

April 15, 1958

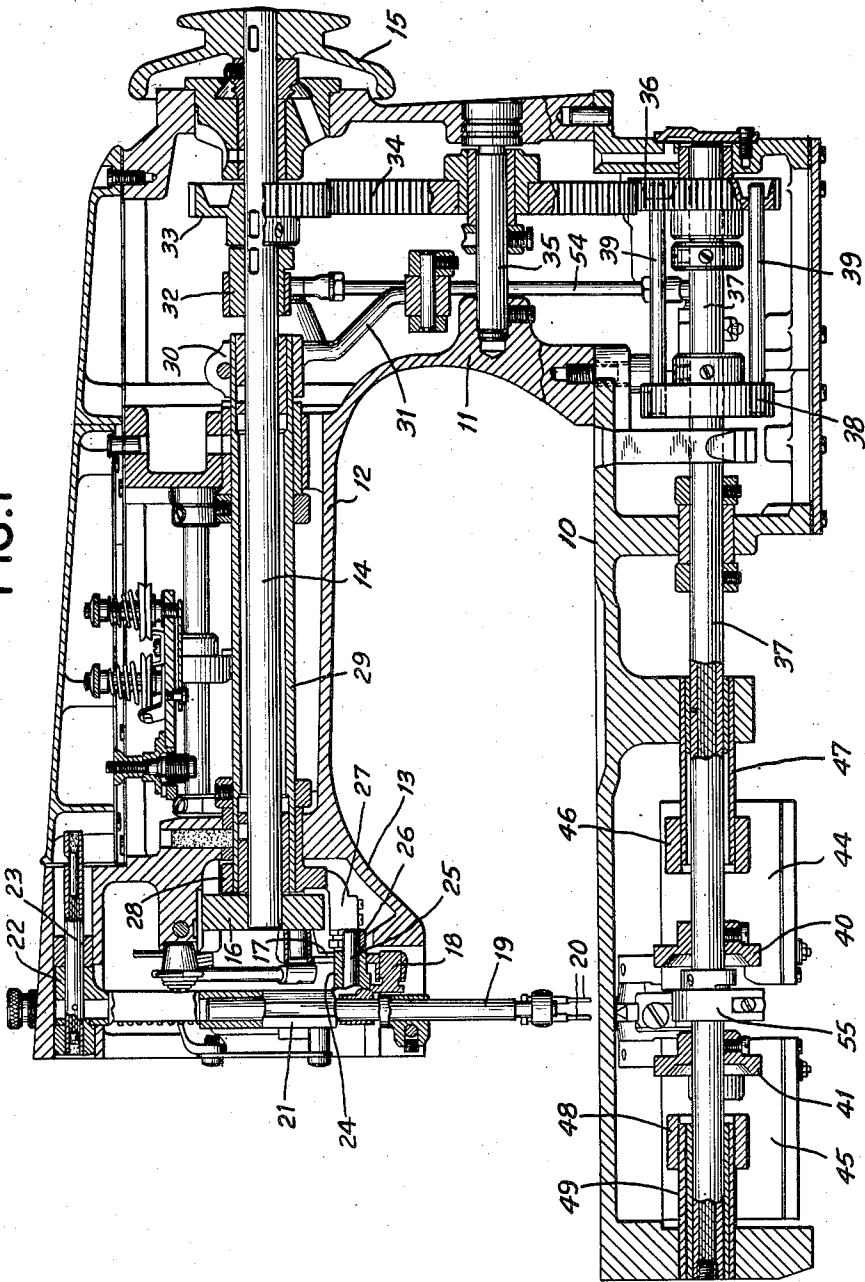
J. G. ATTWOOD ET AL
LOCKSTITCH SEWING MACHINES

2,830,550

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11 Sheets-Sheet 1

FIG. 1



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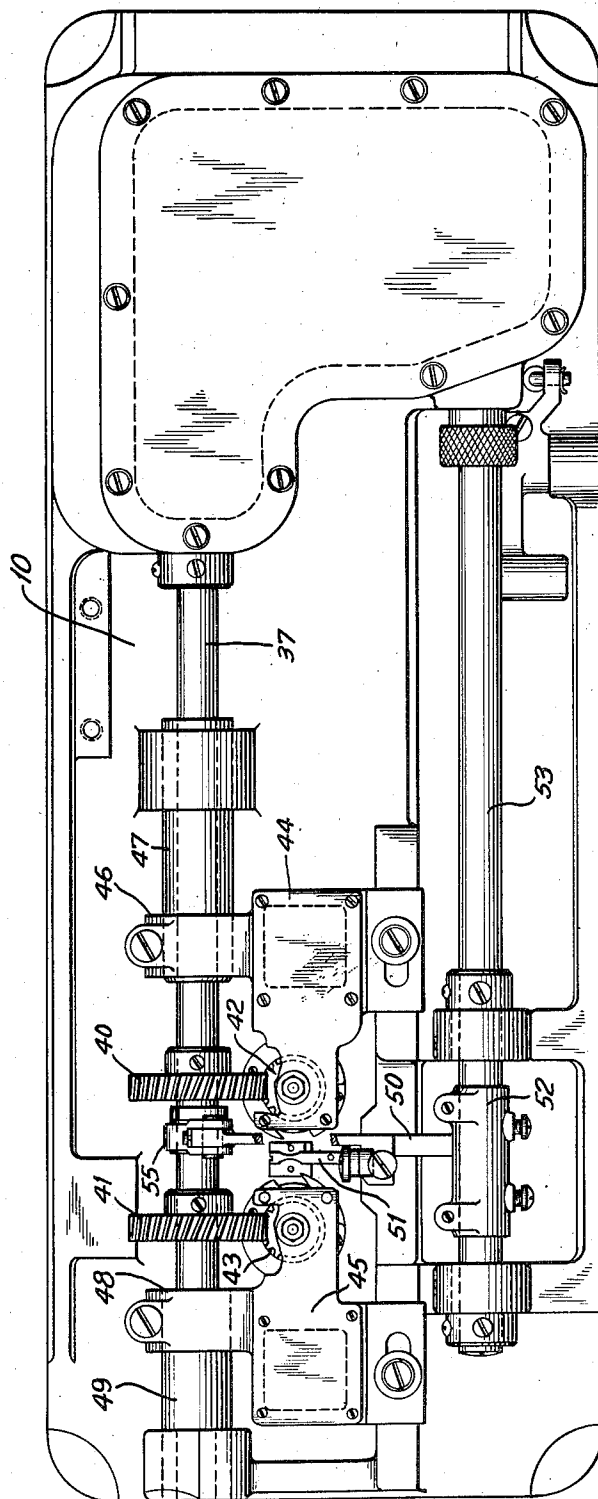
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FIG. 2



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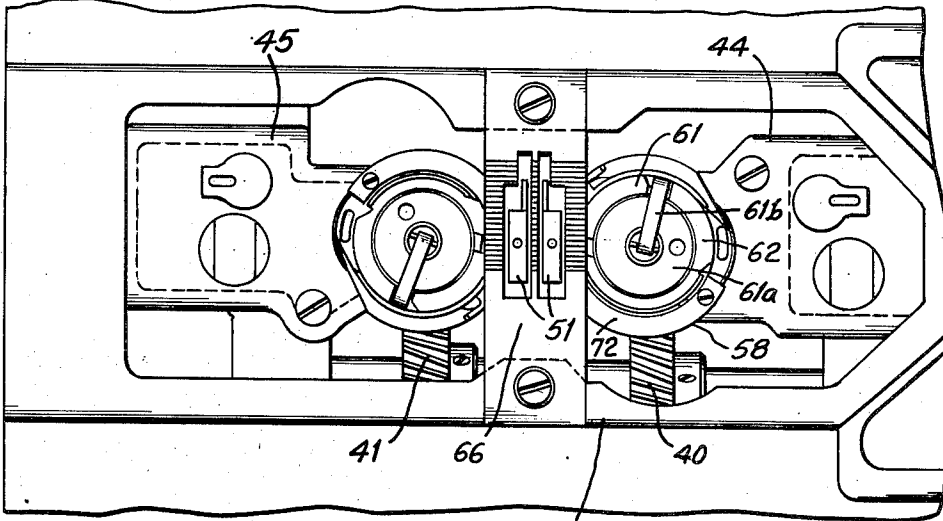


FIG. 3

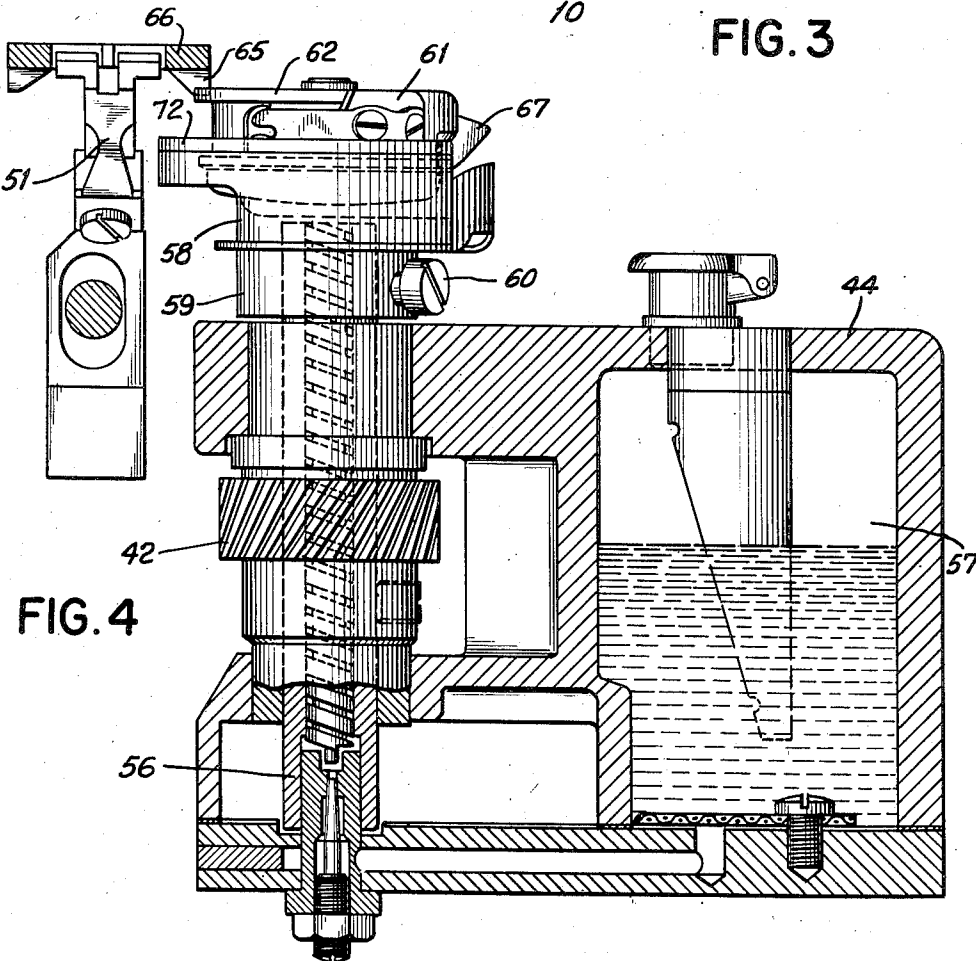


FIG. 4

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FIG. 5

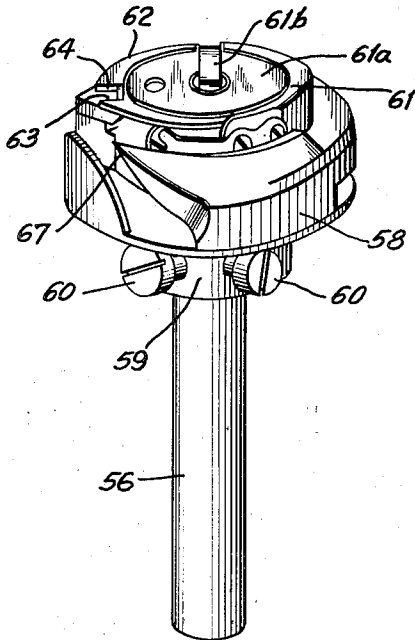


FIG. 6

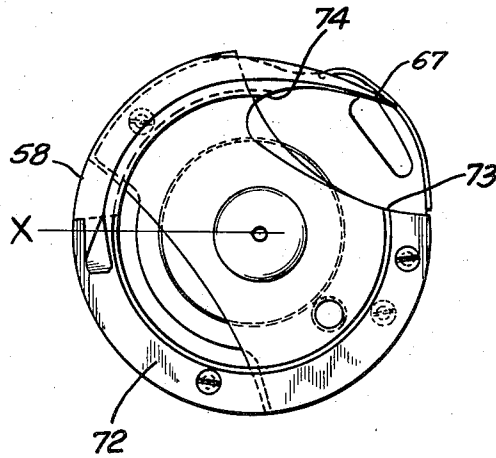


FIG. 8

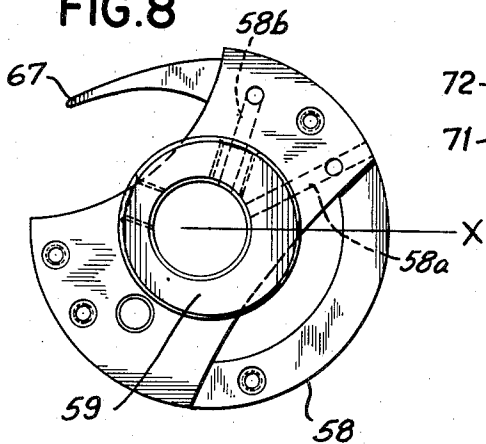
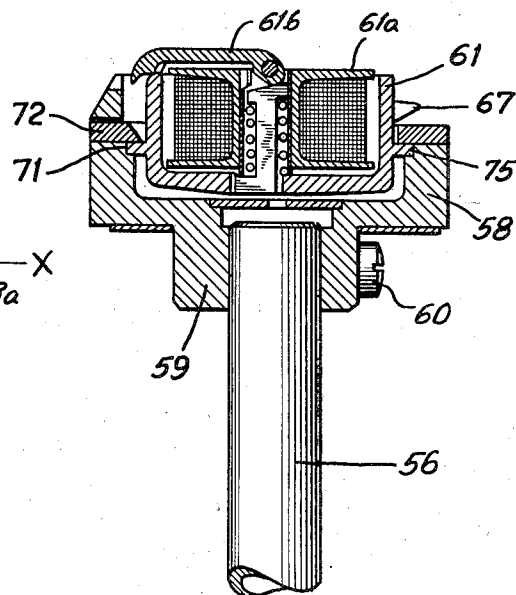


FIG. 7



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FIG. 9

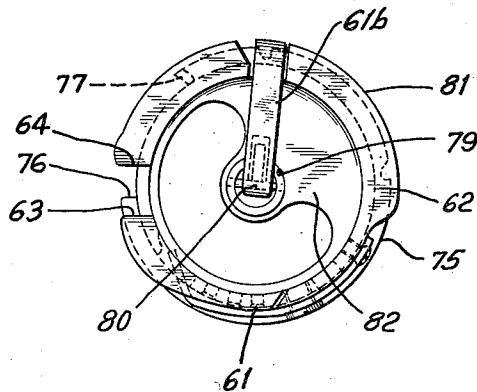


FIG. 10

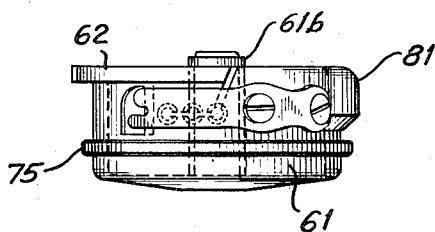


FIG. 11

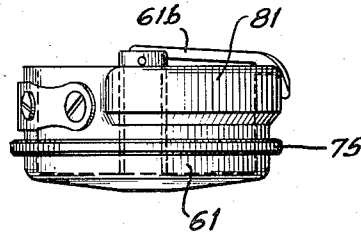
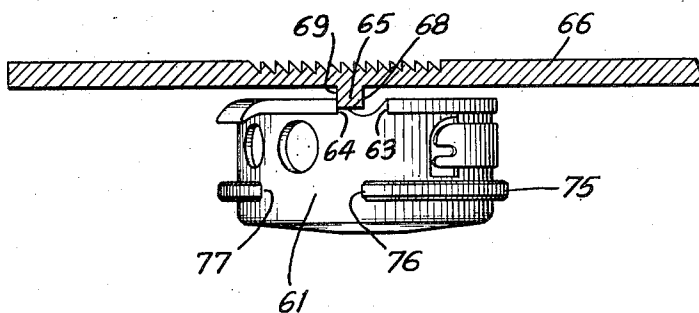


FIG. 12



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FIG.14

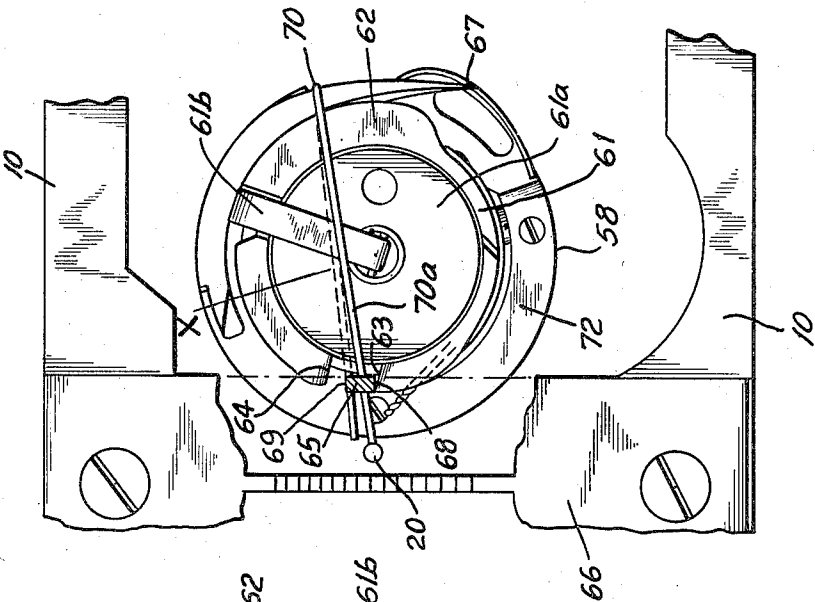
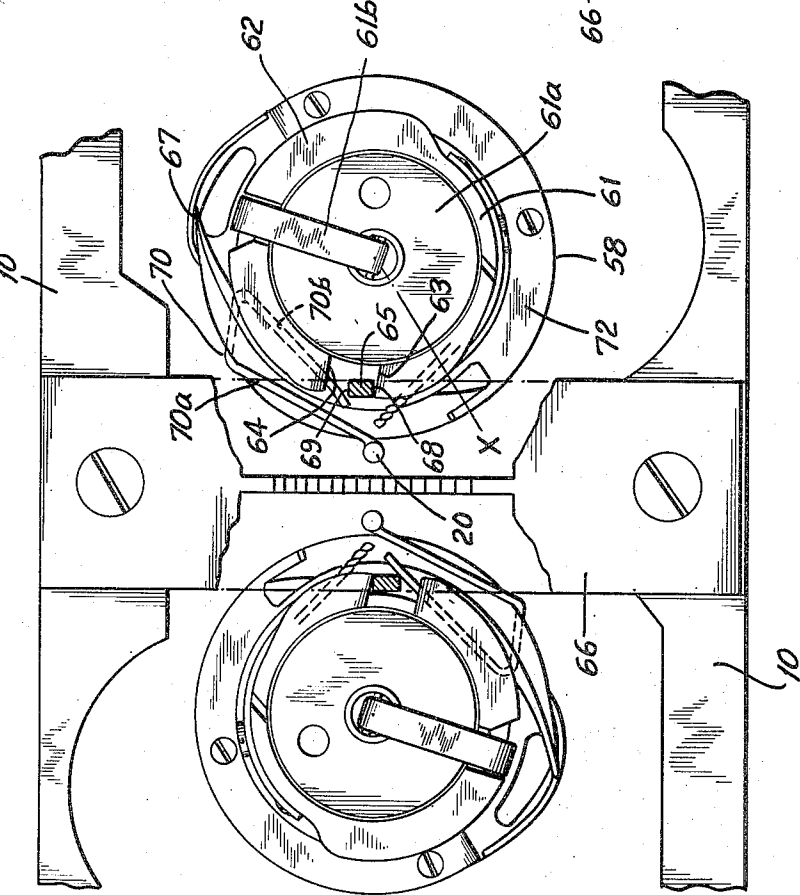


FIG.13



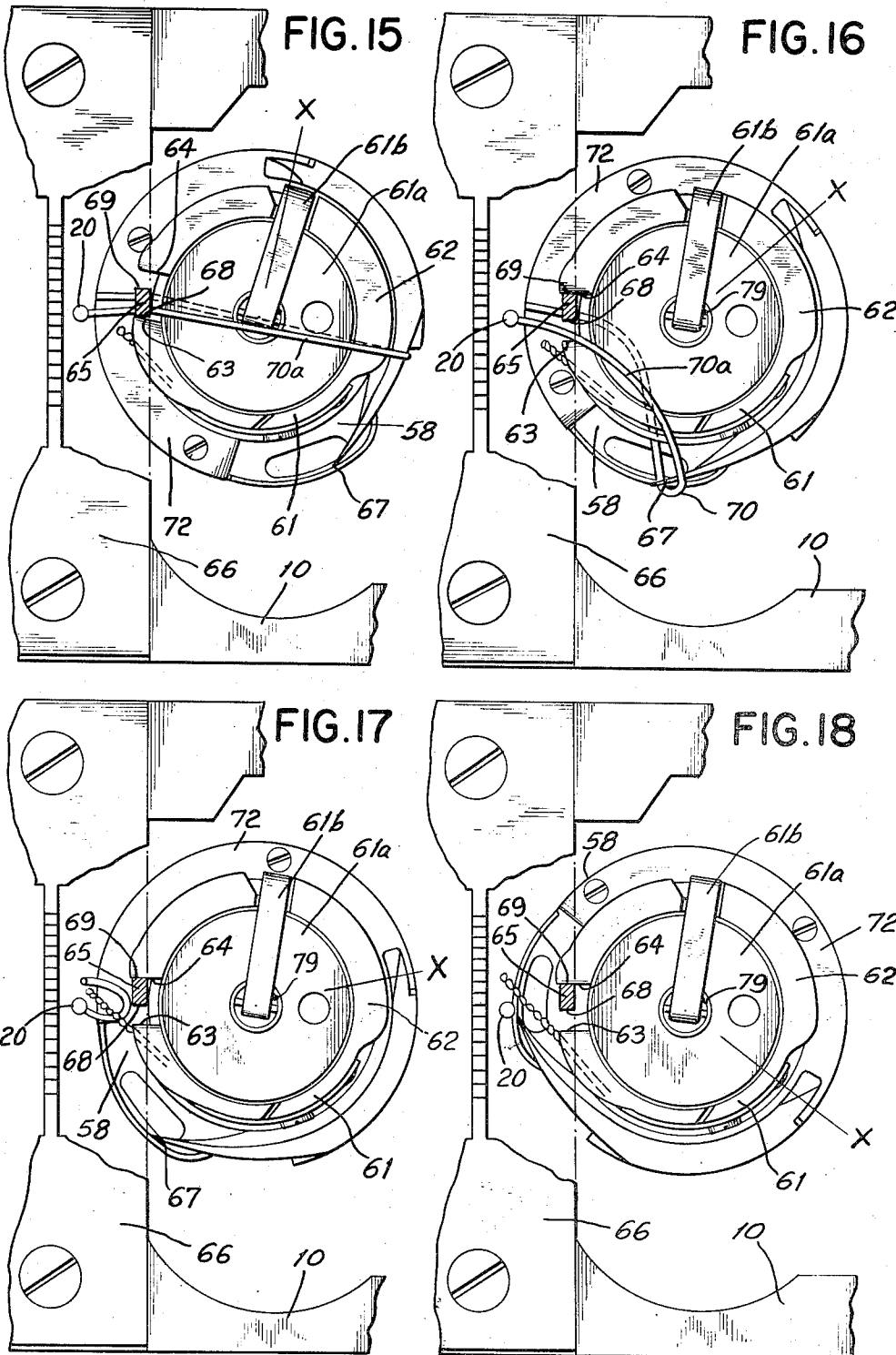
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FIG. 21

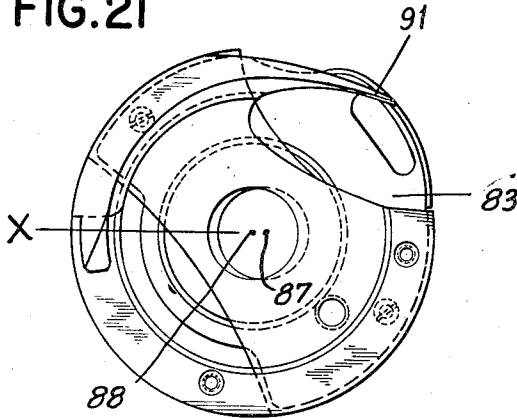


FIG. 20

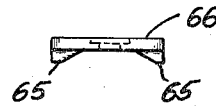


FIG. 19

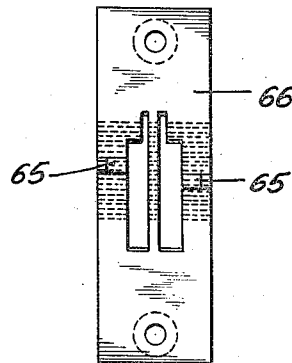


FIG. 22

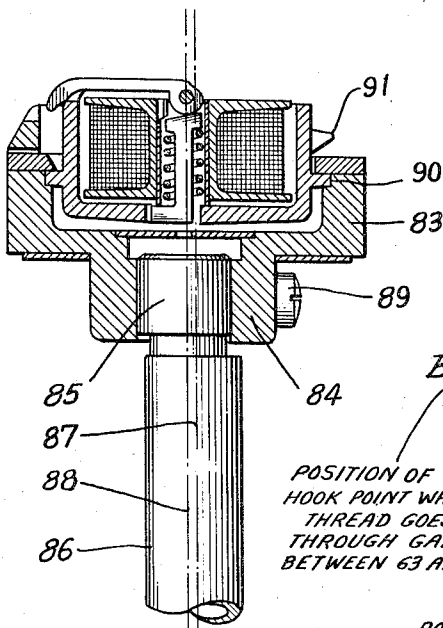
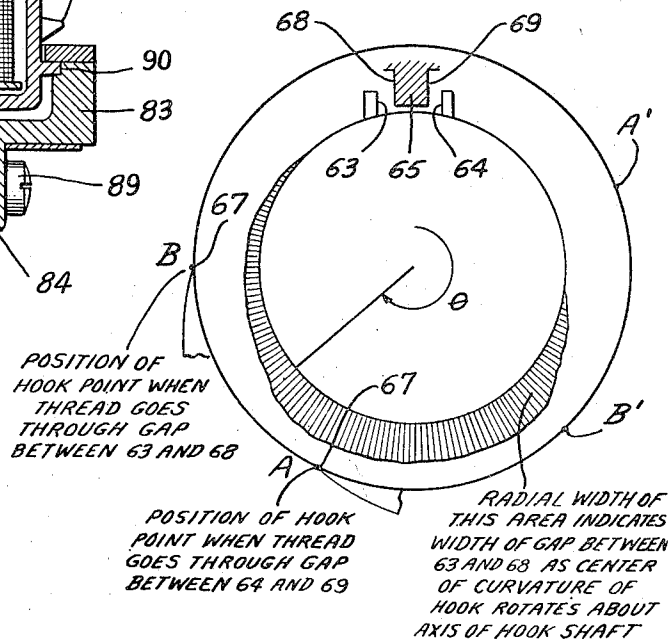


FIG. 23



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FIG. 25

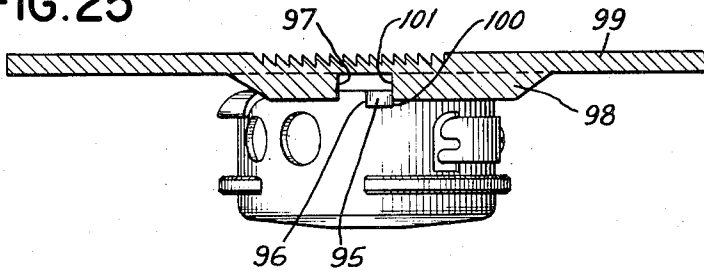


FIG. 24

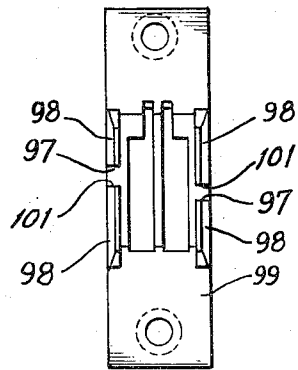
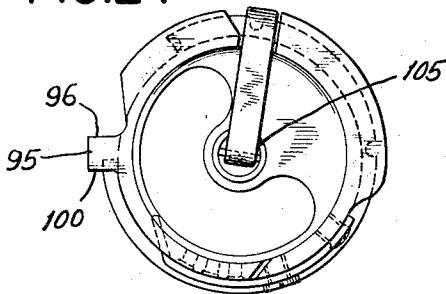
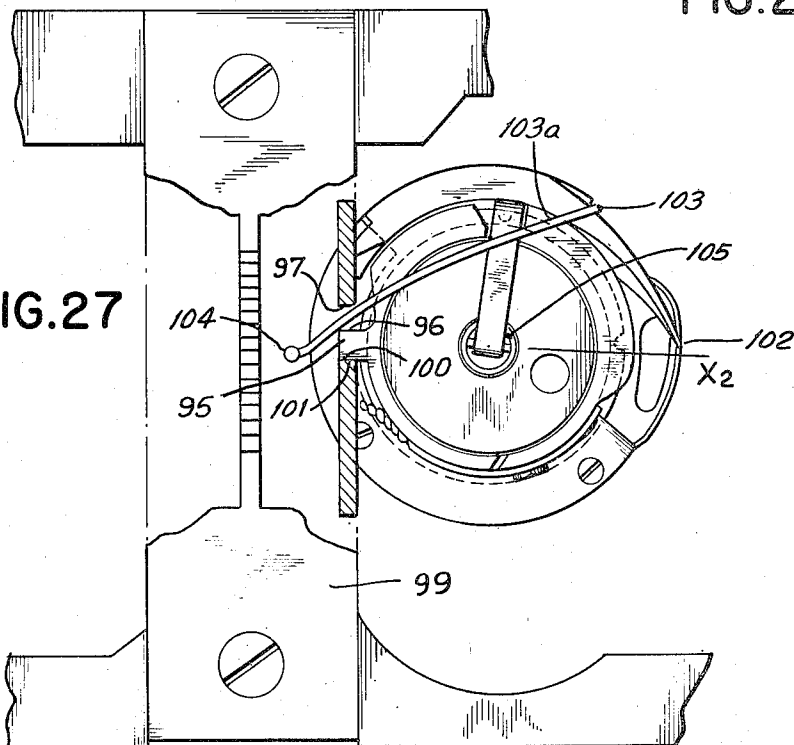


FIG. 26

FIG. 27



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FIG. 29

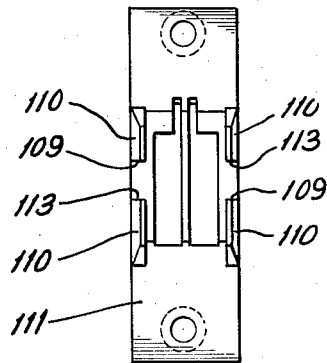
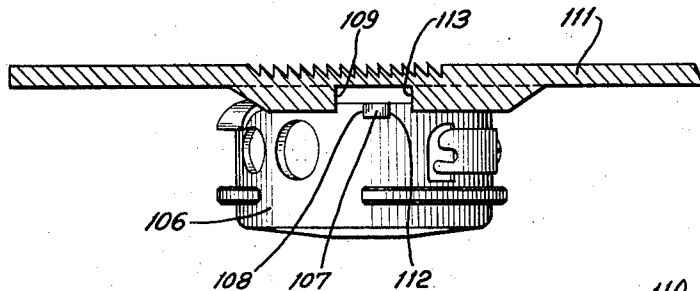


FIG. 28

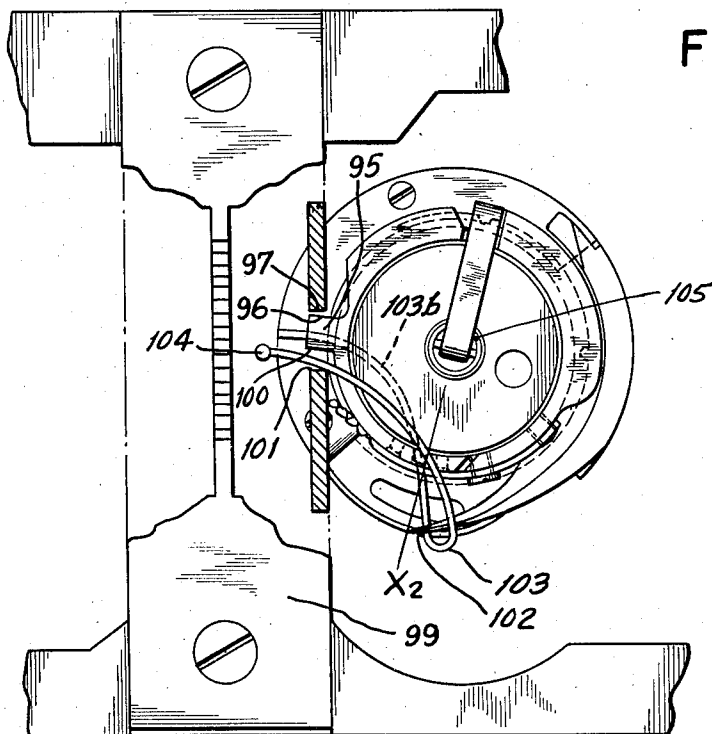


FIG. 30

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FIG. 32

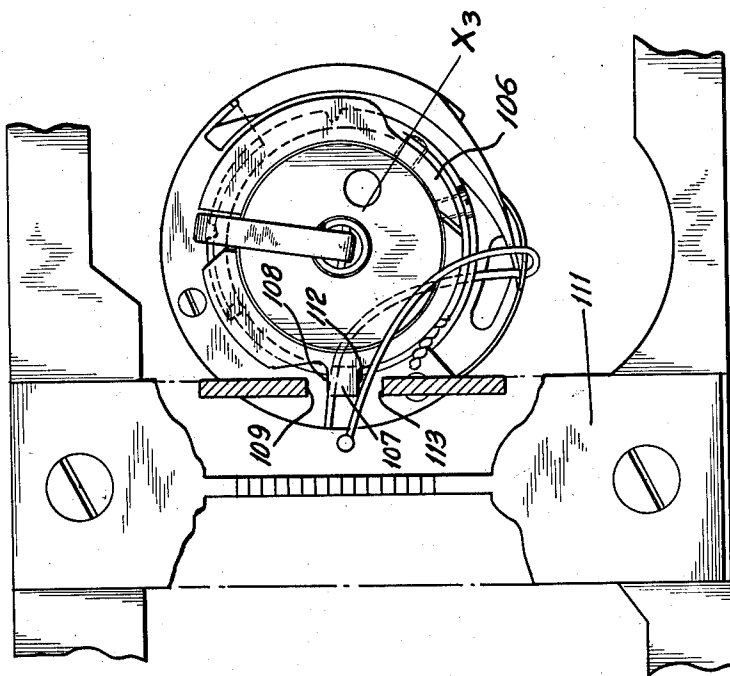
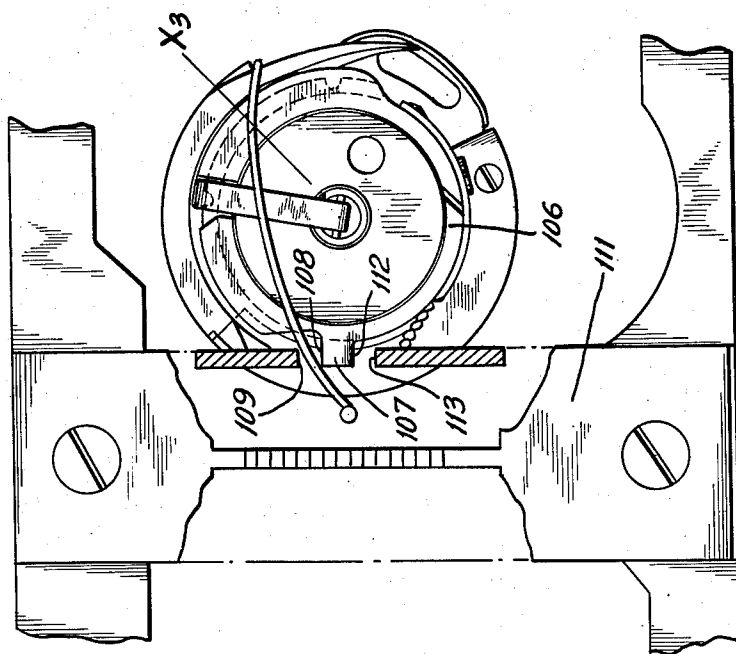


FIG. 31



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LOCKSTITCH SEWING MACHINES

John G. Attwood, Oak Park, Edgar Scholj, Chicago, and Richard G. Palmbach, Lombard, Ill., assignors to Union Special Machine Company, Chicago, Ill., a corporation of Illinois

Application June 15, 1953, Serial No. 361,526

12 Claims. (Cl. 112—181)

This invention relates to lockstitch sewing machines and more particularly to such machines which are provided with rotary hooks arranged for rotation about vertical axes at an angular speed twice that of the main operating shaft.

In machines of the foregoing character the rotary hook has an outer rotating hook body which carries a point or beak adapted to seize the loop of needle thread which is cast into the path of the beak as the needle starts its upward movement from a position in which its point is below the work. This occurs only upon every second revolution of the hook since the needle is above the work throughout one of the revolutions of the hook. Within the rotating body of the hook is a substantially stationary bobbin holder around which a loop of the needle thread is carried by the hook point or beak. Means are provided for restraining the bobbin holder against rotation with the hook body, as a result of the frictional drag of the latter, and such means usually involves a pair of shoulders on the bobbin holder which cooperate with a pair of shoulders on a part fixed to the machine frame, as on the throat plate of the machine. One of the bobbin case shoulders is normally urged against one of the fixed shoulders by the friction between the rotating hook body and the bobbin case which tends to turn the latter in the direction of rotation of the hook. This engagement of the shoulders interferes with the free passage of the thread loop around the bobbin case and its withdrawal from the bobbin case as the thread loop is taken up. It has been the practice heretofore to provide a hook opening device to provide the necessary gap between the normally engaged shoulders to facilitate passage of the thread around the bobbin case. In providing the indicated gap, the hook opening devices have served to bring the other shoulders on the bobbin case and the fixed element into engagement to close the gap normally existing between these and this has necessitated opening of the second gap in time to permit the thread to be passed through it at the appropriate point in the cycle. Such hook opening devices have required the provision of special operating means which have involved the engagement of some member with a projection on the bobbin case to turn the latter, by an external force, against the action of the friction force which tends to turn the bobbin case to close the gap. This has not only resulted in objectionable noise, vibration and wear but has also placed a limit upon the speed of operation of the hook.

A primary object of the present invention has been to so construct a vertical axis rotary hook and its driving means as to bring about the desired hook opening action without the necessity of providing any external, mechanical, operating means therefor.

Another object has been to provide hook opening means of the character indicated which will operate in a manner to enable operation of vertical hook lockstitch machines at higher speeds than have heretofore been attainable due to the limitations of external, mechanical hook opening devices.

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A further object has been to provide a hook opening arrangement of the foregoing type which will not induce or create excessive noise, vibration or wear of the parts.

A still further object has been to provide hook basket retaining means and hook opening means of such character that a gap for the passage of one leg of the needle thread loop is constantly provided between two of the shoulders mentioned and a gap for the same purpose will be provided between the other pair of cooperating shoulders at the proper time in the cycle of rotation of the hook body, without the provision of any external, mechanically operating means to effect such opening of the hook.

An important feature of the invention by which the foregoing objects are achieved is the provision of a raceway in the hook body, for cooperation with the usual rib formation on the bobbin case or basket, which is eccentric to the axis of the shaft that carries and drives the rotary hook member. This eccentricity is so correlated with the location of the thread loop seizing point or beak of the hook as to apply a turning force to the bobbin case or basket, about which the hook rotates, in opposition to, and of sufficient magnitude to overcome the frictional drag on the bobbin case and thus produce the desired hook opening action at the appropriate time in the cycle of the hook. The eccentricity of the hook raceway is great enough to provide the required force, in excess of the friction drag, to produce the hook opening action at the appropriate point in the cycle, with or without the aid of a further feature to be hereinafter mentioned. The eccentricity should not, however, be great enough to produce undue wear of the parts or produce an excessive force in opposition to the friction drag which would tend to delay the return movement of the bobbin case to its normal position into which it is forced by the friction drag.

While we do not wish to be limited by any theory as to why the eccentric disposition of the raceway in the rotating hook body performs the desired hook opening action, it may be accounted for by the fact that the bobbin case behaves initially as a connecting rod in a system in which one end of the rod pivots about a substantially stationary point, provided by the fixed shoulder which retains the case against turning by the frictional drag, while the main body of the case swings about this point due to the eccentricity of the raceway. In this connection it should be noted that the extent of swinging movement of the body of the bobbin case is determined not only by the extent of eccentricity of the raceway but also by the clearance usually provided between the bobbin case and the rotating hook. Thus if the center of the raceway is displaced .01 of an inch from the axis of the hook shaft and the diameter of the hook raceway is .004 of an inch greater than the diameter of the outer edge of the rib formation on the bobbin case, the latter will have its geometrical center shifted to the extent of .012 of an inch to each side of the axis of the hook shaft as the case swings about the pivot provided by the fixed retaining shoulder. The inertia forces created by such swinging of the bobbin case may be readily computed and it will be found that in certain regions of the cycle these inertia forces will oppose the friction drag and exceed the latter in magnitude. Moreover, as the hook tends to open as a result of the inertia forces mentioned, the bobbin case becomes a freely moving body and the resultant of the inertia forces acting upon such a body as a result of the eccentricity of the hook raceway may be computed and found, at certain points in the cycle, to cause continued movement of the shoulder on the bobbin case away from the fixed rotation restraining shoulder. The extent of eccentricity of the raceway required to provide the hook opening action will vary to some extent with the coefficient of friction between the raceway and the cooperating rib of the bobbin case. This

and the magnitude of the hook opening force will vary to some extent with the speed of rotation of the hook body.

The location of the point of maximum eccentricity of the raceway should be varied somewhat in relation to the location of the hook point or beak, depending upon the form of the bobbin case retaining means. This may be of a variety of different forms. For example the bobbin case may be provided with a single projection cooperating with spaced projections or shoulders on the throat plate. Or the throat plate may be provided with a single projection fitting between a pair of projections or shoulders on the bobbin case. Moreover, in accordance with the invention the space between the two projections on either the throat plate or the bobbin case may be relatively wide or relatively narrow. As will be explained, the preferred location of the point of maximum eccentricity of the raceway in relation to the hook point will vary according to the particular form of retaining means employed.

Now, as a further important feature of the invention, it has been found desirable to so form the bobbin case or basket that its center of mass does not coincide with its geometrical center but instead is offset in a predetermined manner from such geometrical center. By geometrical center is meant the center of curvature of the bearing rib of the bobbin holder which rides in the raceway of the hook body. It has been found that when the center of mass of the bobbin case is at a point spaced a suitable distance and in a proper direction from the geometrical center of the case the forces tending to open the hook at the desired time will be greater, for a given extent of eccentricity of the raceway, than if the center of mass of the case coincides with its geometrical center or is displaced therefrom in a different direction. Thus by combining the off-center mass feature with the eccentric raceway feature it is possible to achieve the desired result with certainty at all operating speeds of the sewing machine and through the use of a relatively small amount of eccentricity for the raceway.

More specifically, it has been found desirable to so locate the center of mass of the bobbin case or basket within that sector of the latter which lies between the 90° and the 270° radii from the geometrical center of the case, considering the center line between the basket rotation preventing shoulders as the 0° point. Preferably the center of mass is substantially along the 180° radius or in a sector having a 90° or 120° arc bisected by said radius, and displaced from the geometrical center, i. e. the center of curvature of the bobbin holder rib, by only a small distance, say between $\frac{1}{64}$ " and $\frac{1}{4}$ ", but other locations will provide some of the beneficial results.

With the foregoing objects, features and advantages in view, several illustrative embodiments of the invention will now be described in conjunction with the accompanying drawings, in which:

Fig. 1 is a longitudinal vertical section through a lockstitch sewing machine of the type to which the present invention may be applied;

Fig. 2 is a bottom plan view of the sewing machine;

Fig. 3 is an enlarged top plan view of a portion of the base of the sewing machine with certain cover plates removed to expose the rotary hook units;

Fig. 4 is an enlarged vertical sectional view through one of the hook units and shows the throat plate and a portion of the work feeding devices in relation thereto;

Fig. 5 is a perspective view of one of the rotary hooks and its supporting and driving shaft;

Fig. 6 is a plan view of the rotary hook with the bobbin case removed;

Fig. 7 is a vertical sectional view through the rotary hook;

Fig. 8 is a bottom view of the rotary hook body;

Fig. 9 is a top plan view of the bobbin case;

Fig. 10 is an elevational view of the bobbin case as viewed upwardly in Fig. 9;

Fig. 11 is an elevational view of the bobbin case as seen from the right in Fig. 10;

Fig. 12 is an elevational view of the bobbin case showing its relation to the throat plate, which is shown in section;

Fig. 13 is an enlarged plan view of the two rotary hooks and their relation to the throat plate which is broken away to disclose the hooks completely, the course of the needle thread and the bobbin thread being indicated in relation to each hook;

Figs. 14 to 18 inclusive are views similar to Fig. 13 showing the right hand hook at a number of different positions in the course of a revolution;

Fig. 19 is a bottom plan view of the throat plate;

Fig. 20 is an end view of the throat plate;

Fig. 21 is a plan view of the rotary component of a modified form of hook;

Fig. 22 is a vertical sectional view through the modified hook of Fig. 21, as applied to a supporting and driving shaft;

Fig. 23 is a diagram illustrating schematically the relationship between various parts at different points in a cycle of operation;

Fig. 24 is a top plan view of a modified form of bobbin case;

Fig. 25 is an elevational view of the bobbin case of Fig. 24 showing its relation to a throat plate shown in cross-section;

Fig. 26 is a bottom view of the throat plate of Fig. 25;

Figs. 27 and 28 are top plan views of a rotary hook embodying the bobbin case of Fig. 24, showing its relation to the throat plate at two different points in a cycle of operation;

Fig. 29 is a view similar to Fig. 25 illustrating the bobbin case of Fig. 24 in relation to a different type of throat plate;

Fig. 30 is a bottom plan view of the throat plate of Fig. 29; and

Figs. 31 and 32 are top plan views of a rotary hook carrying the bobbin case of Fig. 24, illustrating its relation to the throat plate of Fig. 30 at two different points in a cycle of operation.

Referring now to the drawings, the invention has been illustrated as applied to a lockstitch machine of the general type disclosed in the patent to Quist, No. 2,329,484, granted September 14, 1943. Certain improvements disclosed in the application of John G. Attwood and Salvatore Lippere, Serial No. 326,498, filed December 17, 1952, are also illustrated.

The machine has a main frame including a work supporting base portion 10, a vertical standard 11, and an overhanging arm 12 carrying at its free end a needle head 13 (Fig. 1). Extending longitudinally of the overhanging arm, and suitably journaled therein, is a rotary shaft 14 which extends through the right end wall of the vertical standard and carries at its outer end a combined handwheel and pulley 15 by which the machine may be driven through a belt extending from any suitable power unit, such as an electric transmitter. Shaft 14 extends into the needle head and is provided therein with a crank member 16 having an eccentrically disposed pin which is connected by means of a link 17 with a pin 18 secured to a needle bar 19 carrying a plurality of needles 20 at its lower end. Upon rotation of the shaft 14 the needle bar 19 will be reciprocated longitudinally within a rock frame 21 having a boss 22 at its upper end pivotally mounted on a pin or stationary shaft 23. Means are provided for rocking the frame 21 in the direction of feed or the line of stitch formation, the arrangement being such that a needle feed action is imparted to the work. For this purpose the frame 21 has a projection 24 which carries a pin 25 providing a pivotal connection for a link 26. At its opposite end the link 26 is pivotally connected with an arm 27 extending downwardly and outwardly from a collar 28 secured to a hollow rock

shaft 29. The latter is suitably journaled in bearings provided in the overhanging arm and in turn carries bearings for the rotary shaft 14 which extends through the hollow shaft. At the right end of the shaft 29 (Fig. 1), which extends into the vertical standard, there is secured by means of a clamp 30 a rock member 31. The latter is arranged to be oscillated by suitable connections from an eccentric 32 secured to the shaft 14. Reference may be had to the above mentioned Quist patent for details as to the form of the connections for oscillating the rock member 31 and the hollow shaft 29 together with the needle bar carrying frame 21.

Secured to the shaft 14 within the vertical standard is a gear 33 which meshes with an idler gear 34 mounted for rotation upon a fixed shaft 35. Gear 34 in turn meshes with a gear 36 mounted on a shaft 37 which extends longitudinally of the base portion of the frame and is suitably journaled therein. Gear 36 is free to turn upon the shaft 37 to a limited extent, but is connected with a disk 38, which is secured to the shaft 37, through spring rods 39. This arrangement, as explained in the Attwood-Lippere application above mentioned, is such as to cause the shafts 14 and 37 to rotate substantially in unison, but vibrations which may be created upon the operation of the machine, and particularly the reciprocation of the needle bar, will be absorbed or damped by the springs 39 and will not be transmitted to the shaft 37.

Shaft 37 has secured thereto a pair of spiral gears 40 and 41 which mesh, respectively, with spiral pinions 42 and 43 carried by hook units 44 and 45, respectively. The relative diameters of the gear 40 and pinion 42, and also gear 41 and pinion 43, are such that the pinions will be driven at twice the angular speed of the shaft 37. Hook unit 44 has a clamping collar 46 by which the unit may be adjustably secured to a bearing sleeve 47 carried by the frame. Similarly the hook unit 45 has a clamping collar 48 by which this unit may be adjustably secured to a bearing sleeve 49 carried by the frame. By proper adjustment of the hook units longitudinally of their bearing supports the spacing between the two lines of stitching formed by the machine may be varied to suit the particular requirements.

Suitable work feeding devices are provided for advancing the work past the stitch forming point. These devices are not fully disclosed herein but include a feed bar 50 which carries a feed dog 51 arranged to be given a four motion movement in the operation of the machine. The feed bar 50 is pivotally connected with an upstanding arm on a rock member 52 secured to a rock shaft 53 mounted in the base of the frame parallel with the shaft 37. Rocking movements are imparted to the shaft 53 by means of a pitman 54 connected at its lower end with an arm secured to the shaft 53 and connected at its upper end to a ball stud carried by the rock member 31. This arrangement is such that any variation of the stitch length, brought about by adjustment of means of the character disclosed in the above mentioned Quist patent, will simultaneously affect the needle feed movement of the needle bar carrier and the work feeding movement of the feed dog. Lifting and lowering movements are imparted to the feed dog by an eccentric, secured to the shaft 37, which cooperates with a strap 55 suitably connected with the feed bar 50.

Referring now to Fig. 4 there is shown, in vertical cross-section, the construction of the hook unit 44. It should be understood that hook unit 45 is of similar construction, except for the reversal of certain parts. The unit 44 is provided with a vertically disposed hollow hook shaft 56 suitably journaled in the bracket or saddle of the unit. Suitable means are provided for delivering lubricant through the bore of the hook shaft 56 from a reservoir 57 to insure adequate lubrication of the relatively rotating parts of the hook unit. Adjacent its upper end there is secured to the hook shaft 56 a rotary hook

body 58 having a hub portion 59 which is mounted on the hook shaft and is secured thereto by one or more set screws 60. Within a cavity in the top of the hook body 58 there is mounted a bobbin holder, such as a basket or case 61, arranged to receive a bobbin 61a which is held in the bobbin holder by means of a spring urged arm 61b. At its top the bobbin holder is provided with a radially extending flange 62 which is cut away at a suitable point to provide spaced shoulders 63 and 64 (Fig. 13). In the space between the shoulders there is disposed a stationary projection 65 (see also Figs. 4 and 12) which projects downwardly from a throat plate 66 carried by the base portion 10 of the machine. As will be apparent, the projection 65 permits limited turning movement of the bobbin holder in relation to the frame of the machine, but prevents any substantial rotation of the bobbin holder along with the rotary hook body. The latter, of course, imparts a frictional drag to the bobbin holder which would tend to turn the latter at substantially the speed of rotation of the hook body, if no means were provided for retaining the bobbin holder against such rotation. Normally this friction drag serves to carry the shoulder 63 on the bobbin holder against a shoulder 68 on the projection 65.

Upon alternate rotations of the hook body the thread seizing point 67 thereof will serve to pick up a loop of needle thread which is cast outwardly toward the rotary hook as the needle starts its upward movement. This occurs just before the hook point reaches the path of reciprocation of the needle. It will be understood that during one revolution of the hook the needle will be above the work and therefore the rotation of the hook will be an idle one. However, on the next revolution of the hook the needle will be below the work and will be starting upwardly at the time the hook point is brought adjacent the needle. At this time a loop 70 of the needle thread will be caught upon the hook and will be carried through the successive positions indicated in Figs. 13 to 18 inclusive. At the outset, as indicated in Fig. 13, the leg 70a of the needle thread loop, which extends from the eye of the needle, passes around the under surface of the hook point but in the course of rotation of the latter this leg of the needle thread will be carried over the upper surface of the bobbin case while the other leg 70b of the needle thread loop, which extends from the last stitch formed in the work, will be carried beneath the bobbin holder and across its under surface. After the needle thread loop has been seized by the hook point the needle is rather quickly raised to a point above the work so that a slightly upward pull is exerted on the leg 70a of the loop toward the needle opening in the feed dog.

As the hook point reaches the position indicated in Fig. 14, or a position even slightly in advance of that, i. e. when the hook point is substantially diametrically opposite the path of the needle, the leg 70a of the needle thread loop passes downwardly through the gap between the shoulder 64 of the bobbin holder and the shoulder 69 on the projection 65. Then, as indicated, it passes along the under surface of the projection 65 as the hook continues its rotation. The form of projection 65 is such as to facilitate such passage of the thread. When the hook point reaches the position indicated in Fig. 15, i. e. about 270° from the position in which it first began to seize the needle thread loop, the leg 70a of this loop is drawn upwardly through the gap provided between the shoulders 63 and 68. To enable this to be done it is necessary to turn the bobbin holder counter to the direction of rotation of the hook body. Heretofore this has been accomplished by external means acting upon a projection on the bobbin holder to force the latter positively and mechanically counter to the friction drag.

In accordance with the present invention, the need for such external mechanical hook opening means is eliminated through the provision of an eccentric raceway in the hook body, and in the preferred embodiment of the

invention the opening action is more definitely assured under all conditions of operation, by the off-center disposition of the center of mass of the bobbin case in relation to the center of curvature of the rib on this element.

Referring to Figs. 6 to 12 inclusive, it will be noted that the hook body is provided with a raceway 71 formed between a circumferentially extending shoulder formed in the hook body itself and a half annular retaining member 72 at the top of the hook body. A portion of the top of the hook raceway is closed by an inwardly extending flange on the hook body itself. The raceway extends over an arc of about 270° from a point 73 (Fig. 6) to a point 74. Over an arc of about 90° in the region of the hook point, the wall of the hook body is cut away so that there is no raceway in this region. Cooperating with the raceway is a bearing rib 75 formed on the bobbin holder, this rib extending around most of the periphery of the bobbin holder but being broken away over an arc of about 60° from a point 76 (Fig. 9) to a point 77. This cut-away portion of the rib facilitates the passage of the needle thread loop around the bobbin holder and its release from the latter at the proper time.

As one simple way of providing the desired eccentricity between the raceway 71 and the axis of the hook shaft 56, the opening through the hub and the bottom of the hook body which receives the upper end of the hook shaft is formed off-center, as best indicated in Fig. 7. The hook body is clamped to the hook shaft by means of one or more set screws 60. Preferably, in this construction, the center of curvature of the raceway 71 is offset from the axis of the shaft 56 in a direction from the latter which is approximately 135° in back of the line extending from said axis to the hook point 67. Thus, in each of Figs. 13 to 18, inclusive, the center of curvature of the hook raceway is displaced from the axis of the hook shaft in the direction of the line designated X. While, as stated, this is the preferred location of the center of curvature of the hook raceway, it has been found that a hook having a single, stationary retaining projection (such as 65) and a pair of spaced shoulders (such as 63 and 64) on the bobbin holder will automatically provide the desired gaps at the appropriate times on the opposite sides of the projection 65, to permit the passage of the needle thread loop in the manner explained, so long as a straight line extending from the axis of the hook shaft through the center of curvature of the raceway crosses the periphery of the hook body at a point between 90° and 135° back of the hook point. Under certain conditions, such as high speed operation and low coefficient of friction between the hook body and the bobbin holder, the line indicated may cross the periphery of the hook body at any point between 75° and 150° back of the hook point.

The action of the inertia forces on the bobbin holder during a revolution of the hook body is graphically illustrated in Fig. 23. This is based upon computations of the character above mentioned in which the coefficient of friction between the raceway and bearing rib is assumed to be .3 and the eccentricity of the raceway .010". Actual observations made with the aid of a stroboscope bear out the reliability of the calculations.

In Fig. 23 the radial lines of the shaded area indicate the extent to which the gap between shoulders 63 and 64 will be opened as the line extending from the axis of the hook shaft through the center of curvature of the hook raceway passes successively from one position to another around the circle. Thus when the indicated line is at an angle θ to the radial line passing through the center of the projection 65 the gap specified will be of a width equal to the distance between the ends of the two arrows at that position. When the indicated line is passing through an arc extending from a point about 45° rearwardly of the center line of projection 65 to a point about 100° forwardly of said center line, the shoulders 63 and 64 will be in engagement while the gap between shoulders 64 and 69 will be at a maximum. When the hook point

67 reaches position A the leg 70a of the needle thread loop should be able to pass through the gap between shoulders 64 and 69; when the hook point reaches position B the thread loop should be able to pass between shoulders 63 and 68. In this connection it should be noted that it is not essential that a gap actually be provided between shoulders 63 and 68 for this purpose so long as the force with which they are urged together is sufficiently small to enable the thread loop to be drawn readily upwardly between them without breakage of the thread. However, it is preferable to provide a gap between these shoulders at this time and to close the opposite gap to avoid having the thread loop improperly caught upon the projection 65. According to the preferred construction described above the line of eccentricity specified will fall at position A' when the hook point is at A, and it will fall at position B' when the hook point is at B.

To insure adequate lubrication of that portion of the hook raceway which receives the greatest wear, the lubricant which is forced upwardly through the bore of the hollow hook shaft is delivered to the raceway through a duct or passage 58a (Fig. 8) in the hook body which extends radially outwardly from the top of the hook shaft in a direction substantially coinciding with the line extending from the axis of the hook shaft through the center of curvature of the hook raceway. It will be appreciated that in the operation of the hook, the bearing rib of the bobbin retainer will be constantly urged against the hook raceway in the direction indicated. In order to insure complete lubrication of the raceway, a further duct or passage 58b may be provided to deliver lubricant to a point adjacent the beginning of the raceway, i. e. adjacent the base of the thread seizing beak.

Preferably the eccentricity of the hook raceway in relation to the axis of the hook shaft is about .010 of an inch. The extent of such eccentricity may, however, be varied. It has been found that eccentricities of between .005 and .015 of an inch will serve to produce the desired result. The smaller eccentricities may be used effectively, especially when the center of mass of the bobbin holder is appropriately displaced from its geometric center. In fact, with the appropriate location of the center of mass of the bobbin holder, the eccentricity of the hook raceway may even be somewhat less than .005 of an inch.

As mentioned in the foregoing, the clearance provided between the hook raceway and the periphery of the rib on the bobbin holder serves to augment the effect of the eccentricity of the raceway itself. Thus, if an overall clearance along a diameter of the hook raceway is .004 of an inch, and the eccentricity of the raceway is .010 of an inch, the inertia forces set up, which tend to turn the bobbin holder counter to the frictional drag of the hook body at certain points in a cycle of operation, are equal to those which would be set up by a raceway having an eccentricity of .012 of an inch with no measurable clearance between the raceway and rib. This, as has been explained, may be established by computations based upon the consideration of the bobbin holder as a connecting rod in a crank and pitman linkage. As a practical matter the indicated clearance should be only sufficient to provide a good hearing relationship between the raceway and rib. Excessive clearance leads to undue noise and vibration and lack of uniformity in the stitch formation.

Turning now to the off-center location of the center of mass of the bobbin holder, it should be understood that we have reference to the displacement of the center of mass from the geometrical center of the bobbin holder. By the geometrical center of the bobbin holder, we have reference to the center of curvature of the periphery of the rib which cooperates with the hook raceway. A suitable location of the center of mass is indicated by the dot 79 in Fig. 9. The geometrical center, or center of curvature of the bobbin holder rib, is indicated at 80.

It will thus be seen that the center of mass is displaced from the geometrical center of the bobbin holder in the opposite direction from the shoulder 63 on the bobbin holder flange. While the extent of displacement may be varied from about $\frac{1}{64}$ inch to $\frac{1}{4}$ inch, it is preferably about $\frac{1}{8}$ of an inch. Moreover, while the direction of displacement is preferably along a line extending through the shoulder 63 and the geometrical center 80, very good results may be obtained so long as it is located in a 90° sector of the bobbin holder, on the opposite side of the same from said shoulder, which is bisected by the indicated line. In fact, some assistance in providing the desired hook opening action will be obtained if the center of mass is located at any point within the sector of the bobbin holder extending from 90° to 270° from the line passing through the shoulder 63 and the geometrical center 80.

Various expedients may be employed to shift the center of mass of the bobbin holder to the desired point. For example, extra metal providing a mass 81 along the periphery of the bobbin holder over a suitable arc may be provided. Inserts formed of a heavy metal, such as lead, may be provided at appropriate points along the periphery of the bobbin holder for the same purpose. Also, the bottom of the bobbin holder, which is normally of symmetrical form, may be largely cut away in a certain area and left intact only in a restricted area, such as that designated 82 in Fig. 9. Other expedients may be employed for lightening the bobbin holder on the side thereof toward the shoulder 63. Thus, holes or openings of any suitable character may be provided in the side wall of the bobbin holder in the region adjacent to shoulder 63. When it is desired to shift the center of mass to a relatively great extent from the geometrical center of the bobbin holder, a number of the foregoing expedients may be employed in combination. Thus, the one side of the bobbin case may be provided with greater weight than usual and the opposite side may be made lighter than usual. In general it is desirable to keep the overall weight of the bobbin holder relatively small so that expedients which accomplish this, and at the same time serve to shift the center of mass in the manner indicated, are preferred.

When a bobbin is inserted in the bobbin case or holder it tends to shift the center of mass of the two substantially stationary members back toward the geometric center of the bobbin holder, and this effect is greater when the bobbin is full than when it is nearly empty. But the bobbin is so much lighter than the bobbin case that this effect is only slight.

In Figs. 21 and 22 there is illustrated a modification in which the eccentricity of the hook raceway is made adjustable in location in relation to the thread loop seizing point of the hook body. This arrangement is particularly desirable for experimental machines to be used in determining the most desirable location of the hook point in relation to the eccentricity of the hook raceway. It is also advantageous in the construction of a number of machines which are basically the same but some of which are provided with one style of hook and bobbin case retainer and others of which are provided with other styles of hooks and bobbin case retainers.

In the construction illustrated in Figs. 21 and 22, the main hook body 83 is provided with a hub 84 having an opening therethrough which is concentric with the raceway and other portions of the hook body. The opening in the hub 84 is fitted upon an eccentric portion 85 at the upper end of a hook shaft 86. The extent of eccentricity of the portion 85 in relation to the main axis of the hook shaft may be of any desired amount, preferably between .005 and .015 of an inch. In Fig. 22 the extent of eccentricity is indicated, on an exaggerated scale, as the distance between the lines 87 and 88, which represent, respectively, the axis of the hook shaft and the axis of the

eccentric portion 85. Now it will be apparent that upon rotation of the hook shaft, the raceway of the hook body, which is concentric with the axis 88, will partake of an eccentric movement similar to that of the raceway 71 in Fig. 7. The center of curvature of the raceway will move in a small circle about the axis of the hook shaft. The location of the center of curvature of the raceway in relation to the hook point 91, may be varied to any extent desired by simply turning the hook body on the eccentric portion 85 of the hook shaft and then tightening the set screw 89, to retain the hook body in such set position. If this is done with the parts assembled in the machine, the driving pinion (such as 42 of Fig. 4) should be loosened, as well as the set screw 89 so that the hook shaft may be turned relative to both the pinion and the hook body. This will avoid throwing out the timing of the stitch forming devices. By appropriate adjustment, the hook point 91 may be directly aligned with the line passing through the axes 87 and 88 of the hook shaft and eccentric portion 85, respectively, or it may be disposed at any desired angle in relation to such line.

Another manner in which the eccentric raceway may be provided in the hook body is by appropriate machining and grinding operations which serve to form the raceway eccentrically within a hook body of otherwise conventional construction mounted upon a completely concentric shaft. However, one disadvantage of this mode of providing the desired eccentricity of the raceway is that it may remove more metal than is desirable at certain points around the wall of the hook body. Even in the construction of Fig. 7 the final grinding of the raceway is preferably performed after the eccentrically disposed opening through the hub 59 is formed, but only a small amount of metal will be removed at this time and it will be taken substantially uniformly around the circumference of the raceway.

Referring now to Figs. 24 through 28 inclusive, a modified construction is shown, which differs from the embodiment above described primarily in the form and relationship of the bobbin holder retaining means. The bobbin holder in the modified construction is provided with a projection 95 on the top flange portion thereof. This projection has a forwardly facing shoulder 96 arranged to cooperate with a shoulder 97 provided on a downwardly extending flange 98 of a throat plate 99. A rearwardly facing shoulder 100 on the projection 95 is arranged to cooperate with another shoulder 101 provided on the flange 98. Normally, the shoulder 96 will be urged into engagement with the shoulder 97 by the frictional drag of the rotary hook body. However, by the provision of an eccentric hook raceway in any of the ways described above, with or without the displacement of the center of mass of the bobbin holder from its geometric center, inertia forces will be set-up upon each revolution of the hook body to cause turning of the bobbin holder counter to the forces of the frictional drag.

An important difference between the modified construction and the first embodiment described, is in the necessity of opening the hook to provide a gap between the shoulders 96 and 97 more promptly after the point 102 of the hook has seized the needle thread loop 103. As shown in Fig. 27, the desired gap between the shoulders 96 and 97 should be present at least by the time the hook point reaches a position diametrically opposite the projection 95, so that the leg 103a of the needle thread loop may be drawn upwardly through the gap and then passed over the top surface of the projection 95. By the time the hook point reaches the position indicated in Fig. 28, i. e., about 270° from the projection 95, it is necessary that the gap between shoulders 96 and 97 be closed and the gap between shoulders 100 and 101 be opened to permit the loop 103 to be drawn through this second gap. This calls for a different timing for the action of the inertia

forces, and consequently makes desirable a different relationship between the hook point and the line extending through the axis of the hook shaft and the center of curvature of the raceway. As indicated in Fig. 27, the preferred location of this line is in the direction of the line X_2 . However, since this is directly in line with the hook point, and since the raceway does not extend through this region of the hook body, it is preferable to locate the center of the raceway at a different point. As we have previously indicated, the bobbin holder is constantly urged in the direction of the line extending from the axis of the hook shaft through the center of curvature of the raceway. That line should pass through a point where the raceway actually exists to provide a good bearing relation with the rib of the bobbin case.

From a computation of the inertia forces in the manner explained in connection with the first embodiment, and from stroboscopic observations, it appears that the point on the raceway through which the indicated line of eccentricity passes should be between 30° back of the hook point and 45° forward of the hook point. To avoid excessive wear of the hook raceway, it is therefore desirable to so locate the center of curvature of the raceway that the indicated line will pass about 45° forward of the hook point. Under certain conditions, such as high speed operations, low coefficient of friction between the raceway and bearing rib of the bobbin holder, and proper location of the center of mass of the bobbin holder, the indicated line of eccentricity may intersect the raceway at a somewhat greater distance forward of the hook point, or a somewhat greater distance in back of the hook point, say as much as 45° back of the hook point or as much as 60° forward of it.

It should be noted in connection with the embodiment of Figs. 24 to 28 inclusive, that the diagram of Fig. 23 is largely applicable to this as well as to the first embodiment. The shaded area in that diagram serves to indicate the extent of opening of the hook as the center of curvature of the raceway sweeps through its circular path about the axis of the hook shaft. However, the projection 95 is normally urged by the frictional drag against the shoulder 97 so that the opening action indicated by the shade lines represents the gap provided between the shoulders 96 and 97. This gap, as we have indicated, must be provided as the hook point reaches position A in the diagram. That gap is preferably closed to insure easy passage of the thread loop through the other gap, i. e. between shoulders 100 and 101, which is opened as the hook point reaches the position B.

Referring now to Figs. 29 to 32 inclusive of the drawings, there is illustrated a further modification which differs from that of Figs. 24 to 28 inclusive merely in the provision of a relatively wide space between the bobbin basket retaining shoulders on the throat plate. Thus, basket 106 is provided with a projection 107 on the top flange and is in other respects also of the same construction as the basket illustrated in Fig. 25. A shoulder 108 on projection 107 is normally urged by the frictional drag of the hook body against a shoulder 109 on a downwardly extending flange 110 of throat plate 111.

The hook raceway in this construction is eccentric to the axis of the hook shaft as in the earlier embodiments, and the direction of eccentricity in relation to the hook point may be the same as for the construction of Figs. 24 to 28 inclusive. However, due to the wider spacing of the shoulders cooperating with the projection 107, a somewhat greater variation is permissible in the direction of eccentricity in relation to the hook point. It may readily be located anywhere between 60° back of the hook point and 45° forward of the hook point, and under certain conditions may be disposed at a somewhat greater angle either in back of or forwardly of the hook point. The arrangement, must, of course, be such as to provide an opening action forming a gap between

the shoulders 108 and 109 as the hook point reaches the position indicated in Fig. 31. At this time, however, the opposite gap provided between shoulder 112 on the projection 107 and a shoulder 113 on the throat plate will not be closed. The projection 107 will assume an intermediate position as indicated in Figs. 29 and 31. As a result of this, it is not essential that the gap between the shoulders 108 and 109 be closed when the hook point reaches the position indicated in Fig. 32 since a gap is always provided between shoulders 112 and 113. It is because of this relationship that a somewhat greater latitude is permissible in the location of the center of curvature of the hook raceway in relation to the hook point.

Again in connection with the embodiment of Figs. 29 to 32 inclusive, the diagram of Fig. 23 is pertinent since the shaded area of that diagram illustrates the extent of opening of the gap between shoulders 108 and 109 at the various points in the path of movement of the center of curvature of the hook raceway.

It will be understood that the machines embodying the novel features described above will be provided with the usual auxiliary devices such as thread supplying and controlling means. Preferably an oscillating take-up of the well known type disclosed within the needle head 13 in Fig. 1 will be provided for taking up the needle thread after it has been passed around the bobbin holder. It is the take-up which serves to draw the needle thread loop off of the hook point and through the second gap of the bobbin holder retaining means at the times explained in the foregoing. If desired, a rotary take-up of the character disclosed in the patent to N. V. Christensen No. 2,453,119 granted November 9, 1948 may be provided in lieu of an oscillating take-up for taking up the needle thread.

The principle of operation of the construction illustrated in Figs. 29 to 32, inclusive, may, if desired, be applied also to the form of basket retaining means disclosed in Figs. 13 to 18, inclusive. Thus the spacing between the shoulders 63 and 64 may be made considerably greater than illustrated so that when the hook opening action takes place to carry the shoulder 63 away from shoulder 68 a gap will still remain between shoulder 64 and shoulder 69. As will be seen from Fig. 23, this permits location of the direction of eccentricity of the raceway anywhere between 45° and 135° , or even a somewhat wider range, back of the hook point. It is necessary only to insure a gap or substantial relief of pressure between the shoulders 63 and 68 as the hook point reaches position B.

In fact, it is not essential that the shoulder 64 be provided at all, and in like manner it is not essential that the shoulder 113 be provided in the embodiment of Figs. 29 to 32 inclusive. These shoulders are not active in the normal operation of the machine. However, their presence is desirable from the standpoint of insuring proper positioning of the bobbin basket or holder in the course of applying the throat plate to the machine.

In connection with all of the forms of the invention, it should be observed that the forces tending to close the hook are greater than those tending to open it. This is because of the fact that the frictional drag of the hook body is constantly acting, and it is sometimes augmented by the inertia forces and at other times opposed by these forces. The hook opening action is provided only by the excess of the inertia forces over the frictional drag when these are working in opposite directions.

While several embodiments of the invention have been described in considerable detail it will be understood that other changes may be made without departing from the general principles and scope of the invention as defined by the appended claims.

What is claimed is:

1. In a lockstitch sewing machine having a frame and a main drive shaft journaled in said frame, a vertically

disposed hook shaft carried by said frame and connections from said drive shaft for imparting two revolutions to said hook shaft upon each revolution of said drive shaft, the combination which comprises a rotary hook body secured to said hook shaft, a bobbin holder mounted in said hook body, said bobbin holder having a circumferentially extending rib, said hook body having a raceway arranged to receive said rib in bearing relation, and means comprising a shoulder on said bobbin holder and a shoulder carried by said frame for arresting said bobbin holder against rotation in response to the frictional drag of said hook body, said raceway being disposed eccentrically in relation to the axis of said hook shaft, the center of mass of said bobbin holder being displaced from the center of curvature of the ribs thereon into that sector of the bobbin holder which extends from 90° to 270° from the radial line connecting said center of curvature with said shoulder on the bobbin holder, the eccentricity of said raceway, its direction in relation to the axis of the hook shaft and said displacement of said center of mass being such that inertia forces are set up which directly of themselves apply a turning moment to said bobbin holder and cause said bobbin holder to turn counter to the frictional drag thereon of said hook body during a predetermined portion of each revolution of the hook body.

2. In a lockstitch sewing machine having a frame and a main drive shaft journaled in said frame, a vertically disposed hook shaft carried by said frame and connections from said drive shaft for imparting two revolutions to said hook shaft upon each revolution of said drive shaft, the combination which comprises a rotary hook body secured to said hook shaft, a bobbin holder mounted in said hook body, said bobbin holder having a circumferentially extending rib, said hook body having a raceway arranged to receive said rib in bearing relation, and means comprising a shoulder on said bobbin holder and a shoulder carried by said frame for arresting said bobbin holder against rotation in response to the frictional drag of said hook body, said raceway being disposed eccentrically in relation to the axis of said hook shaft, the center of mass of said bobbin holder being displaced from the center of curvature of the ribs thereon into that sector of the bobbin holder which extends from 90° to 270° from the radial line connecting said center of curvature with said shoulder on the bobbin holder, the center of curvature of said raceway being displaced between .005" and .015" from the axis of said hook shaft, and said center of mass being displaced between $\frac{1}{64}$ " and $\frac{1}{4}$ " from said center of curvature of the bobbin holder rib, the arrangement being such that inertia forces are set up which directly of themselves cause said bobbin holder to turn counter to the frictional drag thereon of said hook body during a predetermined portion of each revolution of the hook body.

3. In a lockstitch sewing machine having a frame and a main drive shaft journaled in said frame, a vertically disposed hook shaft carried by said frame and connections from said drive shaft for imparting two revolutions to said hook shaft upon each revolution of said drive shaft, the combination which comprises a rotary hook body secured to said hook shaft, a bobbin holder mounted in said hook body, said bobbin holder having a circumferentially extending rib, said hook body having a raceway arranged to receive said rib in bearing relation, and means comprising a shoulder on said bobbin holder and a shoulder carried by said frame for arresting said bobbin holder against rotation in response to the frictional drag of said hook body, said raceway being disposed eccentrically in relation to the axis of said hook shaft, the center of mass of said bobbin holder being displaced from the center of curvature of the ribs thereon into that sector of the bobbin holder which extends from 120° to 240° from the radial line connecting said center of

curvature with said shoulder on the bobbin holder, the eccentricity of said raceway, its direction in relation to the axis of the hook shaft and said displacement of said center of mass being such that inertia forces are set up which directly of themselves apply a turning moment to said bobbin holder and cause said bobbin holder to turn counter to the frictional drag thereon of said hook body during a predetermined portion of each revolution of the hook body and while said bobbin is in contact only with said hook body.

4. In a lockstitch sewing machine having a frame and a main drive shaft journaled in said frame, a vertically disposed hook shaft carried by said frame and connections from said drive shaft for imparting two revolutions to said hook shaft upon each revolution of said drive shaft, the combination which comprises a rotary hook body secured to said hook shaft, a reciprocating thread carrying needle cooperating with said hook, said hook body having a point thereon arranged to seize a loop of thread from said needle, a bobbin holder mounted in said hook body, said bobbin holder having a circumferentially extending rib, said hook body having a raceway arranged to receive said rib in bearing relation, and means comprising a shoulder on said bobbin holder and a shoulder carried by said frame for arresting said bobbin holder against rotation in response to the frictional drag of said hook body, said raceway being arranged eccentrically to a predetermined extent in relation to the axis of said hook shaft, and said bobbin holder having its center of mass disposed at a point removed from the center of curvature of the rib of said bobbin holder between $\frac{1}{64}$ " and $\frac{1}{4}$ " in a sector of said holder extending from 90° to 270° from the radial line passing through the shoulder on said bobbin holder to the center of curvature of the rib thereon, the arrangement being such that inertia forces are set up which directly of themselves cause said bobbin holder to turn counter to the frictional drag thereon of said hook body during a predetermined portion of each revolution of the hook body.

5. In a sewing machine having a frame, a drive shaft journaled in said frame, a hook shaft carried by said frame, and connections from said drive shaft for rotating said hook shaft, the combination which comprises a rotary hook body secured to said hook shaft, a bobbin holder mounted in said hook body, said bobbin holder having a circumferentially extending rib, said hook body having a raceway arranged to receive said rib in bearing relation, and means comprising a shoulder on said bobbin holder and a shoulder carried by said frame for arresting said bobbin holder against rotation in response to the frictional drag of said hook body, said raceway being disposed eccentrically in relation to the axis of said hook shaft, the center of mass of said bobbin holder being displaced from the center of curvature of the ribs thereon into that sector of the bobbin holder which extends from 90° to 270° from the radial line connecting said center of curvature with said shoulder on the bobbin holder, the center of curvature of said raceway being displaced between .005" and .015" from the axis of said hook shaft, and said center of mass being displaced between $\frac{1}{64}$ " and $\frac{1}{4}$ " from said center of curvature of the bobbin holder rib, the arrangement being such that inertia forces are set up which directly of themselves cause said bobbin holder to turn counter to the frictional drag thereon of said hook body during a portion of each revolution of the hook body.

6. In a sewing machine having a frame, a drive shaft journaled in said frame, a hook shaft carried by said frame, and connections from said drive shaft for rotating said hook shaft, the combination which comprises a rotary hook body secured to said hook shaft, a reciprocating thread carrying needle cooperating with said hook, said hook body having a point thereon arranged to seize a loop of thread from said needle, a bobbin holder

mounted in said hook body, said bobbin holder having a circumferentially extending rib, said hook body having a raceway arranged to receive said rib in bearing relation, and means comprising a shoulder on said bobbin holder and a shoulder carried by said frame for arresting said bobbin holder against rotation in response to the frictional drag of said hook body, said raceway being arranged eccentrically in relation to the axis of said hook shaft, the eccentricity of said raceway in relation to said shaft axis being between .005" and .015", and said bobbin holder having its center of mass disposed at a point removed from the center of curvature of the rib of said bobbin holder in a sector of said holder extending from 90° to 270° from the radial line passing through the shoulder on said bobbin holder to the center of curvature of the rib thereon, the arrangement being such that inertia forces are set up which directly of themselves cause said bobbin holder to turn counter to the frictional drag thereon of said hook body during a portion of each revolution of the hook body.

7. In a sewing machine having a frame, a drive shaft journaled in said frame, a hook shaft carried by said frame, and connections from said drive shaft for rotating said hook shaft, the combination which comprises a rotary hook body secured to said hook shaft, a reciprocatory thread carrying needle cooperating with said hook, said hook body having a point thereon arranged to seize a loop of thread from said needle, a bobbin holder mounted in said hook body, said bobbin holder having a circumferentially extending rib, said hook body having a raceway arranged to receive said rib in bearing relation, and means comprising a shoulder on said bobbin holder and a shoulder carried by said frame for arresting said bobbin holder against rotation in response to the friction drag of said hook body, said raceway being arranged eccentrically to a predetermined extent in relation to the axis of said hook shaft, and said bobbin holder having its center of mass disposed at a point removed from the center of curvature of the rib of said bobbin holder between $\frac{1}{64}$ " and $\frac{1}{4}$ " in a sector of said holder extending from 90° to 270° from the radial line passing through the shoulder on said bobbin holder to the center of curvature of the rib thereon, the arrangement being such that inertia forces are set up which directly of themselves cause said bobbin holder to turn counter to the frictional drag thereon of said hook body during a portion of each revolution of the hook body.

8. In a sewing machine having a frame and a main drive shaft journaled in said frame, a vertically disposed hook shaft carried by said frame and connections from said drive shaft for rotating said hook shaft, the combination which comprises a rotary hook body secured to said hook shaft and provided with a beak arranged to seize a needle thread loop, a bobbin holder mounted in said hook body, said bobbin holder having a circumferentially extending rib, said hook body having a raceway arranged to receive said rib in bearing relation, means comprising a shoulder on said bobbin holder and a shoulder carried by said frame for arresting said bobbin holder against rotation in response to the frictional drag of said hook body, and means for turning said bobbin holder against the action of said frictional drag to provide a gap between said shoulders for the passage of a leg of said loop at a predetermined time in a revolution of said

hook body which comprises the disposition of said raceway eccentrically in relation to the axis of said hook shaft, the extent of such eccentricity being sufficient and the direction of displacement of the center of curvature of the raceway in relation to the axis of rotation of said hook body being such as to set up inertia forces in the bobbin holder of such magnitude and in such a direction as to apply a turning moment of themselves directly to said bobbin holder which serves to turn the latter counter to the frictional drag of said hook body during that portion of each revolution thereof in which the leg of said thread loop is to be drawn through said gap and while said bobbin holder is out of contact with any part of said frame.

9. In a sewing machine of the character set forth in claim 8, said frame having a plurality of spaced shoulders and said bobbin holder having a projection interposed between said spaced shoulders on the frame, said projection providing a shoulder cooperating with one of said shoulders on the frame to arrest rotation of said bobbin holder in response to the frictional drag of said hook body, said displacement of the center of curvature of the raceway in relation to the axis of rotation of the hook body being between .005 and .015 of an inch and being along a line extending from the axis of rotation of said hook body to a point within a region which extends from 30° back of said thread seizing point of said hook body to 45° forward of said thread seizing point.

10. In a sewing machine of the character set forth in claim 8, said bobbin holder having a plurality of spaced shoulders, a projection on said frame disposed between said shoulders and cooperating therewith to limit turning movement of said bobbin holder relative to said frame, one of said shoulders on the bobbin holder being urged against a shoulder provided by said projection as a result of the frictional drag created by said hook body on said bobbin holder, the extent of said eccentricity of the raceway being between .005 and .015 of an inch, the point on said raceway which is at the greatest distance from the axis of said hook shaft being disposed within a region which is from 30° to 150° from the free end of said thread seizing beak of said hook body.

11. In a sewing machine of the character set forth in claim 8, said eccentricity of said raceway being such that its center of curvature is disposed at a distance of from .005" to .015" from the axis of said hook shaft and in a direction therefrom which is within 150° of a line extending from the axis of said shaft to the free end of said thread seizing beak of said hook body.

12. In a sewing machine of the character set forth in claim 8 said hook shaft having a portion adjacent its upper end which is eccentric to a predetermined extent to the axis of said shaft, and said hook body being secured to said eccentric portion of said shaft to thereby position the raceway in said hook body eccentrically of the axis of said shaft in the manner defined.

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