PATENT SPECIFICATION (11) 1 561 415

(21) Application No. 28450/77 (22) Filed 7 July 1977 (19)

(31) Convention Application No. 51/089 327 (32) Filed 27 July 1976 in

(33) Japan (JP)

(44) Complete Specification published 20 Feb. 1980

(51) INT. CL.³ B23Q 3/157

(52) Index at acceptance

B3B 12B1 12B6 12C1

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(54) AUTOMATIC TOOL CHANGING DEVICE IN A MACHINING CENTRE

(71) I, KOICHIRO KITAMURA, of Japanese nationality, of 11-5 Ekinan-3-chome, Takaoka-shi, Japan, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to an automatic tool changing device in a machining centre, e.g. a numerical control milling machine having an automatic tool changing device.

Two principal types of such device are known in the art, namely, a turret head type, and an arm type in which the necessary tool changes are accomplished by means of an arm and tool transport unit, such as, a robot which is arranged between a tool magazine and the spindle of a machine tool. A disadvantage of the turret head type is that while the tool changing time is relatively short, the number of tools that can be held on the head is usually of the order of 6 to 8 tools thus making it unsuitable for use on machining centres designed to handle a wide range of machining operations, and moreover there is the disadvantage of causing indexing errors, misalignment and the like. The aforesaid arm type is also disadvantageous in that since the tool holding head must first be raised to a predetermined height to permit the tool change by the robot and then the head must be lowered to permit the machining of the work, even in the case of a small-sized work, the head must be raised to such predetermined height thus requiring a dead time, causing wasting time in changing the tools, unavoidably making the device large and complicate in construction and making it impossible to use this type of device on machining centres in view of the recent trend in designing toward smaller machining centres.

It is an object of the present invention to provide an improved automatic tool changing device in a machining centre.

The invention provides a machining centre having a movable head, and a tool rack supported movably in vertical direction on said head and incorporating an automatic tool changing device, wherein said tool rack comprises a rack base adapted to be guided by guide rail means on the forward end of said movable head, a casing integral with said rack base, a fixed shaft projecting from said base, a disc rotatably mounted on said fixed shaft, an annular space defined between a peripheral portion of said casing and a peripheral portion of said disc, a plurality of movable plates received in said annular space for movement around said annular space each of said movable plates being adapted to hold rotatably a tool holding arbor, a cam and a carrier mechanism for maintaining a predetermined angle between a movable plate at the time being positioned at a work station in said annular space and the movable plates adjacent to and on opposite sides of the movable plate at said work station so that the respective spacings therebetween are wider than the spacings between the rest of the movable plates in said annular space, and a ratchet means for rotating said disc through said predetermined angle; and wherein said movable head comprises a tool spindle having in the lowest position thereof a socket for receiving the shank of each said arbor, and a chuck adapted to be opened and closed in response to the movement of a head at the top thereof alternately to release and hold firmly the end of each said arbor, a drive means for driving said tool spindle, a second cam operatively associated with said mechanism adapted to open and close said chuck in said tool spindle, a third cam operatively associated with a mechanism adapted to move vertically said tool rack, a first cam operatively associated with said ratchet means to rotate said disc through said predetermined angle when said tool rack is lowered by the action of said third cam, and a driven cam shaft means operatively associated with all of said cams for controlling the operation thereof, the arrangement being such that during one revolution of the cam shaft means the second cam operates to cause the chuck to open so as to release an arbor held therein, the third cam oper-

ates to cause the tool rack to move downwardly so as to remove the arbor from the chuck, the first cam then operates to rotate through said predetermined angle the disc to bring another plate to said work station, the third cam then operates to cause the tool rack to move upwardly so as to insert the arbor of that another plate in the chuck and the second cam operates to close the chuck so as to grip that arbor.

The improved device provided in accordance with the present invention is designed so that a multiplicity of tools can be held in such a manner that the tool change may be accomplished at a position nearest to the work without any possibility of interference with the work, thus reducing the tool changing time and ensuring more accurate indexing of tools.

It is an advantage of the present invention that it makes it possible to provide an improved automatic tool changing device which can be made smaller and more compact by so designing that the tool indexing and changing operations can be accomplished by means of only one revolution of a rotary shaft.

It is further advantage of the present invention that it makes it possible to provide an improved automatic tool changing device which is so designed that the tools can be positively held in positions which are free from interference with a piece of work both before and after their use.

One embodiment of the invention will now be described by way of example and with reference to the accompanying drawings, in which:

Fig. 1 is a front view of an automatic tool changing device in a machining centre according to the invention.

Fig. 2 is a side view of Fig. 1.

Fig. 3 is a sectional view of the device shown in Fig. 1.

Fig. 4 is a back view of the rotary tool rack as viewed in the direction of the line IV—IV of Fig. 3.

Fig. 5 is a plan view of the cylindrical cam mount as viewed in the direction of the line V—V of Fig. 3.

Fig. 6 is a plan view of the chuck control cam.

Fig. 7 is a diagram showing in developed form the relationship of the cylindrical cams and the chuck control cam one to another.

Fig. 8 is a sectional view showing the operative association between a rotary disc of the tool changing device and the inner cylindrical cam.

The present invention will now be described in greater detail with reference to the illustrated embodiment.

Referring to the drawings, there is shown a machining center 50 equipped with an automatic tool changing device 60. A head 2 is vertically movably mounted on a pair of guide rails 3 on the front part of a column 1, and a rotary tool rack 4 comprises a rack base 5 adapted to be vertically guided by a pair of guide rails 3^1 on the front part of the head 2, and a frusto-conical casing 6 integral with the base 5. Referring to Fig. 3, there is shown, a disc 8 rotatably mounted on a fixed shaft 7 projected from the central portion of the base 5 to slant downwardly, a front wall portion 9 fixedly mounted on the outer end of the fixed shaft 7 to form the front part of the rack, an annular space 10 (see Figure 4) defined between the peripheral portions of the casing 6 and the disc 8, and a large number of movable plates 12 received in the annular space 10 and each being adapted to rotatably hold a tool holding arbor 11.

Each movable plate 12 is provided at its one end with a roller 13 (see Figure 3) to contact with the peripheral portion of the casing 6 and at its other end with a roller mounted holder 14 fitted thereon through a spring 15 with the roller of the holder 14 being placed in contact with the peripheral portion of the disc 8. One of a large number of the arbors 11 is positioned at a work station at the lowermost part of the annular space 10 and the remaining arbors 11 are arranged along the upper peripheral portion on both sides of the lower arbor 11 with a predetermined angle between the arbor at the work station and the arbors adjacent to and on opposite sides of that arbor. This predetermined angle must be in such a range that the tools which are not in use are free of interference with the work, and the angle is 60° in the illustration. The shank of the arbor 11 positioned on the lower side of the casing 6 is inserted in the shank socket in the lower end of an upright cutter head spindle 28 in the head 2, and the machining is effected by the tool attached to the lower arbor 11.

To suitably arrange the arbors 11, as shown in Figs. 3 and 4, the back surface of the disc 8 is formed with a plurality of radial open channels (6 channels in the illustrated embodiment) and the back surface is covered with a ratchet wheel 16 thus providing a plurality of covered channels into which bars 18 are radially and slidably fitted. Fixedly mounted at the outer end of each bar 18 is a C-shaped carrier 19 fitted on the roller mounted holder 14 of the movable plate 12, and also fixedly mounted on the fixed shaft 7 is a cam 20 against which the bars 18 are pressed by their respective springs 21 and whose crest portion 20*a* is positioned on the underside of the shaft 7. A movable plate 12 is supported on each of a carrier 19a positioned on the lower side of the casing 6 and carriers 19*b* and 19*f*

positioned on both sides of the carrier 19*a* and spaced by 60° therefrom. A ratchet wheel 22 fixed with respect to the disc 8 is fixedly mounted in place in such a manner that its teeth are aligned with the bars 18 respectively, and the disc 8 is rotated by applying in the manner that will be described later a turning force to an outer wheel 23 carrying a pawl piece 24 adapted to engage with the teeth of the ratchet wheel 2. The front wall 9 fixedly mounted on the fixed shaft 7 is provided in the outer periphery thereof with a plurality of notches 25 containing springs which are placed in positions corresponding to the carriers 19. Fitted in each notch 25 is a supporting piece 26 with a V-groove, and each of the roller holders 14 is provided with a projection 27 adapted to fit in the V-groove. In this way, the positions of the arbors 11 can be accurately maintained by means of the notches 25.

The arbor 11 located on the lower side of the rotary tool rack 4, is fitted in the shank socket in the cutter head spindle 28 of the head 2 and is held by a chuck 29 disposed above the shank socket. The chuck 29 is designed so that when the head 30 of a spindle, which head has a conical upper part and is spring biased upwardly against a cam plate 35, is depressed downwardly by the cam plate 35, the spindle is also depressed so as to cause the chuck 29 to open, the arbor being clamped in response to the return motion of the spindle head 30. The cutter head spindle 28 is provided with a rotary motion transmission unit 31 which may comprise a gearing or the like.

The structure for engaging and disengaginng the arbors 11 with the cutter head spindle 28 includes a rotary shaft 32 disposed above the cutter head spindle 28 in the head 2 so as to be slightly offset from the central axis of the cutter head spindle 28 but to extend parallel therewith, a reduction gear 33 and a supporting plate 34 which are mounted on the rotary shaft 32, the chuck control cam 35 fixedly attached to the lower end of the shaft 32, and a motor 37 disposed in the head 2, whereby the driving force of the motor 37 is transmitted at a reduced speed to drive the rotary shaft 32. The chuck control cam 35 consists of a disc against the lower surface of which is pressed the spindle head 30 disposed at the upper end of the chuck 29. Also the cam 35 is formed with a depression 36 in a portion of the path of contact with the spindle head 30 so that the arbor 11 is held when the spindle head 30 is in engagement with the depression 36, and the arbor 11 is released when the spindle head 30 comes out of engagement with the depression 36. The supporting plate 34 is provided with a pair of cylindrical cams 38 and 39 which are fixedly mounted concentrically thereon, so that the outer cylindrical cam 38 vertically moves the rotary tool rack 4, and the inner cylindrical cam 39 rotates the disc 8 through a desired angle. The relationship of the cylindrical cams 38 and 39 and the chuck control cam 35 to one another is shown in developed form in Fig. 7, namely, as shown by the one-dot-chain line, the outer cylindrical cam 38 has a slope which gradually descends from a highest position A toward a lowest position B and again returns to the highest position A from a position C spaced from the lowest position B, and the cam 38 is in engagement with a roller 40 projected from the base 5 of the tool rack 4, as shown in Fig. 5. Also, as shown by the dotted line in the Figure, the inner cylindrical cam 39 is formed so that while its slope descends from the highest position A toward the lowest position B as in the case of the outer cam 38, the slope immediately ascends with a gradient toward a highest position D from which the slope returns to the original position A. On the other hand, as shown by the two-dot-chain line, the chuck control cam 35 is so formed that the spindle head 30 is raised at each of positions E opposite to the highest positions A and lowered between the positions E.

As is shown in Fig. 8, the structure for rotating the disc 8 by the inner cylindrical cam 39 includes a rod 42 vertically movably supported by a bracket 41 and provided at its upper end with a roller 43 disposed to contact with the inner cylindrical cam 39, and the lower end of the rod 42 is coupled through a universal joint 44 to the outer wheel 23 of ratchet wheel 22 mounted on the disc 8.

With the construction described above, the device of this invention operates as follows. When it is desired to change the tools, the head 2 is first raised to a position where the tools are free of interference with the work during the tool changing operation, and the motor 37 is operated to complete the tool change during one revolution of the rotary shaft 32. As the shaft 32 is rotated, the spindle head 30 of the cutter head spindle 28 is first lowered by the chuck control cam 35 so that the grip on the arbor 11 is released, and at the same time the rotary tool rack 4 is lowered by the outer cylindrical cam 38 thus withdrawing the arbor 11 from the taper shank socked at the lower end of the cutter head spindle 28. The rod 42 is raised first by the inner cylindrical cam 39 while the rotary tool rack 4 remains in the lowered position and relative movement between the rod 42 and the rack 4 causes the disc 8 to be rotated through a predetermined angle (60° to the right in the illustrated embodiment). Consequently, as shown in Fig. 4, the carrier

19*a* with its arbor 11 is moved to the position where the carrier 19*b* previously was, and the carrier 19*f* is moved, along with the arbor 11 engaged therewith, to the position where the carrier 19*a* previously was. Then the rotary tool rack 4 is raised so that the taper shank of the next arbor 11 to be used is inserted into the shank socket of the cutter head spindle 28, and at the same time the head 30 is raised by the chuck control cam 35, thus causing the arbor 11 to be firmly held by the chuck 29.

The movement of the respective arbors 11 and carriers 19 made in response to the rotation of the disc 8 by the rod 42 will now be described in greater detail. When the carrier 19*a* located on the lower side in the illustration is moved 60° to the right along with the movable plate 12 engaged therewith, the carrier 19*b* is moved simultaneously. In this case, however, the carrier 19*b* is lowered by the cam 20 toward the center of the disc 8 so that the carrier 19*b* is disengaged with the movable plate 12*b* and it is rotated as such, thus causing the movable plate 12*b* to remain in its position. However, the movable plate 12*a* now being moved strikes against and shoves the movable plate 12*b*. On the other hand, the movable plate 12*n* located on the left side in the illustration is engaged with the carrier 19*f* and moved downwardly therewith. At the same time, a carrier 19*e* is moved to the position where the carrier 19*f* previously was, so that the carrier 19*e* is pushed by the cam 20 toward the outer periphery of the disc 8 and it is thus engaged with a movable plate 12*m* adjoining a movable plate 12*n*. Consequently, the carrier 19*e* stands by at the position where the movable plate 12*n* previously was. The notches 25 ensure accurate positioning of the movable plates 12 which engage with the carriers 19. Thereafter, the head 2 is lowered and the desired machining of the work is accomplished.

It will thus be seen from the foregoing description that the automatic tool changing device of the machining centre has among its great advantages the fact that the outer peripheral surface of a rotary tool rack is formed with an annular space with which a large number of arbors are rotatably engaged, and the arbors are arranged in such a manner that one of the arbors is engaged with the cutter head spindle of a head and the arbors on both sides of the engaged arbor are held in positions which are free of interference with the work to be machined, thus making it possible to continuously arrange the remaining arbors between the two arbors in the non-interfering positions and thereby hold a large number of tools.

Another advantage of this device is that to make the tool change, after the head has been raised, the rotary tool rack is lowered thereby withdrawing the arbor from the cutter spindle, and after the disc disposed in the tool rack has been rotated through a predetermined angle, the tool rack is again raised thereby engaging the next arbor with the cutter spindle thus ensuring rapid tool changes, and moreover the fact that these operations can be accomplished by a pair of concentrically arranged cylindrical cams adapted to be rotated by a single rotary shaft has the effect of making the device relatively simple and compact in construction and also considerably reducing, in the case of small works, the time required for making the tool change and commencing the machining by the next tool since it is only necessary to raise the head to such an extent that the tools are free from contact with the work during the above described tool changing operation.

Still another advantage is that with the arbor engaged with the cutter head spindle and the arbors located on both sides of the engaged arbor so as to be free from interference with the work, in the course of the machining by the tool there is no danger of the other arbors carrying the tools slipping towards the work station and a very high degree of operating safety is ensured, since the disk is provided with a plurality of equally spaced carriers adapted to engage with a plurality of movably plates adapted to support the arbors and movable from the center of the disk toward and away from the outer periphery thereof, and a cam is mounted on a fixed shaft supporting the disk so as to move the carriers forward and backward and thereby hold the movable plates of the abovementioned three arbors.

Still another advantage is that by virtue of the fact that a rod is vertically moved by an inner cylindrical cam and its upward movement if transmitted through a ratchet mechanism to cause a predetermined degrees of rotation of the disc, there is no danger of the disc being rotated in the reverse direction but the disk can be positively rotated through a predetermined angle each time, thereby indexing and moving the arbors to the proper positions.

WHAT I CLAIM IS:—

1. A machining centre having a movable head, and a tool rack supported movably in vertical direction on said head and incorporating an automatic tool changing device, wherein said tool rack comprises a rack base adapted to be guided by guide rail means on the forward end of said movable head, a casing integral with said rack base, a fixed shaft projecting from said base, a disc rotatably mounted on said fixed shaft, an annular space defined between a peri-

pheral portion of said casing and a peripheral portion of said disc, a plurality of movable plates received in said annular space for movement around said annular space each of said movable plates being adapted to hold rotatably a tool holding arbor, a cam and a carrier mechanism for maintaining a predetermined angle between a movable plate at the time being positioned at a work station in said annular space and the movable plates adjacent to and on opposite sides of the movable plate at said work station so that the respective spacings therebetween are wider than the spacings between the rest of the movable plates in said annular space, and a ratchet means for rotating said disc through said predetermined angle; and wherein said movable head comprises a tool spindle having in the lowest position thereof a socket for receiving the shank of each said arbor, and a chuck adapted to be opened and closed in response to the movement of a head at the top thereof alternately to release and hold firmly the end of each said arbor, a drive means for driving said tool spindle, a second cam operatively associated with said mechanism adapted to open and close said chuck in said tool spindle, a third cam operatively associated with a mechanism adapted to move vertically said tool rack, a first cam operatively associated with said ratchet means to rotate said disc through said predetermined angle when said tool rack is lowered by the action of said third cam, and a driven cam shaft means operatively associated with all of said cams for controlling the operation thereof, the arrangement being such that during one revolution of the cam shaft means the second cam operates to cause the chuck to open so as to release an arbor held therein, the third cam operates to cause the tool rack to move downwardly so as to remove the arbor from the chuck, the first cam then operates to rotate through said predetermined angle the disc to bring another plate to said work station, the third cam then operates to cause the tool rack to move upwardly so as to insert the arbor of that another plate in the chuck and the second cam operates to close the chuck so as to grip that arbor.

2. A device as claimed in claim 1 wherein said fixed shaft extends downwardly from said base at an angle to the vertical, and the casing has a frusto-conical rim projecting towards the disc and defining said annular space.

3. A device as claimed in claim 1 or claim 2 wherein said cam and carrier mechanism comprises a series of radial arms which are mounted on said disc and are equiangularly spaced by said predetermined angle, said arms having means for engaging said plates to move them along said annular space when the disc is rotated, wherein means are provided to engage, when the disc is rotated, each arm in turn with a plate temporarily held at a first position angularly spaced by said predetermined angle upstream (in the direction of rotation of the disc) of said work station and to maintain such engagement until the arm and plate reach a second position angularly spaced by said predetermined angle downstream of said work station, which means are adapted to effect disengagement of the arm and plate at said second position, and wherein readily releasable means are provided to hold plates at said first and second positions when not engaged by one of said arms.

4. A device as claimed in claim 3 wherein the arms are slidable radially of the disc and are biassed inwardly of the disc into engagement with an annular cam on said fixed shaft, said cam being shaped to effect sliding of the arms to engage and disengage them with the plates as aforesaid.

5. A device as claimed in claim 3 or claim 4 wherein said readily releasable means comprise resiliently biassed latching members mounted on the periphery of a stationary disc, which is fixedly mounted on said fixed shaft, and adapted to engage cooperating parts on the plates to hold such plates as aforesaid.

6. A device as claimed in any preceding claim wherein said second cam is mounted on one end of said cam shaft, and said head of the tool spindle is resiliently biassed against a surface of the cam remote from the spindle socket, such surface being shaped to depress the head against its bias during a greater portion of each revolution of the cam shaft to effect opening of the chuck.

7. A device as claimed in any preceding claim wherein said first and third cams comprise annular cam members one within the other, the members being coaxial with, and fixed to rotate with, the cam shaft, wherein a follower is provided on said rack base to co-operate with said third cam which is shaped to effect raising and lowering of the rack base and the plates carried thereon when the cam shaft is rotated through one revolution, and wherein a follower co-operating with said first cam is carried at one end of a rod the other end of which is connected through a universal joint to said ratchet mechanism, the arrangement being such that during one revolution of the cam shaft the ratchet mechanism is operated to rotate the disc through said predetermined angle.

8. A device as claimed in any preceding claim wherein said ratchet mechanism comprises an annular driving member surrounding a driven ring fixed coaxially with respect to the disc, at least one spring loaded

driving pawl being provided between the member and the ring to transmit drive in one direction of rotation of the member.

9. An automatic tool changing device, substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

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Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1980.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY
from which copies may be obtained.

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Sheet 1

FIG. 1

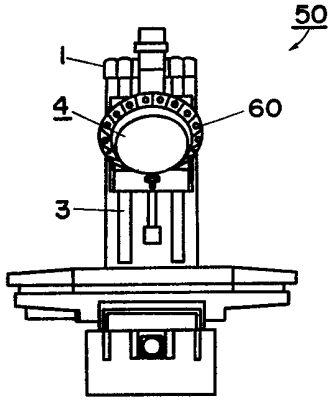

FIG. 2

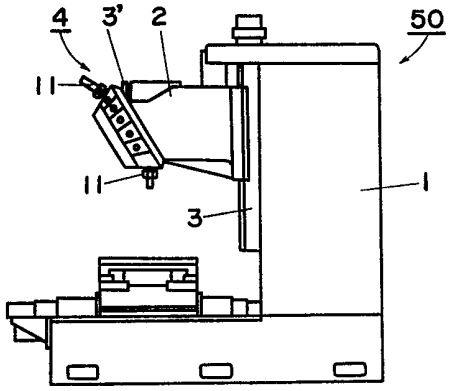

FIG. 3

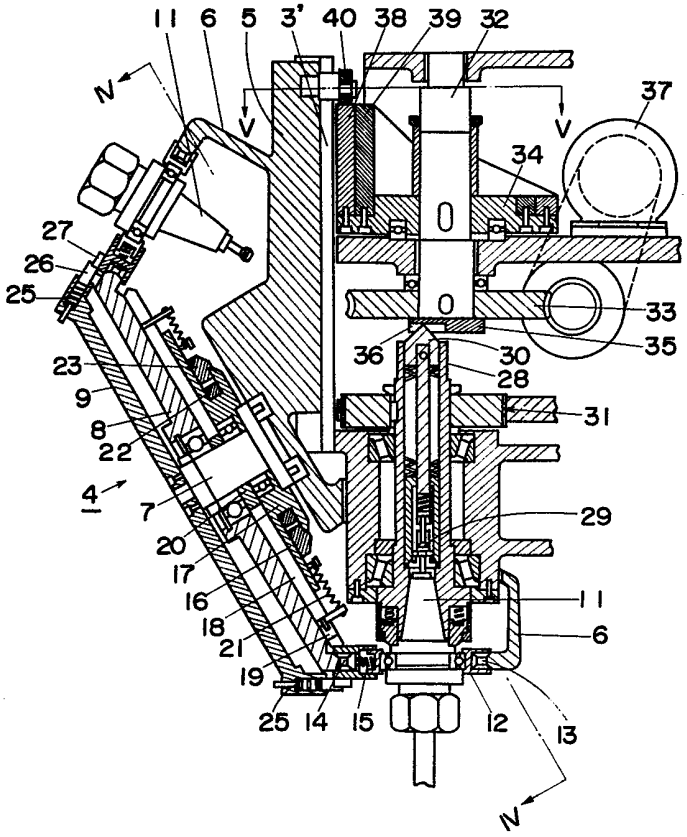
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FIG. 4

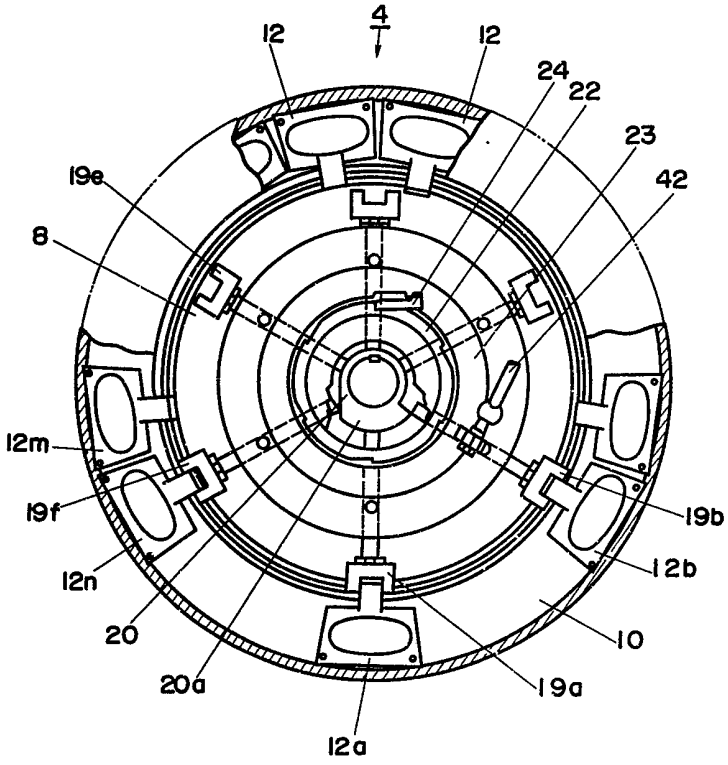

FIG.8

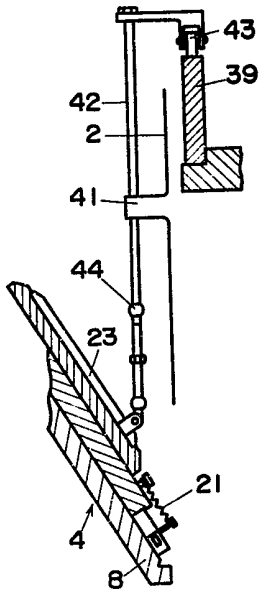

FIG.5

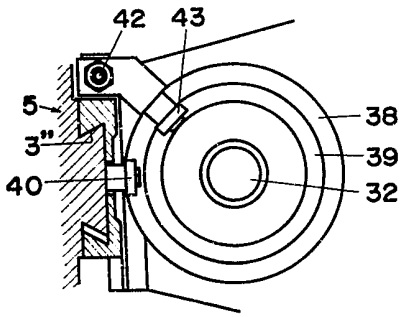

FIG.6

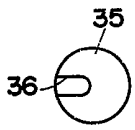

FIG.7