

[54] **MICROSCOPE MANIPULATOR**

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[51] Int. Cl. **G05g 9/00**

[58] Field of Search **74/471 XY, 479, 491;
308/6 R**

[56] **References Cited**

UNITED STATES PATENTS

2,680,397 6/1954 Saunders-Singer 74/491 X

2,857,808	10/1958	Hastings.....	74/471 XY X
3,321,993	5/1967	Pomerantz.....	74/491
3,396,598	8/1968	Grispo	74/479
3,474,685	10/1969	Miller	74/471 X

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[57]

ABSTRACT

A movement reduction apparatus comprising first and second plates which are supported in parallel relationship for the movement of the first plate, which carries a manipulator, relative to the second plate under the action of an operating member which cooperates with each plate by way of a respective ball joint and is handled by the operator.

5 Claims, 14 Drawing Figures

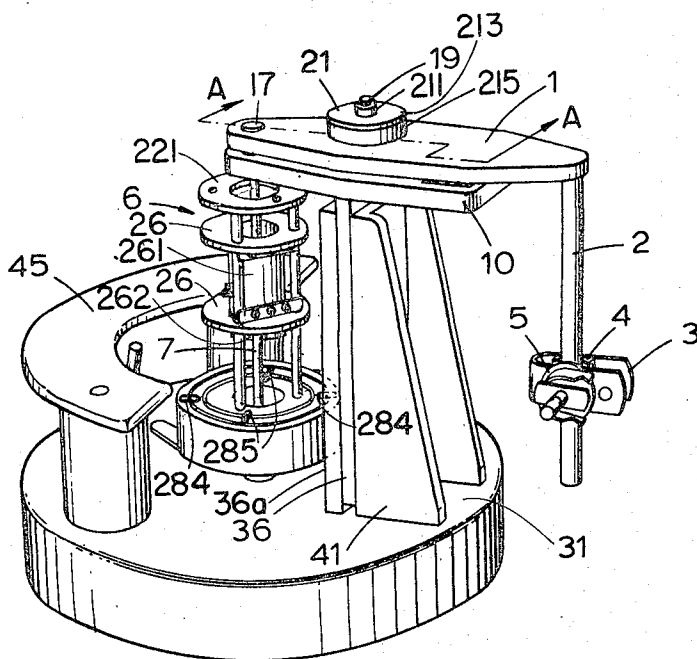


Fig. 3.

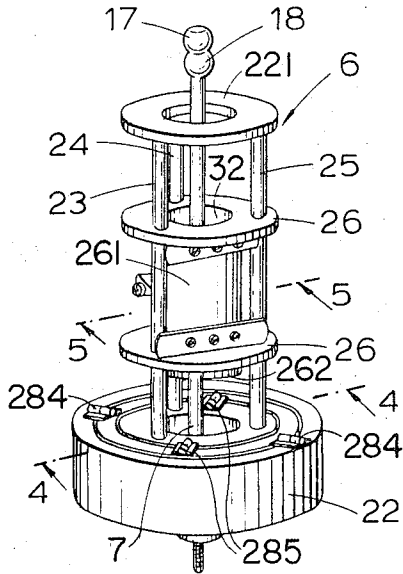


Fig. 4.

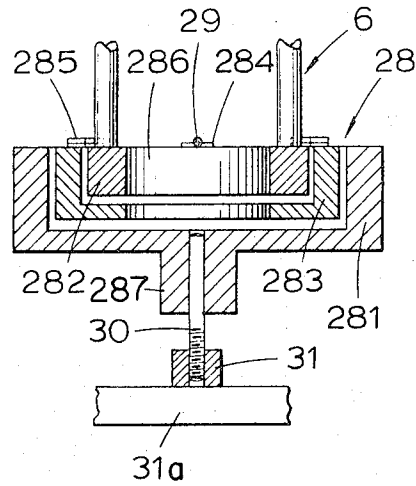


Fig. 5.

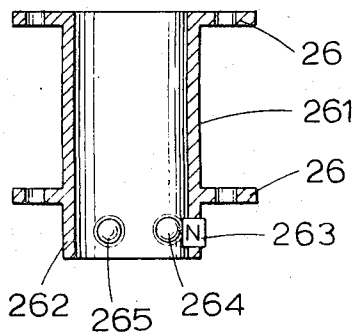


Fig. 6.

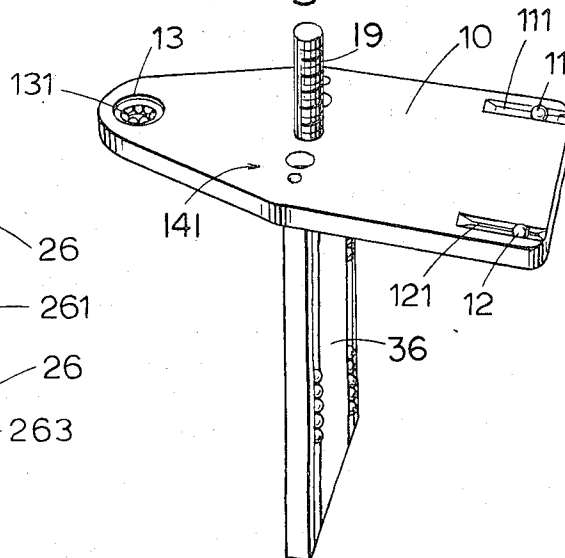


Fig. 3A

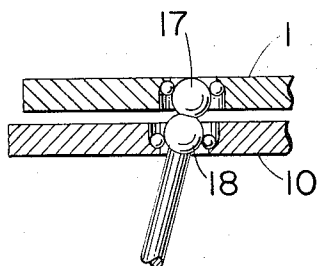
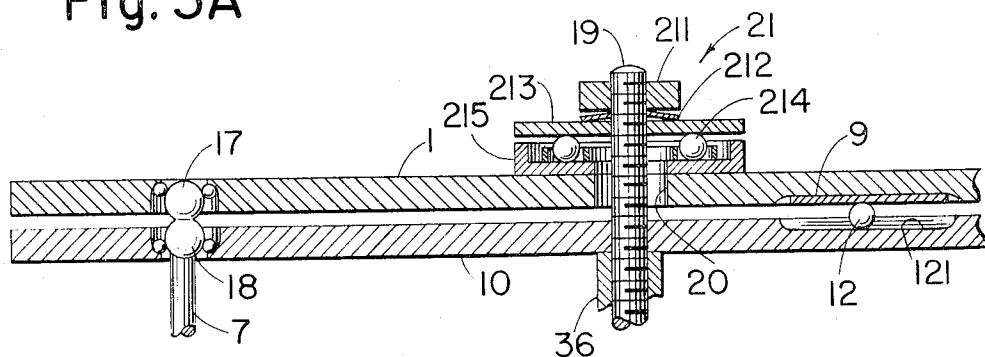
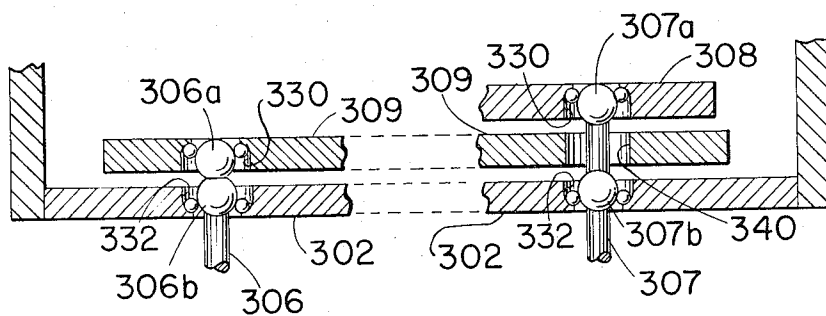


Fig. 3B

Fig. 12



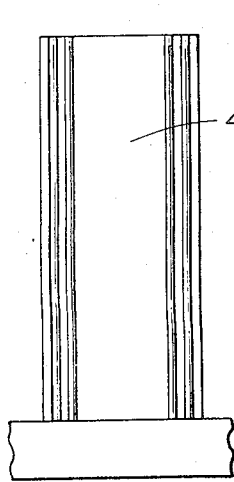


Fig. 7.

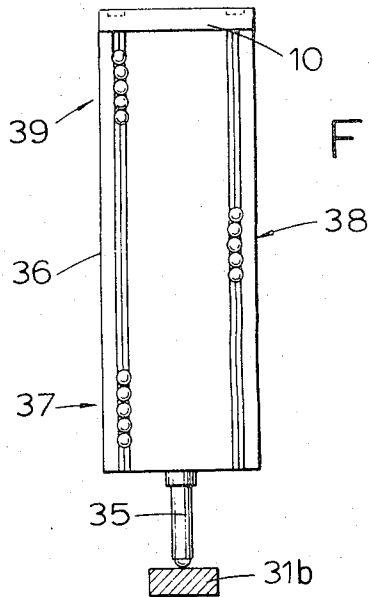


Fig. 8.

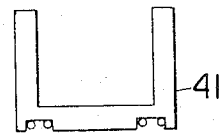


Fig. 9.

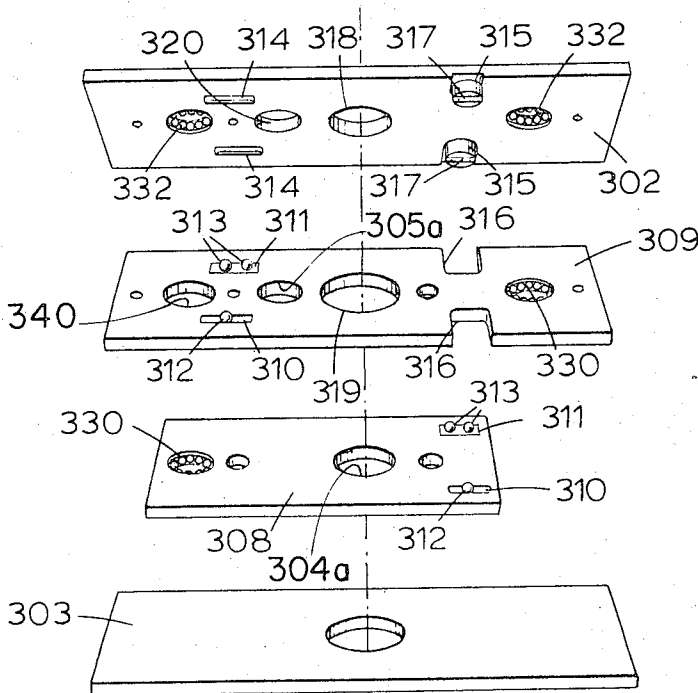


Fig. 11.

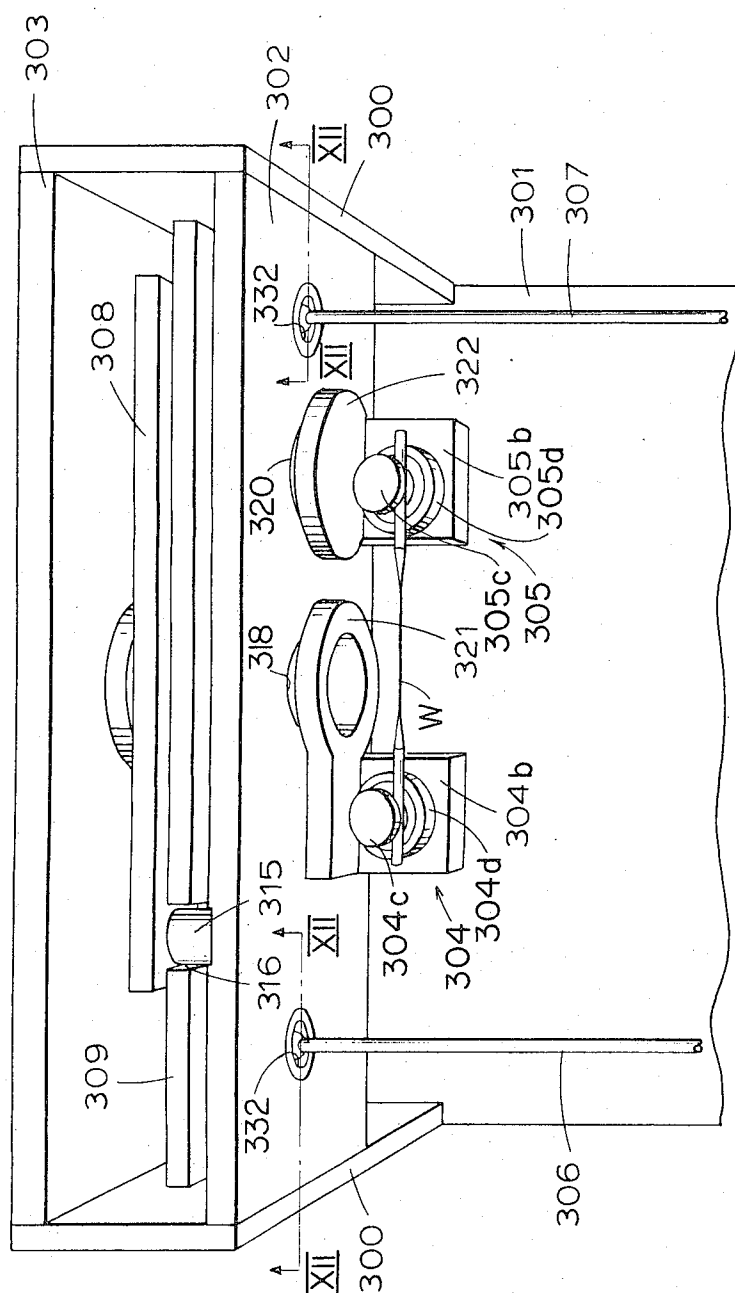


Fig. 10.

MICROSCOPE MANIPULATOR

BACKGROUND OF THE INVENTION

This invention relates to a movement reduction apparatus in which the movements performed by an operating member handled by an operator are transmitted to a manipulator through a mechanism which reduces the scale of the movements to such an extent that the movements of an instrument or other item held by the manipulator may be observed through a microscope.

The known apparatus of this type such as that described in my U.S. Pat. No. 2,680,397 issued June 8, 1954 are attended by certain deficiencies and it is a general object of the invention to provide an improved apparatus.

It is another object of the invention to provide movement reduction apparatus comprising first and second plates which are supported in parallel relationship for the movement of the first plate, which carries the manipulator, relative to the second plate under the action of the operating member which cooperates with each plate by way of a respective ball joint.

It is a further object to provide such apparatus in which the plates are held apart by balls which are free to roll in tracks on the second plate.

It is a further object to provide such apparatus in which each of the plates accommodates a ball race in an opening, which races serve as bearings for the ball joints of the operating lever.

It is a further object to provide such apparatus in which a handpiece includes a slider movable relative to the operating lever which is held in contact therewith by magnetic means, such as a pair of magnetised balls set into the wall of the slider.

It is a further object of the invention to provide such apparatus in which the handpiece is pivotally movable about a universal joint assembled from three rings hinged together, the centre ring having an opening large enough to receive the sliding connection between the slider and operating lever.

It is a further object of the invention to provide such apparatus in the form of a micro-forge comprising a front plate having openings to receive operating levers, a pair of plates each movable by a respective operating lever, and each plate bearing a tube holder. It is a further object of the invention to provide such apparatus in the form of a micro-manipulator or microforceps.

The improvement made by the invention enables the parts to be held together by a greatly increased spring pressure than hitherto. In this way, the apparatus can be made to exert very considerable working pressure or be loaded with considerable weights without detriment to its performance. The apparatus can also be turned sideways without there being any loss of contact between the balls and their tracks.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a micromanipulator;

FIG. 2 is an underneath perspective view of the upper horizontal movable plate;

FIG. 3 is a side perspective view on an enlarged scale of the hand grip and second reduction mechanism;

FIG. 3A is a sectional view taken on the line A—A in FIG. 1;

FIG. 3B is a view similar to FIG. 3A but showing just part of the structure illustrated therein in an adjusted position;

FIG. 4 is a section taken on the line 4—4 of FIG. 3;

FIG. 5 is a section taken on the line 5—5 of FIG. 3;

FIG. 6 is a perspective view looking downwards onto the lower fixed horizontal plate;

FIG. 7 is a side view of the fixed vertical plate;

FIG. 8 is a side view of the vertically movable plate;

FIG. 9 is a plan view of the part shown in FIG. 7;

FIG. 10 is a plan perspective view of a micro-forge embodying the invention;

FIG. 11 is an exploded plan view of the main components of the micro-forge of FIG. 10, and

FIG. 12 is a section on the lines XII—XII of FIG. 10.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIG. 1 of the drawings, a micro-manipulator comprises a movable plate 1 which carries a depending link arm 2. A clamping mechanism 3 clamps to the arm a slidable carrier 4 supporting gripping jaws 5. The gripping jaws 5 constitute a manipulator which may support directly or indirectly a stylus to which movement is imparted. A hand grip 6 is movable manually to swing an operating lever 7 about a pivot formed by a lower ball joint 18 (FIG. 3). The plate 1 rests on a horizontal fixed plate 10 on bearing points comprising steel or phosphor bronze balls 11 and 12 capable of running on guideways 111 and 121 as shown in FIG. 6. To cooperate with the balls, the plate 1 has a guideway 15 and an elongate plane bearing surface 9. Each guideway may be in the form of a v-groove. The guideways and bearing surface are formed from a hard material such as a steel agate hard alloy. Alternatively, the guideways may be constituted by a pair of parallel steel rods set into a rectangular channel. At the tapering ends of the plates 1, 10 are apertures 13 (FIG. 6) and 16 (FIG. 2) which receive races of balls 131 and 161. When assembled, the race of balls 161 rests on the endmost ball joint 17 of the operating lever while the lower ball joint 18 of the latter rests on the race of balls 131. The two horizontal plates are therefore separated by bearing points at each corner. A screwed fixing bolt 19 is provided which passes through the plate 1 by way of an aperture 20 (FIG. 2) sufficiently large to allow the plate some freedom of movement. The plate 1 is pressed down onto the bearings by a clamping device 21 which includes a nut 211 which is screwed onto the bolt 19 and acts through the intermediary of a spring 212 on a circular plate 213. A ring of balls 214 is interposed between circular plate 213. A ring of balls 214 is interposed between the plate 213 and a receptacle 215 and transmits the clamping force to the plates 1 and 10.

Movement of the operating lever 7 about its pivot point, so as to cause ball 18 to pivot in the ball race 13 results in a very much reduced movement being transmitted by the ball 17, without backlash to the movable plate 1 and thus without alteration to the arm 2 and the parts associated therewith. Having regard to FIG. 3A, if the lever 7 is pivoted in the plane of the paper, say into the position of FIG. 3B, the plate 1 and hence the stylus carried by jaws 3 are moved linearly. If now the

lever 7 is pivoted out of the plane of the paper, the plate 1 swivels about the ball 11 which is trapped between the guideways 111, 15. During this movement, the plane bearing surface 9 rides on the ball 12. A composite movement in two dimensions may therefore be applied to the stylus. The length of the associated parts will increase or decrease by normal leverage the movement of the remote ends associated with the stylus but this can be readily adjusted by the user.

The apparatus includes a second reduction mechanism which includes a lower rotatable disc 22 from which three rigid rods 23, 24 and 25 extend upwardly. The rods are joined at their upper ends to an annular plate 221. Sliding upon these rods are twin collars 26 of a tube 261 having a downwardly extending extension 262 incorporating a device for providing an adjustable connection with the lever 7 (FIG. 5). This device comprises a magnet 263 set into the wall of the extension piece. Two balls 264, 265, within the extension piece are associated with the poles and form induced magnets to which the lever 7 acts as an armature. A strong connection is thereby formed between the extension piece and the lever, but is one which nevertheless permits sliding, rotary and pivotal movement of one relative to the other. Thus by sliding the collars up and down the rods 23, 24 and 25 the point of contact between the magnet which forms part of the hand grip 6 and the lever 7 can be moved towards or away from the fulcrum 18 giving increased or decreased leverage as required. This movement can take place without preventing or being affected by rotation of the hand grip 6 or movement of the hand grip 6 about its pivot 29 as hereinafter described.

Referring now to FIG. 4, from which for clarity the lever 7 has been omitted, the hand grip 6 is pivoted to the base for universal movement by a joint 28. This joint comprises an outer ring 281 an intermediate ring 282 and an inner ring 283. The ring 283 is able to pivot relative to the ring 281 about the axis of hinges 284, which axis extends perpendicular to the plane of the paper. The ring 282 is permitted to pivot relative to the ring 283 about the axis of hinges 285, which axis lies in the plane of the paper. Through both of the rings 282 and 283 extends a bore 286 into which the extension piece 262 can project so as to enable the point of connection between the hand grip and the lever 7 to be made to coincide with, or be located below, the point 29 at which the inner ring 282 is able to pivot universally relative to the outer ring 281. The ring 281 has a spigot 287 to which is fitted a threaded rod 30 which screws into the base 31, only a fragment of which is depicted in FIG. 4.

It thus follows that the hand grip 6 can be rocked universally by hand about the pivot point 29 within the limits imposed by the size of the hole 32 in the centre of the hand grip 6 and the size of the operating lever 7. This rocking motion will thus move the arm 2 under extreme reduction, the degree of reduction being controlled by the position of collars 26 up and down the rods 23 and 24 and 25.

Rotation of the hand grip 6 will rotate the assembly of rings 281, 282, and 283, and cause the rod 30 to be screwed into or out of the base. Mounted beneath the base, is a two armed lever on one arm 31a of which bears the rod 30 and on the other arm 31b of which bears an extension 35 of a vertically movable plate 36 shown in FIG. 8. The plate 10 is secured to the plate 36

by screws passing through screw holes 141 in the plate 10. The vertically movable plate 36 is held by a fixed plate 36a against a fixed vertical plate 41 mounted on the base 31 so as to raise or lower the plate 10 in response to rotation of the hand grip 6.

The vertically movable plate 36 is provided with three sets of bearings 37, 38 and 39 each formed from five balls supported in tracks similar to those provided on the plate 10. The fixed plate 41 is provided with a pair of vertical tracks against which the balls of the plate 36 bear. These tracks may be constituted by pairs of parallel rods. It will be seen that rotation of the hand grip 6 serves to raise both of the horizontal plates 1 and 10 and in consequence the stylus attached to the rod 2, whilst rocking movement of the hand grip moves the plate 1 and hence the stylus in any desired horizontal direction.

A semi-circular hand rest 45 (FIG. 1) is provided upon which the hand or wrist of the operator can be rested while operating the hand grip.

The invention may be applied to a micro-forge as shown in FIGS. 10 and 11. As shown in FIG. 10, the apparatus comprises a pair of end plates 300 which extend vertically from a base 301. The end plates are rigidly joined together by a front plate 302 and a back plate 303. Forwardly of the front plate 302 are supported a pair of manipulators, namely a left manipulator 304 and a right manipulator 305. The manipulator 305 is operated from a control lever 306 and the manipulator 304 from a control lever 307. The manipulators are arranged to grip a workpiece W such as a tube or rod. Movement of the control levers is transmitted to the manipulators by way of movable plates 308 and 309. The plate 308 has a socket 304a into which a connection 321 of the manipulator 304 is fitted, the connection 321 passing through holes 318 and 319 in the plates 302 and 309 respectively. The plate 309 has a socket 305a into which a connection 322 of the manipulator 305 is fitted, the connection passing through a hole 320 in the front plate 302.

As shown in FIGS. 11 and 12, the plates 308, 309 have respective apertures 330, 331 provided with ball races for the endmost balls 307a, 306a on the control levers 307 and 306 respectively. The plate 302 has two apertures 332, each provided with ball races and receiving a respective one of the other balls 306b, 307b of the control levers while the plate 309 has an aperture 340 devoid of ball races for the part of the lever 307 intermediate the balls 307a and 307b.

As shown in FIG. 11, each of the plates 308, 309 has a planar bearing surface 311 against which bears two balls 313, and a groove 310 in which is received a ball 312. The plate 302 has at one end a pair of grooves 314 for cooperation with the balls shown in contact with the plate 309 and short pillars 315 which project through recesses 316 in the plate 309 and have grooves 317 for engagement with the balls 312, 313 shown in contact with the plate 308.

Each of the manipulators has a body part 304b, 305b into which is screwable a screw 304c, 305c, between which and a ring 304d, 305d the ends of the workpiece are gripped.

The mechanism provides a reversal of movement so that when viewed through a microscope the movement viewed is apparently in the same direction as the movement given to the levers. Also, horizontal movement is subjected to a moderate reduction whereas vertical

movement is subjected to a substantial reduction. This feature is especially useful in that it allows the tension applied to the tube or rod being forged to be kept relatively large while vertical movements transversally of the tube or rod to be kept small.

A knob to control the intensity of heat may be separate from the control knobs or may be incorporated in one or both of the two ball operating levers. One or both of the tool holders (one of which may hold the filament) is rotatable in the vertical plane and also the tool holders may be rotatable in the horizontal plane to enable the hot filament glass rod tube to be in focus alignment. A small flame operated by coal, propane, butane, hydrogen or other gas may either supplement or wholly replace the hot platinum filament. This flame has vertical, sideways and back and forth rocking movements enabling fine adjustment of the size and intensity of the heating provided by the gas jet.

The invention may also be applied to a pair of micro-forceps comprising a fixed plate and a movable plate to each of which is attached a clamp for a point tool and an arm adjustable horizontally, vertically and angularly by means of a joystick control.

I claim:

1. A movement reduction apparatus comprising:

- a. a support structure comprising a base member from which there extends upwardly a support post having a vertical support surface provided with two vertical bearing tracks;
- b. a vertically extending plate disposed in co-planar relationship with said vertical support surface and likewise being provided with two vertical bearing tracks narrowly spaced from those of the vertical support surface;
- c. three sets of rolling bearings disposed between the bearing tracks of the plate and vertical support surface; said plate being pressed against said bearings so as to be movable vertically in relation to said vertical support surface;
- d. a first horizontal plate fixed to the upper end of said vertically extending plate, said horizontal plate having at one end an opening in which is received a race of ball bearings and at the other end on its top side two spaced bearing guideways;
- e. a second horizontal plate supported above said first horizontal plate, said second plate having at one end an opening in which is received a race of ball bearings, and at the other end on its underside a guideway and a spaced elongate plane bearing surface;
- f. ball bearings disposed between the guideways and plane bearing surface of the two said plates, so that said second plate is movable relative to said first plate;
- g. an operating lever having an elongate rod-like portion depending from a pair of rounded portions, one of which portions is received in the race of bearings of the first plate so as to form therewith a first ball joint and the other of which portions is received in the race of bearings of the second plate so as to form therewith a second ball joint;
- h. a rotatable hand grip surrounding the rod-like portion of said operating lever, said hand grip including a plurality of upwardly extending guides terminating at their lower ends in one component of a universal joint, the other component of which joint

has a screw-threaded part adapted to screw into a part rigid with the said base member;

- i. lever means under the action of said screw threaded part when said hand grip is rotated to raise and lower said vertically extending plate;
 - j. a slider movable vertically on said guides;
 - k. magnetic means holding the elongate rod-like portion of said lever in contact with said slider, whereby when the slider is moved vertically the point of contact between said lever and hand grip is adjusted; and
 1. an instrument holding device carried by said second plate at the end remote from said opening.
2. Apparatus as in claim 1, wherein said slider consists of a tube into the wall of which is set two magnetised balls.
3. Apparatus as in claim 1, wherein said universal joint is assembled from three concentric rings, the inner of which rings is hinged to the intermediate one for pivoting about a first axis while the outer of the rings is hinged to the intermediate ring for pivoting about a second axis perpendicular to the first axis, said inner ring having a central opening sufficiently large to receive that part of said slider in which said magnetised means are located.
4. A movement reduction apparatus comprising:
- a. a support structure comprising a base member from which there extends upwardly a support post having a vertical support surface provided with two vertical bearing tracks;
 - b. a vertically extending plate disposed in co-planar relationship with said vertical support surface and likewise being provided with two vertical bearing tracks narrowly spaced from those of the vertical support surface;
 - c. three sets of rolling bearings disposed between the bearing tracks of the plate and vertical support surface; said plate being pressed against said bearings so as to be movable vertically in relation to said vertical support surface;
 - d. a first horizontal plate fixed to the upper end of said vertically extending plate, said horizontal plate having at one end an opening in which is received a race of ball bearings and at the other end on its top side two spaced bearing guideways;
 - e. a second horizontal plate supported above said first horizontal plate, said second plate having at one end an opening in which is received a race of ball bearings, and at the other end on its underside a guideway and a spaced elongate plane bearing surface;
 - f. ball bearings disposed between the guideways and plane bearing surface of the two said plates, so that said second plate is movable relative to said first plate;
 - g. an operating lever having an elongate rod-like portion depending from a pair of rounded portions, one of which portions is received in the race of bearings of the first plate so as to form therewith a first ball joint and the other of which portions is received in the race of bearings of the second plate so as to form therewith a second ball joint;
 - h. a rotatable hand grip surrounding the rod-like portion of said operating lever, said hand grip including a plurality of upwardly extending guides terminating at their lower ends in a hollow first ring;

- i. second and third rings disposed in concentric relationship with said first ring, hinge means pivoting said first ring to said second ring and said second ring to said third ring, the pivot axes of said hinge means being perpendicular whereby said first ring has universal movement relative to said third ring; 5
- j. A screw means carried by said third ring, said screw means screwing into a part rigid with said base member when said third ring is rotated; 10
- k. means responsive to axial movement of said screw means to produce movement of said vertical plate in the vertical direction;
- l. a slider movable vertically on said guides, said slider comprising a cylinder having large and small diameter sections, said small diameter section housing means for retaining said lever in contact with said slider, whereby when said slider is moved vertically the point of contact between said lever and hand grip is varied, said small diameter section being adapted to enter the said hollow first ring, whereby said point of contact is disposed at least as low as the point about which said hand grip has universal movement. 15 20 25
- m. an instrument holding device carried by said second plate at the end remote from said opening. 25
- 5. A movement reduction apparatus comprising:
 - a. a housing having a front wall formed therein with first and second spaced openings at its one and other ends respectively, and with third and fourth openings between said first and second openings, a pair of first bearing tracks at one end, and a pair of posts with bearing tracks at the other end, each of said first and second openings having retained therein a race of balls; 30 35
 - b. a first movable plate disposed rearwardly of said front wall, said plate having formed therein first,

- second and third spaced openings in alignment with the openings in the front wall, a groove and spaced planar bearing surface at said one end and cut-outs at said other end, in which cut-outs are received said posts, said second opening having retained therein a race of balls;
- c. a second movable plate disposed rearwardly of said first plate, said plate having formed therein an opening in alignment with said second openings in said front wall and first plate, and a groove and spaced planar bearing surface in alignment with said posts, a race of balls being retained in said opening,
- d. first and second operating levers each formed at one end with a pair of rounded portions, said first lever extending through said first openings, and having its endmost rounded portion received within the race of balls received in said first opening in said first plate and its other rounded portion retained in said first opening in said wall, said second lever having its endmost rounded portion received in the race of balls retained in the opening in said second plate, and its other rounded portion received in the race of balls retained in the second opening in the wall;
- e. rolling bearing means disposed between the bearing tracks of the wall and said groove and spaced planar bearing surface of said first plate and between the bearing tracks on the posts and said groove and spaced planar bearing surface of said second plate,
- f. manipulator means carried by the first plate and extending through the fourth opening in the wall, and manipulator means carried by the second plate and extending through the third openings in said wall and first plate.

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