# United States Patent

[11] 3,596,526


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[73] Assignee Ferranti Limited, Hollinwood, England
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[33] Great Britain
[31] 2028/68


[54] **MEANS FOR PRODUCING RELATIVE MOVEMENT BETWEEN TWO BODIES**
**5 Claims, 6 Drawing Figs.**


[52] U.S. Cl. ..... 74/110
[51] Int. Cl. ..... F16h 21/44
[50] Field of Search ..... 74/110, 126, 129, 130, 142, 567



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ABSTRACT: Means for moving one body relative to another comprises a main toothed rack carried on one body and at least three actuators carried on the other body. Each actuator carries a stub rack of similar form to the main rack and is operable to force the stub rack into engagement with the main rack. The spacing between the actuators causes the bodies to move relative to one another in the required direction.

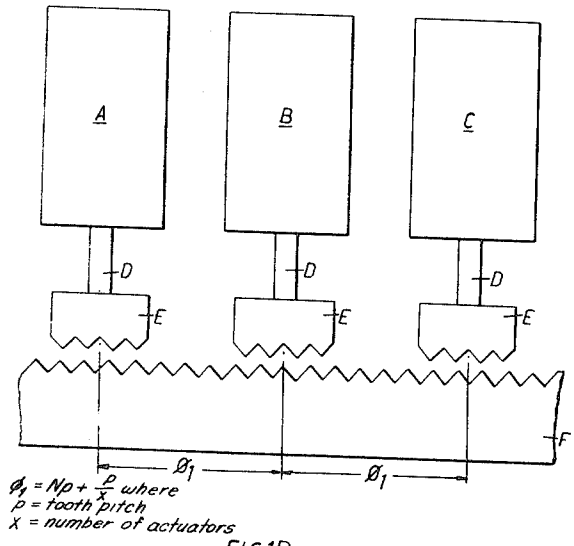




FIG.1B

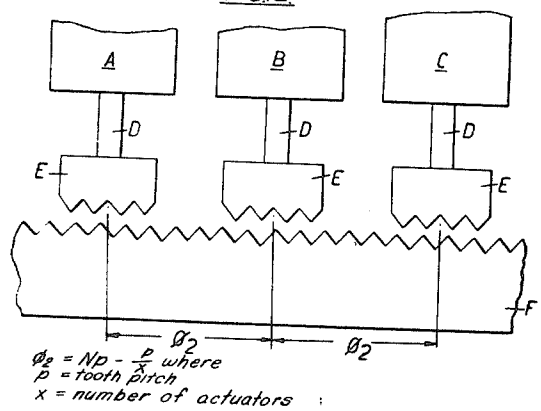
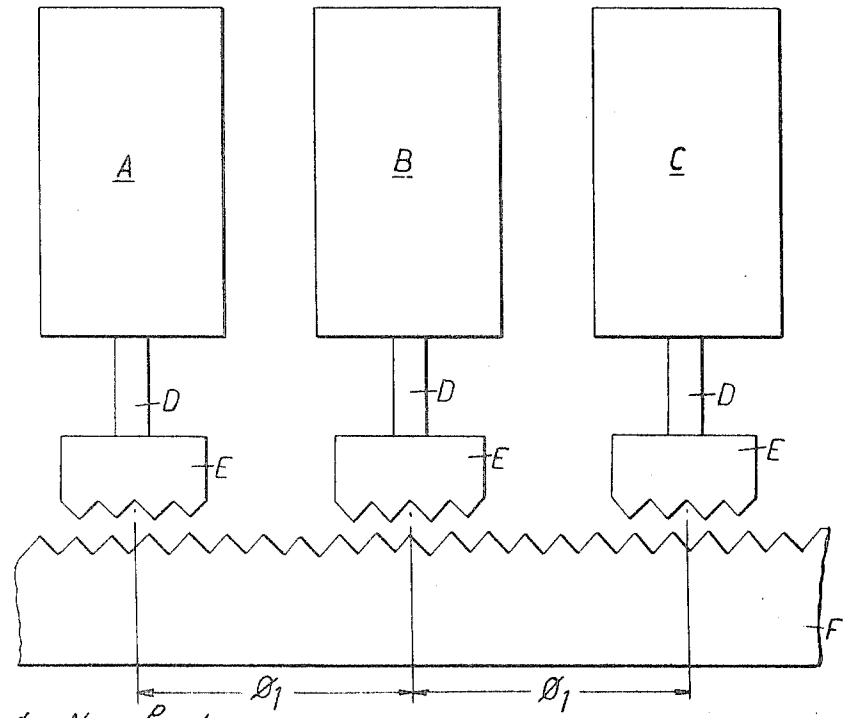
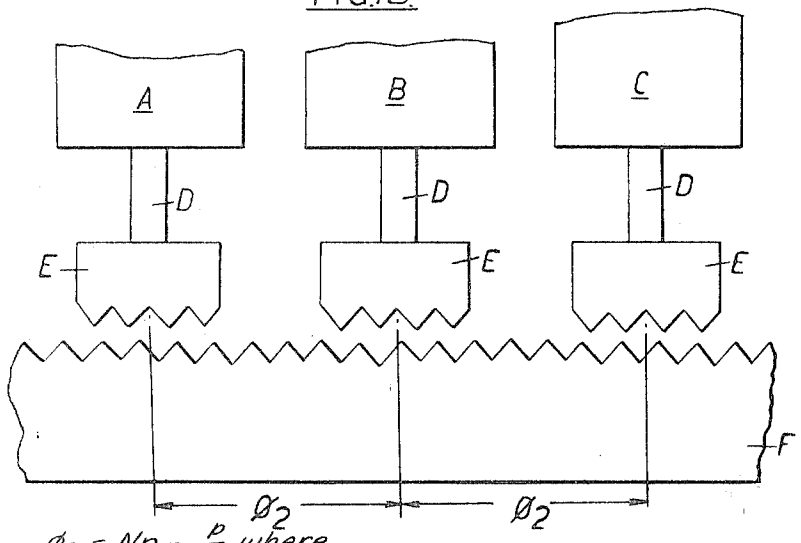


FIG. 1A.




$\phi_1 = Np + \frac{p}{x}$ where
$p$ = tooth pitch
$x$ = number of actuators

FIG. 1B.




$\phi_2 = Np - \frac{p}{x}$ where
$p$ = tooth pitch
$x$ = number of actuators

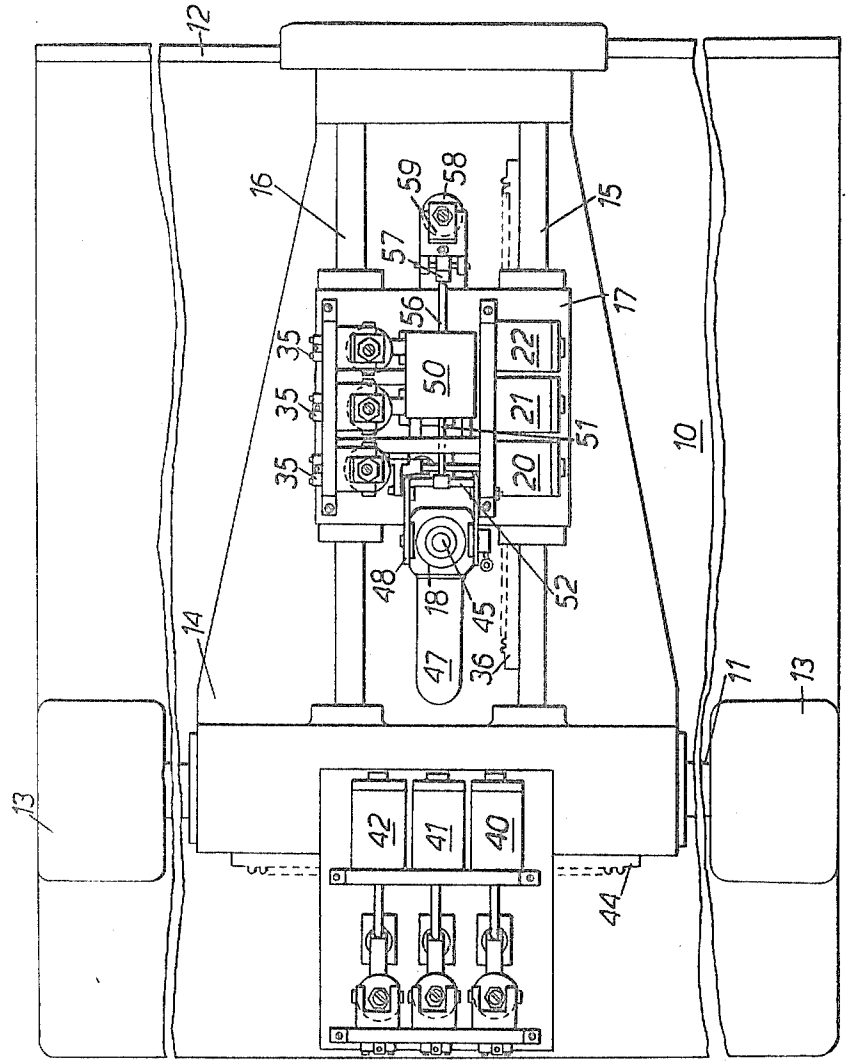

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FIG.2.

FIG. 3

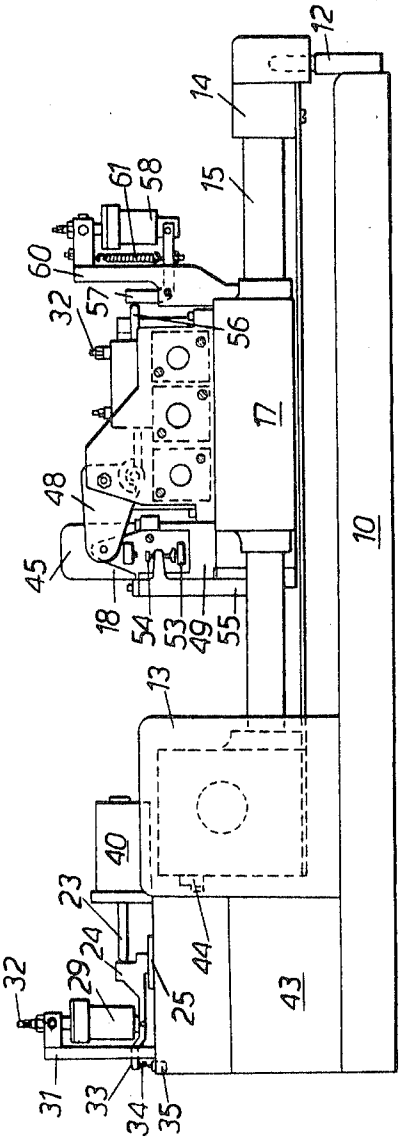

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FIG.4.

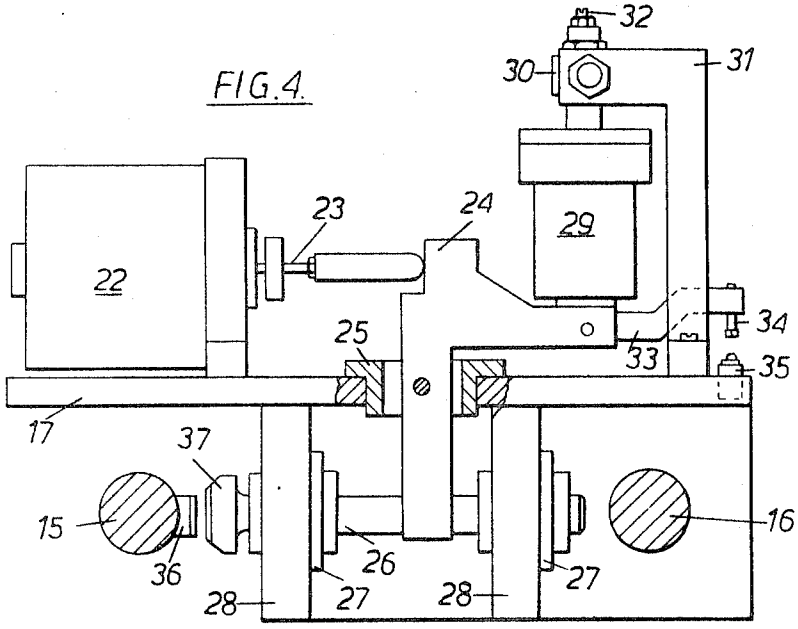
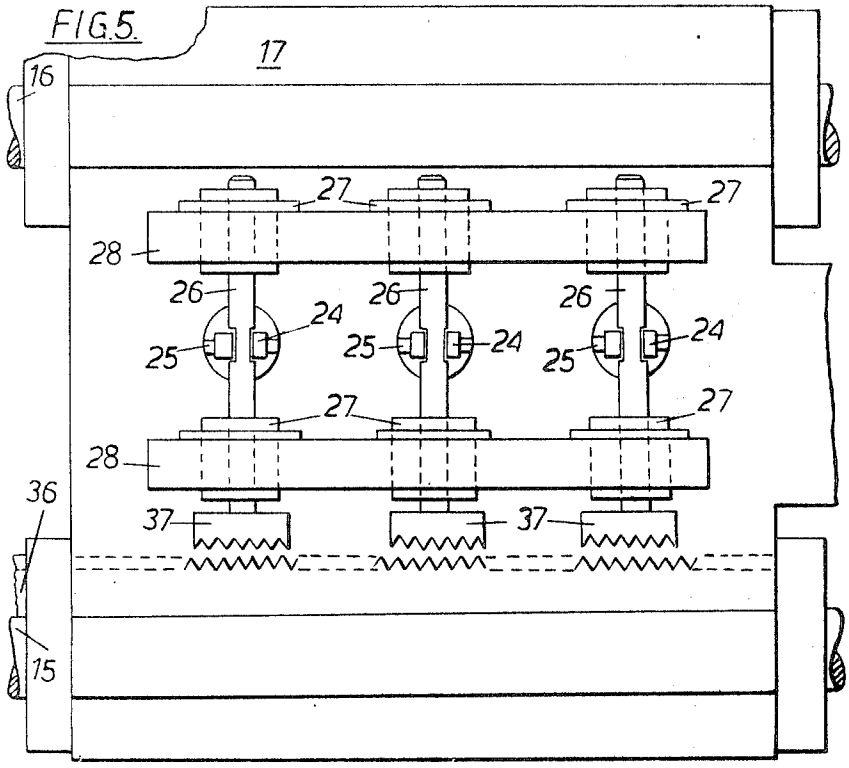

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FIG.5.


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# MEANS FOR PRODUCING RELATIVE MOVEMENT BETWEEN TWO BODIES

This invention relates to means for producing relative movements between two bodies.

More specifically it relates to means for accurately positioning a machining head in any of a series of positions with respect to a workpiece, said positions being defined by the intersections of the rows and columns of a rectangular grid.

According to the present invention there is provided means for producing relative movement between two bodies comprising a main toothed rack attached to one of the two bodies and at least three actuators attached to the other body, each actuator being operable to force into engagement with the main toothed rack a stub toothed rack of the same tooth pitch as the main rack, the stub racks being spaced from one another along the main rack by a distance differing from an integral number of rack tooth pitches by a like fraction of a pitch equal to the reciprocal of the number of actuators.

Also according to the invention there is provided means for accurately positioning an operational head in any of a series of positions with respect to a member, the positions being defined by the intersections of the rows and columns of a rectangular grid, including

a. A fixed bed on which is located the member and which carries a carriage movable in a straight line relative to the member,

b. A slide carrying the operational head and mounted on the carriage so as to be movable relative thereto in a straight line perpendicular to the direction of movement of the carriage,

c. Control means responsive to information signals to control the movement of the carriage, slide and operational head, and

d. transport means operable to move the carriage relative to the fixed bed and the slide relative to the carriage in response to the information signals, wherein the transport means comprises a main toothed rack attached to one of each pair of relatively movable bodies and at least three actuators attached to the other of each pair of bodies, each actuator being operable to force into engagement with the associated main toothed rack a stub toothed rack of the same tooth pitch as the main rack, the stub racks being spaced from one another along the associated main rack by a distance differing from an integral number of rack tooth pitches by a like fraction of a pitch equal to the reciprocal of the number of actuators.

The invention will now be described with reference to the accompanying drawings, in which:

FIGS. 1A and 1B show a simplified form of the invention;

FIG. 2 is a plan view of a machine tool incorporating the invention;

FIG. 3 is a side elevational view of the machine tool of FIG. 2;

FIG. 4 is an enlarged end elevational view of part of the machine tool; and

FIG. 5 is an underside view of the part of the machine tool shown in FIG. 4.

Referring now to FIGS. 1A and 1B, these show three actuators, A, B and C, which are fastened to one of the two bodies. Each actuator is operable to move a plunger D which carries at its extremity a stub toothed rack E. The three stub racks are of the same form and pitch as one another, and as a long main rack F which is fastened to the other of the two bodies.

The spacing $\Phi$ between the actuators is such that the plungers are separated by a distance equal to an integral number of rack tooth pitches plus or minus a fraction of a pitch equal to the reciprocal of the number of actuators. In the case shown in FIG. 1A there are three actuators, and the offset $\Phi_1$ between plungers is shown as seven plus one-third rack tooth pitches. Operation of actuator B will have no effect, but operation of actuator A will cause the rack F to move to the left by one-third of a rack tooth pitch, and operation of the actuator C will cause the rack to move to the right by one-third of a rack tooth pitch. Continuous movement of rack F to the left is thus produced by operating the actuators sequentially in the order ACBACB, and continuous movement of the rack F to the right is produced by operating the actuators in the order CABCAB.



In FIG. 1B, the spacing $\Phi_2$ of the plungers is seven minus one-third rack tooth pitches. The direction of movement of the rack F for any sequence of operation of the actuators is the reverse of that given above. Movement will still be in steps of one-third of a rack tooth pitch. Hence continuous movement of rack F to the left is produced by operation of the actuators in the sequence CABCAB, whilst movement of rack F to the right is produced by operation of the actuators in the sequence ACBACB.

If more than three actuators are used, then the fraction of a rack tooth pitch included in the offset between plungers will, of course, no longer be one-third. This fraction is always the reciprocal of the number of actuators.

It must be noted that, as described above, the fraction of a pitch must always be added to the integral number of pitches, or must always be subtracted from the integral number of pitches, though the integral number itself need not be constant.

Nothing has yet been said about the type of actuator. The most likely forms are hydraulic, pneumatic or electromagnetic.

Referring now to FIGS. 2 and 3, the machine tool includes a fixed bed 10 on which is fixed a pair of rails 11 and 12. The rail 11 is supported in blocks 13 fastened to the bed, and the rail 12 is fastened to one edge of the bed parallel to rail 11. Slidable on the rails 11 and 12 is a carriage 14 which supports a further pair of rails 15 and 16 arranged at right angles to the rails 11 and 12. The rails 15 and 16 carry a slide 17 on which is mounted a machining head 18 and also the means for moving the slide 17 relative to the carriage 14, hereafter referred to as "transport means."

Hereinafter the direction parallel to the rails 15 and 16 will be referred to as the Y direction and the direction parallel to the rails 11 and 12 will be referred to as the X direction.

The transport means for moving the carriage 14 relative to the fixed bed 10 are mounted on the bed. Since the two transport means are substantially identical, the same reference numerals will be used to refer to both, where applicable.

FIGS. 4 and 5 show more detail of the transport means attached to the slide, and hence this will be described in detail with reference to FIGS. 2 to 5.

Three electromagnets 20, 21 and 22, hereafter referred to as the Y electromagnets, are carried on the slide, each having a straight armature 23 movable in the X direction. The end of each armature remote from the associated electromagnet abuts against a pivoted bellcrank lever 24. The lever is pivoted in a bush 25 passing through the body of the slide 17, and extends below it. The lower end of the bellcrank is forked and fits astride a narrowed portion of a horizontal pushrod 26, movable in the X direction and supported in ball bearings 27 located in two webs 28 under the slide. The pushrods 26 are located in line with the center of the rail 15 on which the slide is carried.

The remote end of each bellcrank lever 24 is pivotally attached to the cylinder of a dashpot 29, the piston of which is attached to a trunnion 30 carried on a supporting member 31. A needle valve is carried on the dashpot piston and is adjustable by means of a screwed extension 32. An extension 33 of the bellcrank lever 24 beyond the dashpot carries an adjusting screw 34 and is arranged so as to actuate a microswitch 35 when the mechanism is in one of its two extreme positions.

Each electromagnet operates a mechanism identical to that described in FIG. 1 above, the three pushrods 26 being parallel to one another and at right angles to the rail 15. On the rail 15 is carried a toothed main rack 36, projecting towards the pushrods 26. Each pushrod carries a stub toothed rack 37 of the same pitch and form as the main rack 36. The spacing between the pushrods 26 is equal to an integral number of

rack tooth pitches plus (or minus) a fraction of a pitch equal to the reciprocal of the number of electromagnets as described above. Hence the stub racks **37** are offset from one another by one-third of a rack tooth pitch.

The transport means for moving the carriage **14** in the X direction is identical to the means described above. The only differences are in the location of the parts of the mechanism. For example the electromagnets **40**, **41** and **42**, hereafter referred to as the X electromagnets, together with the associated bellcrank levers, dashpots, pushrods and the like are all mounted on a supporting block **43** fastened to the bed **10** of the machine. The corresponding main rack **44** is carried on the carriage as shown in FIG. **2**. The X electromagnets such will be required to be more powerful than the Y electromagnets such the carriage **14** will be heavier than the slide **17**.

The remaining part of the mechanism is that controlling the machining head. This comprises an electric motor **45** carried on the slide and operating a drill bit or milling cutter (not visible) which projects through a slot **47** in the base of the carriage **14**. The motor **45** is carried in eccentric trunnions **48** and is constrained by a guide **49** so that is only able to move vertically, that is in the Z direction. Movement of the motor is controlled by an electromagnet **50**, the Z electromagnet, the armature **51** of which acts on a tie bar **52** connecting one end of each eccentric trunnion **48**. Carried on the motor housing are two microswitches **53** which cooperate with an adjustable stud **54** carried on a rod **55** fastened to the slide. An extension **56** of the electromagnet armature away from the motor **45** cooperates with one end of a pivoted cranked lever **57** attached at the outer end to the cylinder of a dashpot **58**. The dashpot piston is supported in a trunnion **59** pivotally carried on a supporting member **60**.

In order to reduce frictional forces the slide **17** and carriage **14** will be carried on the rails **15**, **16** and **11**, **12** respectively by ball bearing bushes.

The energization of a single electromagnet, say **22**, results in the armature **23** causing the bellcrank lever **24** to pivot about the pivot pin in bush **25**. The lower forked end of the lever **24** moves the pushrod **26** so that the stub rack **37** is moved towards the main rack **36**. As shown in FIG. **5**, the stub rack **37** operated by electromagnet **22** is offset from the position of the main rack by one-third of a rack tooth pitch. Hence as the stub rack is forced into engagement with the main rack, the slide will move along the rails **15** and **16** to bring the two racks into alignment. If, therefore, it is required to move the slide sideways, it is necessary to energize the three Y electromagnets sequentially in the correct order. For example, to move the slide to the right as shown in FIG. **2**, the Y electromagnets must be energized in the order **20**, **21**, **22**, **20**, **21**.... It is necessary for each electromagnet to be deenergized before the next one is energized. To lock the slide in a particular position it is only necessary to maintain the energization of the electromagnet which causes the final movement to that position.

Movement of the carriage is brought about by operating the X electromagnets in a similar manner.

The dashpots connected to the transport means are provided to prevent too abrupt movement of the mechanism. The speed of movement may be controlled by altering the delay provided by the dashpots. This is done by adjustment of the needle valve **32** of each dashpot.

As well as operating the dashpots, the bellcrank lever **24** also control microswitches **35**. The transport means are controlled by signals from a punched tape driven through a tape reader by a stepping motor. The microswitches **35** control the stepping motor in known manner so that the tape cannot be advanced until the previous signal has been acted on. This is necessary on account of the complexity of the transport means and the fact that the carriage and slide will move at different speeds.

The operation of the machining head is straightforward. When the electromagnet **50** is energized the operational head is lowered, one of the microswitches **53** indicating when this has occurred. Deenergization of the electromagnet **50** raises the machining head and operates the other one of the two microswitches **53**.

Movement in the X and Y directions may take place simultaneously, but the carriage and slide must be locked in position when the operational head is moving.

The positioning accuracy of the machine is dependent only on the pitch of the two main racks **36** and **44**. The workpiece to be operated upon will be clamped to the bed of the machine by clamping means (not shown).

Nothing has been said about the method of coding the required signals on to the punched tape since this is well known to those skilled in the art. Control means other than punched tape may be used, for example, magnetic tape.

I claim:

**1.** Means for producing relative movement between two bodies comprising a main toothed rack attached to one of the two bodies and at least three actuators attached to the other body, each actuator comprising a stub toothed rack having a plurality of teeth of the same tooth pitch as the main rack and being operable to force the teeth thereof into engagement with the main toothed rack, the stub racks being spaced from one another along the main rack by a distance differing from an integral number of rack tooth pitches by a like fraction of a pitch equal to the reciprocal of the number of actuators.

**2.** Means as claimed in claim **1** in which the stub racks are spaced from one another by a distance equal to an integral number of rack tooth pitches plus a fraction of a pitch equal to the reciprocal of the number of actuators.

**3.** Means as claimed in claim **1** in which the stub racks are spaced from one another by a distance equal to an integral number of rack tooth pitches minus a fraction of a pitch equal to the reciprocal of the number of actuators.

**4.** Means as claimed in claim **1** which includes three actuators.

**5.** Means as claimed in claim **1** in which the actuators are electromagnets.