket 41 and which normally rests upon a stop 78^3. In Figure 4, the handle 78 is shown locked by the catch 78^1. Prior to raising the casing 33 by the handle 78, the coupling 70*a* between the shafts 42 and 70 is manually detached. Normally, the upper casing 33 is fastened to the lower casing 34 by means of a screwed clamping pin 79 (Figure 1) adapted to be passed into a slot 79^1 (Figure 3) in the upper casing and screwed into the lower casing.

The needle bar 26 receives its oscillatory motion from a group of eccentrics keyed to, and arranged at intervals along, a main shaft 80 (a section of which is indicated by 58 in Figure 7), one of said eccentrics being shown in Figure 1 and being indicated by 81. As shown, the eccentric 81 is embraced by an eccentric strap 82, whose short eccentric rod 83 is pivotally attached to the lever 28, which forms one of a group of similar levers arranged at intervals along the shaft 29. Correspondingly, the tongue bar 21 receives its oscillatory motion from a group of eccentrics keyed to, and arranged at intervals along, the shaft 80, and said eccentrics are embraced by straps whose eccentric rods are pivotally attached to the levers 30 journalled on the shaft 29; one of these eccentrics being indicated by 84 and the respective short eccentric rod by 85. The needle-operating eccentrics are set in advance of the tongue-operating eccentrics at an angle of 26½°, which has been found to ensure accurate cooperation between each needle-hook and tongue.

The rock-shaft 32 supporting the sinker-bar 22 and series of sinkers *c* thereon receives its rocking motion from two or more similar cams spaced apart along and keyed to the rotary shaft 80, one of these cams being shown in Figure 8 and being indicated by 86. Each cam has for its follower a roller 87 on a lever-arm 88 clamped rigidly to the rock-shaft 32, there being the same number of lever-arms as cams. The arm 88 is maintained in contact with the cam by a spring 89, and a stationary but adjustable stop 90 serves to prevent vibration between the cam and roller when the latter is riding upon the inactive portion of the cam face.

The sinkers *c* consist of a series of inter-needle blades respectively presenting active fabric-engaging edges 91, 92 (Figure 9) which restrain the fabric from following the needles as they are advanced and returned and also control the length of the loops formed in the warps by the needles.

The active fabric-engaging edges of each sinker emerge into one another in the form of a recess 93, at one side of which is the main body of the sinker and at the other side a projection 94 extending approximately parallel to said body. The recess may be utilised for the introduction of the wefts *b* to be bound into the body of the fabric.

The sinker edges 92 which restrain the fabric from following the returning needles serve the function of the usual stationary "tricks", which are therefore, in this case, unnecessary. These edges are slightly arcuate, and a tangent to one of these edges where it crosses the upper needle surface is substantially at right angles thereto. Accordingly the oscillatory sinker motion is arranged to take place about an axis (namely, that of the shafts 32) in or near the plane of movement of the upper needle surfaces where these are crossed by the edges 92.

The sinkers are adjustable relatively to the knitting centre by moving the shaft 32 and its bearing brackets 95*a* by means of screws 95*b*, which are screwed through fixed lugs 95*c* on the caps of the bearings 80*a* of shaft 80. The adjustable bearing brackets 95*a* have feathers 95*d* movable on fixed guides 95*e* on the caps of the bearings 80*a* and are clamped in position by screws 95*f* each passing through a slot in its brackets 95*a*. When the screws 95*f* are slackened, the sinker bar can be nicely adjusted relatively to the knitting centre by the screws 95*b*. The arms 88 can also be adjusted angularly on the shaft 32 owing to provision of the clamping device 96 (see also Figure 8). This has the effect of adjusting the positions of the sinkers about the axis of the shaft 32.

The construction of the warp knitting machine parts hereinbefore described can be modified in various respects without departing from the scope of the invention hereinafter claimed, and

various modifications and alternatives will now be described by way of example.

Regarding the mechanism for actuating the rock shaft **42**, **43**, the eccentric mechanism described (Figure 7) has certain advantages over cam mechanism. Nevertheless cam mechanism can be adopted; for example, mechanism including cam-followers maintained by springs against the cams, or alternatively mechanism including cam-followers actuated by cams and countercams. Or other multi-eccentric arrangements can be adopted; for example, a triple-eccentric arrangement such as shown in Figure 10.

Referring to Figure 10, the arrangement therein shown differs from that according to Figure 7 mainly in that a third eccentric **100** is provided on a shaft **101** parallel to other two shafts **102**, **103** having eccentrics **104**, **105** whose eccentric rods **106**, **107**—as in the previously described arrangement—are coupled by a floating link **108**. The shafts **101**, **102** and **103** are rotated through gearing at speeds bearing the ratio 3:2:1. The end of the third eccentric rod **109** is coupled by a second floating link **110** to a point (which may be adjustable) between the ends of the first floating link **108**; and the second floating link **110** is coupled at a point (which may be adjustable) between its ends to the stationarily fulcrumed lever **66**. As in the previously described arrangement, this lever has an operative connection through links **68** with the rock shaft **70**, **42** or **71**, **43** to be actuated. Again, the eccentrics may be angularly adjustable in relation to one another.

In a triple-eccentric arrangement such as above described, it is possible to provide a floating link such as **108** between any two of the eccentric rods and connect that link to another link such as **110** connected to the third eccentric rod.

It will be clear that multi-eccentric arrangements, such as before described, afford a comparatively wide range of motions.

Referring to Figure 11, which shows an arrangement whereby the axis of oscillation of the sinkers is contained within the arc of movement of the needles, the sinkers c^1 stand erect in series on the sinker bar **120**, the sinkers having downturned projections **121**. The sinker bar is journalled on a supporting shaft **122** having an adjustable mounting consisting of levers **123**, the positions of which are controlled by adjustable eccentrics **124**, the rods **125** of which are pivotally connected to the adjacent ends of the levers **123**. The sinker bar has pin-and-slot connections **126** with tumblers **127** journalled on the fulcrum shaft **128** of the levers **123** and connected to an adjustable link **129**, which is attached to a bell crank **130** oscillated by a rotary cam **131**, from which the tumblers **127** transmit the requisite up-and-down oscillatory motion to the sinkers c^1. The shaft **128** may also carry levers like the levers **28** and **30** (Figure 1) supporting the needles and tongues.

The arrangement according to Figure 11, in which the sinkers are arranged to oscillate about an axis located between the needles and their axis of oscillation, gives direct access to the needles and tongues for the purpose of effecting replacements of damaged or broken parts.

According to the modification shown in Figure 12, a series of stationary inter-needle "trick" blades j are provided, these being especially suitable in a machine adapted to knit fabrics incorporating stuffer warps; and, a series of sinkers c^2, preferably recessed, are provided to oscillate in the same manner as sinkers c. Trick blades such as aforesaid are embedded (like the other knitting elements) in blocks secured side-by-side along a bar. One of these blocks is denoted by **140** and the bar by **141**. The bar has a stationary support **142** and it may be vertically adjustable. There may be one of said sinkers c^2 per trick blade j, and there would be one trick blade per knitting needle; but, where the sinkers are intended also to introduce wefts, their number may be considerably reduced, since the wefts assist to restrain the knitted fabric from following the needles as they advance and thus assist the sinkers in this function.

Regarding the knitting needles and tongues, an alternative form is illustrated in Figures 13 and 14. As shown therein, the needle a^1 has a hook which is downturned to face the axis of oscillation; and the tongue b^1 passes from its oscillatory bar through an opening a^2 in the needle shank, the tongue being slidable near its end along the arcuate inner portion of the needle. The form of the sinker C^3 has been modified as shown to suit the action of the needle and the changed direction in which the fabric g is led away from the knitting zone. The sinker C^3 is supported and oscillated in similar manner to the sinker C according to Figure 1.

The arrangement according to Figure 15 differs mainly from that according to Figure 13 as regards the manner in which the sinker C^4 is supported and oscillated. As shown, the sinker bar **150** is simply secured directly to an oscillatory shaft **151**.

Although for high speed working the knitting needles are preferably arcuate and are arranged to co-operate with independently operated tongues, yet, the same principle may be applied to latch or bearded needles and the needles may or may not be arcuate.

Regarding the eccentric devices **49**, **50**, connecting the arms of the rock-shaft **42**, **43**, to the warp guide bars **23**, any of the various other connections can be adopted instead. For example, the same effect can be obtained by using pin-and-fork or pin-and-slot connections. Alternatively, simple pin-joints may be used, in which event however the guide bar would be laterally displaced during the rocking movement and accordingly the bar would not be rigidly secured to the segmental members **35** but would be laterally displaceable relatively thereto.

Regarding the provision of a rock-shaft (**42** or **43**) and casing (**33** or **34**) for each warp guide bar, two or more bars may have their bearings in a single casing and may have operative connections with a single rock shaft. The operative connections, whether between a rock-shaft and a single bar or a rock-shaft and two or more bars can involve the use of cams. Where there are two or more rock-shafts, these can be driven in common by the same actuating mechanism.

Although we have described and shown rock shafts as being employed for effecting the oscillatory movements, rotary shafts with cams can be employed for the purpose.

If desired, instead of providing as the guide-bar journals segmental members **35** made of self-lubricating material these can be made of any good journal metal and provision can be made for the application of lubricant. The casing constituting a supporting bearing for a guide bar, or guide bars, may be made as a receptacle for lubricant, in which event some form of seal would be provided between adjacent segmental

members to prevent egress of the lubricant. For example, absorbent material such as felt or cotton could be packed into the spaces between adjacent segmental members, and such material would serve to lubricate the bearing surfaces during the shogging movements of the guide bar.

We claim:

1. In a warp knitting machine, in combination, a plurality of elements arranged, when the machine is working, to take part in the knitting of a plurality of warps into fabric at points approximately located at a knitting centre constituted by an imaginary fixed line, said elements comprising a row of knitting needles arranged to draw loops in the warps, a row of tongues arranged to take part in the casting off of loops from said needles, a row of warp guides arranged to lap the warps over said needles, thereby enabling said needles to draw the loops, and a row of sinkers arranged to define the lengths of the loops drawn by the needles, a plurality of long, thin bars allocated respectively to said rows of knitting elements and each carrying one row of said knitting elements parallel to said knitting centre, pivotal supporting means for each of said bars distributed along the length thereof to hold same against deflection while permitting pivotal movement about a fixed axis parallel to and close to said knitting centre and means for oscillating said bars about their respective axes, said elements being arranged to act on the warps at points near the ends of said elements which are oscillated in arcs of short radii.

2. In a warp knitting machine, in combination a plurality of elements arranged, when the machine is working, to take part in the knitting of a plurality of warps into fabric at points approximately located at a knitting centre constituted by an imaginary fixed line, said elements comprising a row of needles for drawing loops in the warps, a row of tongues for taking part in the casting off of the loops from the needles, a row of warp guides for lapping the warps over the needles so that the latter can draw the loops, and a row of sinkers for defining the lengths of the loops drawn by the needles, supporting means for said needles, supporting means for said tongues, said two supporting means being arranged to allow said needles and said tongues to be oscillated independently about a common axis in close proximity to said needles and tongues, supporting means for said warp guides arranged to allow said warp guides to be oscillated about an axis remote from said first-mentioned axis and in close proximity to said warp guides, supporting means for said sinkers arranged to allow said sinkers to be oscillated about an axis remote from said previously-mentioned axes and located in close proximity to said sinkers but on the side of said knitting centre remote from said second-mentioned axis while said sinkers are located on the side of said knitting centre remote from said warp guides, and means for oscillating said elements about said axes, said elements being arranged to act on the warps at points near the ends of said elements which are oscillated in arcs of short radii, each of said supporting means comprising a bar, inherently subject to deflection under its own weight carrying its respective row of knitting elements, and pivotally mounted elements supporting the bar at points distributed along the length thereof to hold it against deflection.

3. In a warp knitting machine, in combination a plurality of elements arranged, when the machine is working, to take part in the knitting of a plurality of warps into fabric at points approximately located at a knitting centre constituted by an imaginary fixed line, said elements comprising a row of needles for drawing loops in the warps, a row of tongues for taking part in the casting off of the loops from the needles, a row of warp guides for lapping the warps over the needles so that the latter can draw the loops, and a row of sinkers for defining the lengths of the loops drawn by the needles, two supporting means associated respectively with said needles and said tongues and arranged to allow said needles and said tongues to be oscillated about a common axis in close proximity to said knitting centre, supporting means for said warp guides arranged to allow said warp guides to be oscillated about an axis remote from said first-mentioned axis and in close proximity to said knitting centre, supporting means for said sinkers arranged to allow said sinkers to be oscillated about an axis located on the side of said knitting centre remote from said second-mentioned axis and approximately the same distance from said knitting centre as the distance of said second-mentioned axis from said knitting centre, means for oscillating said elements about said axes, said elements being arranged to act on the warps at points near the ends of said elements which are oscillated in arcs of short radii, and each of said supporting means comprising a long, thin bar, carrying its respective row of knitting elements, and pivotally mounted elements supporting the bar at points distributed along the length thereof to hold it against deflection.

4. In a warp knitting machine, in combination a plurality of elements arranged, when the machine is working, to take part in the knitting of a plurality of warps into fabric at points approximately located at a knitting centre constituted by an imaginary fixed line, said elements comprising a row of needles for drawing loops in the warps, a row of tongues for taking part in the casting off of the loops from the needles, a row of warp guides for lapping the warps over the needles so that the latter can draw the loops, and a row of sinkers for defining the lengths of the loops drawn by the needles, two supporting means respectively for said needles and said tongues arranged to allow said needles and said tongues to be oscillated about a common axis in close proximity to said knitting centre, supporting means for said warp guides arranged to allow said warp guides to be oscillated about an axis remote from said first-mentioned axis and in close proximity to said knitting centre, and supporting means for said sinkers arranged to permit said sinkers to be oscillated about an axis located between said needles and said first-mentioned axis, each of said supporting means comprising a long, thin bar, carrying its respective row of knitting elements, and pivotally mounted elements supporting the bar at points distributed along the length thereof to hold it against deflection.

5. In a warp knitting machine, in combination, a plurality of elements arranged, when the machine is working, to take part in the knitting of a plurality of warps into fabric at points approximately located at a knitting centre constituted by an imaginary fixed line, said elements comprising a plurality of knitting needles for drawing loops in the warps and a plurality of warp guides for lapping the warps over the needles to enable the loops to be drawn, supporting

means for said needles including a bar, carrying said needles, and pivotally mounted elements holding said bar against deflection and arranged to allow said needles to be oscillated about an axis located in close proximity to said knitting centre, a guide bar to which said warp guides are attached, supporting means for said guide bar arranged to hold said guide bar against deflection while allowing said guide bar to be reciprocated longitudinally and to be oscillated about an axis extending along said guide bar in close proximity to said knitting centre, means for oscillating said needles about said first-mentioned axis, means for oscillating said guide bar about said second-mentioned axis, and means for reciprocating said guide bar longitudinally, said elements being arranged to act on the warps at points near the ends of said elements which are oscillated in arcs of short radii.

6. In a warp knitting machine, in combination a plurality of elements arranged, when the machine is working, to take part in the knitting of a plurality of warps into fabric at points approximately located at a knitting centre constituted by a fixed imaginary line, said elements comprising a plurality of knitting needles for drawing loops in the warps and a plurality of warp guides for lapping the warps over the needles to enable the loops to be drawn, supporting means for said needles arranged to allow said needles to be oscillated about an axis located in close proximity to said knitting centre, means for oscillating said needles about said axis, a guide bar to which said warp guides are attached, journal members mounted on said guide bar, a supporting structure for said guide bar, said supporting structure being formed with journal bearings embracing said journal members and aranged to allow said guide bar to be reciprocated longitudinally and oscillated about the axis of said journal members, and eccentric and eccentric-rod gear operative to impart oscillatory motion to said guide bar about said axis of said journal members, the arrangement being such that said axis of said journal members is located in close proximity to said knitting centre so that the points at which the warp guides act on the warps are oscillated in arcs of short radii.

7. In a warp knitting machine for knitting a plurality of warps into fabric, in combination a plurality of elements arranged to act on the warps and thereby take part in the knitting process, supporting means for said elements arranged to allow said elements to be oscillated about an axis, a plurality of eccentrics, means for rotating said eccentrics in timed relationship at different speeds, members operatively associated respectively with said eccentrics to be oscillated by said eccentrics, and link mechanism interconnecting said members with said elements whereby said elements are oscillated about said axis, the oscillation of said elements being a resultant of the oscillations of said members.

8. In a warp knitting machine for knitting a plurality of warps into fabric, in combination a plurality of warp guides arranged to act on the warps, thereby taking part in the knitting process, a guide bar to which said warp guides are attached, supporting means for said guide bar arranged to allow said guide bar to be oscillated about an axis extending along said guide bar, two eccentrics, means for rotating said eccentrics in timed relationship at different speeds, two members operatively associated respectively with said eccentrics to be oscillated by said eccentrics, and link mechanism interconnecting said two members with said guide bar whereby said guide bar is oscillated about said axis, the oscillation of said guide bar being a resultant of the oscillations of said two members.

9. In a warp knitting machine, in combination a plurality of elements arranged, when the machine is working, to take part in the knitting of a plurality of warps into fabric at points approximately located at a knitting centre constituted by an imaginary fixed line, said elements comprising a plurality of knitting needles for drawing loops in the warps and a plurality of warp guides for lapping the warps over the needles to enable the loops to be drawn, supporting means for said needles arranged to allow said needles to be oscillated about an axis located in close proximity to said knitting centre, means for oscillating said needles about said axis, a guide bar, each warp guide being attached at one end to said guide bar and arranged to act at its other end on a warp, supporting means for said guide bar arranged to allow said guide bar to be reciprocated longitudinally and to be oscillated about an axis extending along said guide bar in close proximity to said knitting centre, a rock shaft disposed parallel to said guide bar, supporting means for said rock shaft arranged to allow said rock shaft to be oscillated about an axis extending through said rock shaft, means for oscillating said rock shaft about said last-mentioned axis and means interconnecting said rock shaft and said guide bar whereby said guide bar is oscillated about said second-mentioned axis by said rock shaft when the latter is oscillated.

10. In a warp knitting machine, in combination, a plurality of elements arranged, when the machine is working, to take part in the knitting of a plurality of warps into fabric at points approximately located at a knitting centre constituted by an imaginary fixed line, said elements comprising a plurality of knitting needles arranged to draw loops in the warps, a plurality of tongues arranged to take part in the casting off of loops from said needles, a plurality of warp guides arranged to lap the warps over said needles, thereby enabling said needles to draw the loops, a plurality of sinkers, supporting means for said elements arranged to allow said elements to be oscillated about axes grouped closely around said knitting centre, means for oscillating said elements about said axes and a plurality of fixed trick blades serving in co-operation with said sinkers to restrain movement of the loops with the needles when the latter are oscillated, said elements being arranged to act upon the warps at points near the ends of said elements which are oscillated in the arcs of short radii.

11. In a warp knitting machine, in combination, a plurality of elements arranged, when the machine is working, to take part in the knitting of a plurality of warps into fabric at points approximately located at a knitting centre constituted by an imaginary fixed line, said elements comprising a plurality of sinkers, at least twice as many needles as there are sinkers, as many tongues as there are needles and a plurality of warp guides supporting means for said elements arranged to allow said elements to be oscillated about axes grouped closely around said knitting centre, means for oscillating said elements about said axes, and as many fixed trick

blades as there are needles, said needles being arranged to draw loops in the warps, said tongues being arranged to take part in the casting off of the loops from said needles, said warp guides being arranged to lap the warps over said needles, thereby enabling said needles to draw the loops and said trick blades being arranged to co-operate with said sinkers so as to restrain the movement of the loops with the needles when the latter are oscillated.

12. In a warp knitting machine, in combination a plurality of elements arranged, when the machine is working, to take part in the knitting of a plurality of warps into fabric at points approximately located at a knitting centre constituted by an imaginary fixed line, said elements comprising a plurality of knitting needles arranged to draw loops in the warps and a plurality of sinkers arranged to define the length of the loops drawn by the needles, supporting means for said needles arranged to allow said needles to be oscillated about an axis, a shaft to which said sinkers are attached, supporting means for said shaft arranged to allow said shaft to be oscillated about an axis parallel to said first-mentioned axis, adjusting means for said second-mentioned supporting means through the medium of which the position of said shaft relatively to said knitting centre may be adjusted within a predetermined range, and means for oscillating said shaft about said second-mentioned axis, said last mentioned means including a plurality of cams mounted to rotate about a fixed axis, cam followers fixed to said shaft and resilient means holding said cam followers in position to be engaged by said cams in all positions of said shaft within its range of adjustment.

13. In a warp knitting machine, in combination a plurality of elements arranged, when the machine is working, to take part in the knitting of a plurality of warps into fabric at points approximately located at a knitting centre constituted by an imaginary fixed line, said elements comprising a plurality of arcuate knitting needles formed with hooks having their tips disposed on the inner arcuate sides of said needles, and a plurality of arcuate tongues having their operative ends disposed respectively on the inner arcuate sides of said knitting needles, supporting means for said knitting needles attached to the latter at their ends remote from the hooks and arranged to permit said knitting needles to be oscillated about an axis located in the vicinity of the centres of imaginary circles along which said arcuate sides extend, supporting means for said tongues to which said tongues are attached at their ends remote from their operative ends and arranged to permit said tongues to be oscillated about said axis and means for oscillating said needles and said tongues in timed relationship about said axis, said needles being arranged to draw loops in the warps, while said tongues are arranged to take part in the casting off of the loops from said needles.

14. In a warp knitting machine, in combination a plurality of arcuate needles formed with openings intermediate their ends and with hooks having their tips disposed on the inner arcuate sides of said needles, supporting means for said needles arranged to allow said needles to be oscillated about a common axis disposed remotely from said needles and on the inner arcuate sides thereof, a plurality of tongues associated respectively with said needles and having operative ends arranged to co-operate with said hooks in the drawing of loops in warps and in the casting off of the loops from said needles, supporting means for said tongues arranged to allow said tongues to be oscillated in timed relationship with said needles about said axis, said tongues being so mounted on said last-mentioned supporting means that they extend from said supporting means through said openings in said needles, and means for oscillating said tongues and said needles about said axis in timed relationship.

15. In a warp knitting machine, the combination of a plurality of hook needles mounted for oscillation about an axis parallel to and in close proximity to the knitting centre constituted by a fixed line substantially in which a plurality of warps are knitted by the machine into fabric, a plurality of tongues operative to close the hook needles and mounted for oscillation about said axis, means for oscillating said needles and said tongues about said axis, a plurality of warp guides mounted for oscillation about a second axis parallel to the knitting centre and spaced therefrom substantially the same distance as the first-named axis is spaced from the knitting centre, means for oscillating said warp guides about said second axis, a plurality of sinkers mounted for oscillation about a third axis parallel to the knitting centre and spaced therefrom substantially the same distance as the first-named axis is spaced from the knitting centre, and means for oscillating said sinkers about said third axis.

16. In a warp knitting machine, in combination, a plurality of elements arranged, when the machine is working, to take part in the knitting of a plurality of warps into fabric at points approximately located at a knitting center constituted by an imaginary fixed line, said elements comprising a row of knitting needles arranged to draw loops in the warps, a row of tongues arranged to take part in the casting off of loops from said needles, a row of warp guides arranged to lap the warps over said needles, thereby enabling said needles to draw the loops, and a row of sinkers arranged to define the lengths of the loops drawn by said needles, a pair of long, thin bars carrying respectively to said rows of needles and tongues parallel to said knitting center, supporting means for each of said bars distributed along the length thereof to hold same against deflection while permitting to-and-fro movement to said bar, a pair of long, thin bars allocated respectively to said row of warp guides and said row of sinkers and each carrying one of said two last-mentioned rows parallel to said knitting center, and pivotal supporting means for each of said two last-mentioned bars distributed along the length thereof to hold same against deflection while permitting pivotal to-and-fro movement about a fixed axis parallel to and close to said knitting center.

17. In a warp knitting machine of the character set forth in claim 16 in which the elements are arranged to act on the warps at points near the ends of said elements which are oscillated in arcs of relatively short radii.

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