

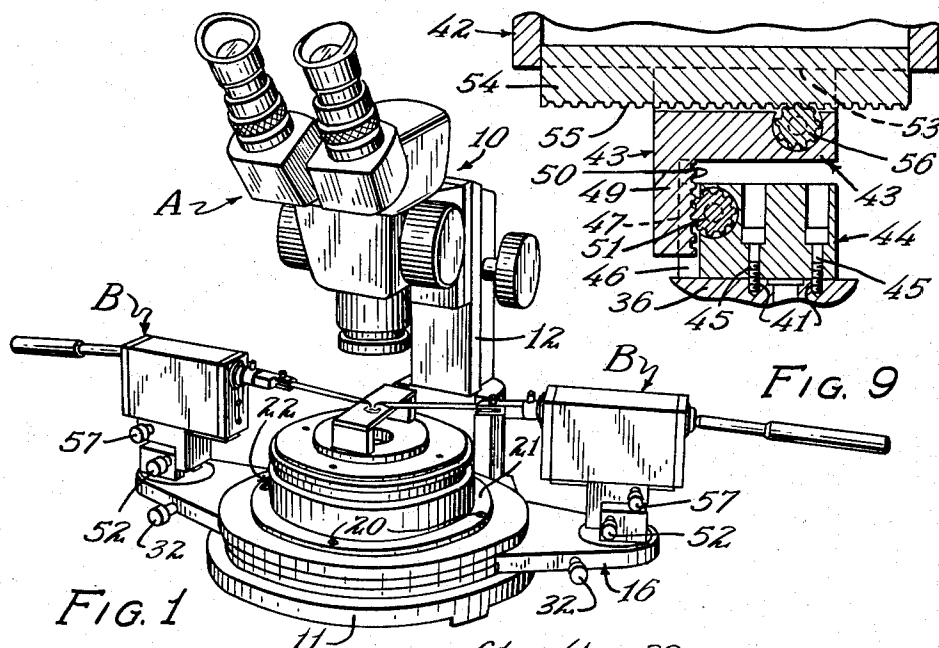
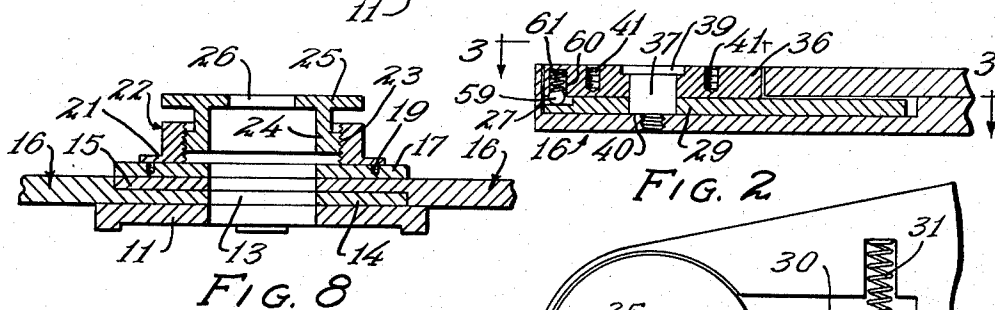
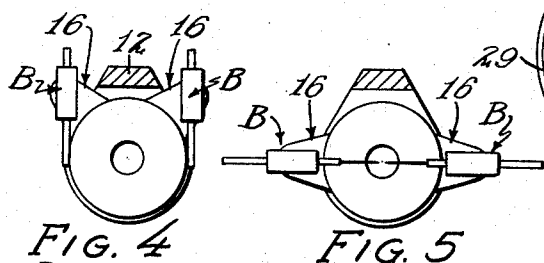
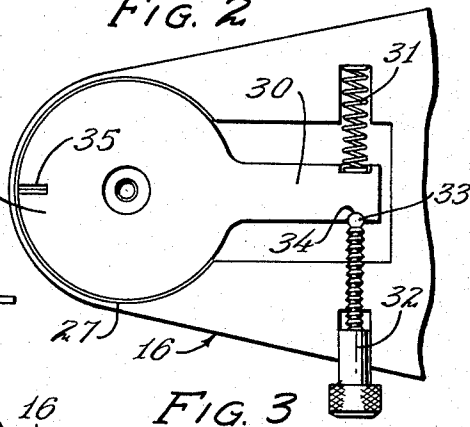
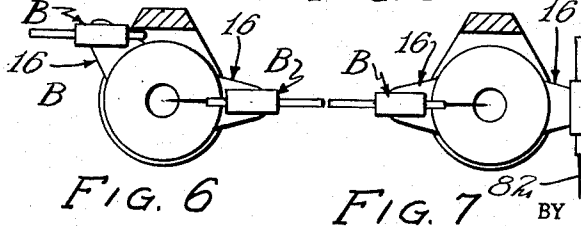
April 20, 1965

R. P. FERLEN
MICROMANIPULATOR

3,179,260

Filed May 18, 1962

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

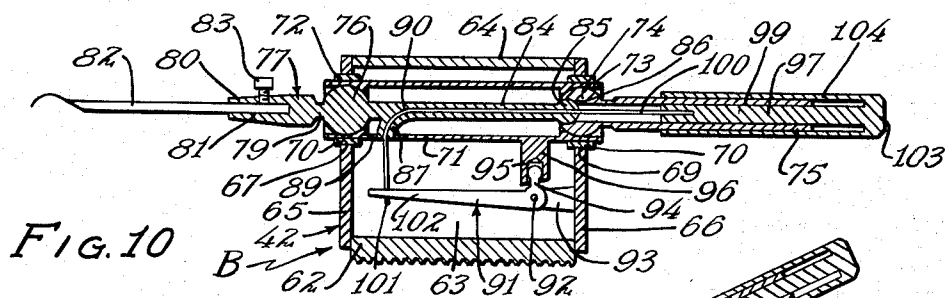


FIG. 10

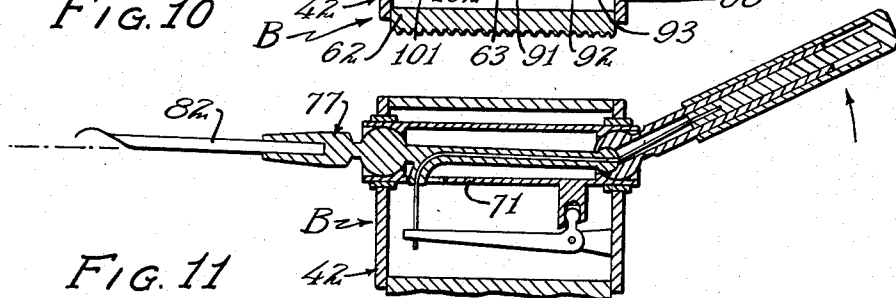


FIG. 11

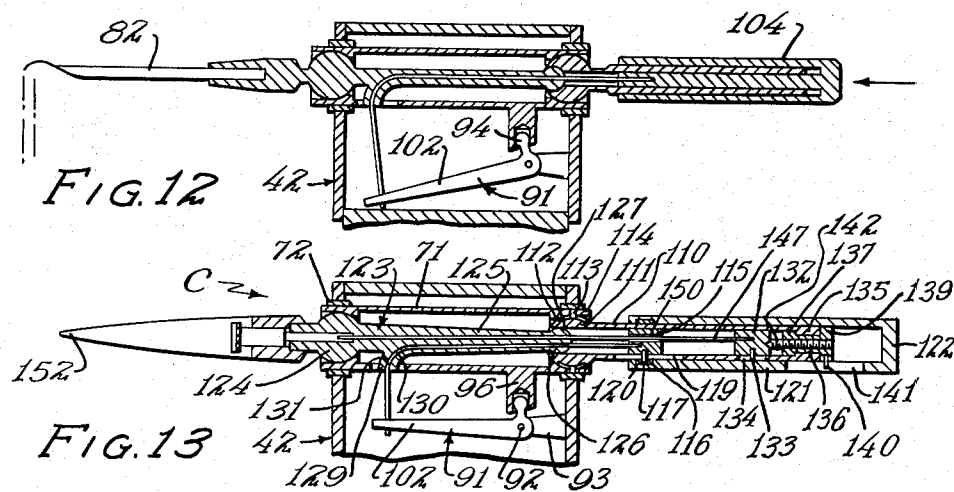


FIG. 12

FIG. 13

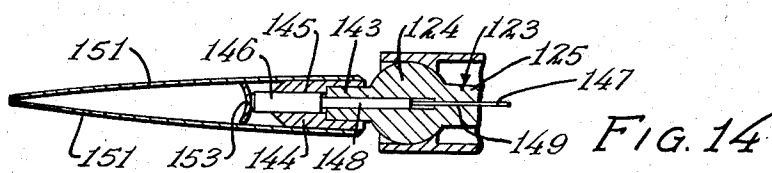


FIG. 14

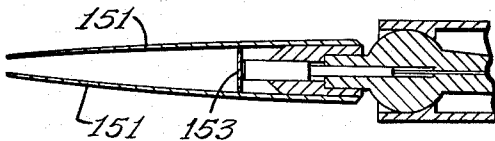


FIG. 15

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3,179,260

MICROMANIPULATOR

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13 Claims. (Cl. 214-1)

This invention relates to an improvement in a simple and inexpensive micromanipulator designed to work in the intermediate range between delicate hand operations and the extremely minute motions required for manipulation under a high powered microscope. The invention also includes a versatile means of supporting the micromanipulator adjoining the base of the microscope so that the device may be quickly and easily moved into operating position and out of operating position.

An object of the present invention in its simplest form comprises essentially a two-lever system so arranged that gross motions of an input handle are reduced and transmitted to a tool point or other instrument. As the device may be operated solely by operation of the single input lever, the device may be readily used after a minimum of training.

In its simplest form, the device comprises a hollow housing or support which slidably supports a sleeve for movement on a horizontal axis. The operating handle is universally supported at one end of the sleeve and the secondary lever supporting the tool point is universally mounted at the other end of this sleeve. The operating handle includes a pair of handle sections in telescoping relation. By moving one section of the operating handle relative to the pivotally supported section, movement is transmitted through a flexible connector to the long arm of a lever within the housing or support. Pivotal movement of the lever acts through a short lever arm to slide the sleeve relative to the housing and to produce movement of the tool point in a direction axially of the sleeve. The reduction in the movement transmitted depends upon the ratio of the length of arms of the pivoted lever.

Means is also provided to translate movement of the operating handle in any direction from a center position in co-axial relation to the sleeve to the secondary lever supporting the tool point. The secondary lever is provided with a relatively long arm extending through the supporting sleeve and engageable with the handle lever at a distance relatively close to the axis of universal support of this handle lever. If the tool point is supported at a distance equal to that between the axis of the universal support and the point or engagement with the handle socket, the reduction in movement transmitted to the tool point will comprise the ratio between the length of the long arm of the secondary lever and the short arm of the primary or handle lever.

A feature of the present invention lies in the fact that if desired, forceps or a similar tool may be used in place of the tool point. A means is provided within the primary or handle lever which is moved longitudinally of the pivoted primary lever upon rotation of the telescoping portion of the handle. This motion is translated through a suitable flexible connector through the secondary lever to operate the forceps. This, of course, can be similarly used to operate switches, a tool turret, a micro-larriet, or some other device of this type.

A further feature of the present invention resides in the manner in which one or more of the micromanipulators can be mounted with respect to the base of the microscope to function in conjunction therewith. A supporting base is provided which supports a primary stage which is rotatable about the optical axis of the microscope and also supports one or more radially extending arms which may also rotate on the same axis. Supporting means are provided on these arms which permit the micromanipulator

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housings to rotate about a vertical axis or to be moved vertically, radially, or in virtually any desired direction to properly locate the tool point or other instrument with respect to the microscope field.

These and other objects and novel features of the present invention will be more clearly and fully set forth in the following specification and claims:

In the drawings forming a part of the specification:

FIGURE 1 is a perspective view of a microscope showing a pair of micromanipulators mounted for use in conjunction therewith.

FIGURE 2 is a vertical sectional view through one of the radial supporting arms.

FIGURE 3 is an elevational view, partly in section, showing the end portion of one of the arms, the position of the section being indicated by the line 3-3 of FIGURE 2.

FIGURES 4, 5, 6, and 7 are all diagrammatic views showing the micromanipulator supporting arms in various positions relative to the microscope.

FIGURE 8 is a vertical sectional view through a simple form of secondary stage which may be used in conjunction with the microscope base.

FIGURE 9 is a vertical sectional view through a portion of the micromanipulator support illustrating diagrammatically the manner in which the support may be adjusted vertically and radially.

FIGURE 10 is a vertical sectional view through the micromanipulator showing the general arrangement of parts therein.

FIGURE 11 is a view similar to FIGURE 10 and showing the operating elements in a different relative position.

FIGURE 12 is a view similar to FIGURES 10 and 11, showing the manner in which the tool point may be moved in a direction axially of its support.

FIGURE 13 is a vertical sectional view through a modified form of micromanipulator which may be used to develop an additional force for use in operating forceps or the like.

FIGURE 14 is a horizontal sectional view through the operating end of the micromanipulator shown in FIGURE 13.

FIGURE 15 is a view similar to FIGURE 14 but showing the forceps in open position.

The microscope A which is illustrated in FIGURE 1 of the drawings may comprise a microscope body 10 supported above a base plate 11 by an upright standard 12. The microscope is equipped with the usual adjustments to regulate the height of the microscope as well as the focus thereof. As this structure is well known in the art, a detailed description of the structure is believed unnecessary.

As indicated in FIGURE 8 of the drawings, the base 11 may be provided with a cylindrical light compartment 13 about which are rotatably supported a pair of rings 14 and 15 each of which supports a radially extending arm 16. A primary stage 17 is rotatably supported above the rings 14 and 15 and may be provided with threaded sockets 19 extending into its upper surface for accommodating accessories of various types. For example, the sockets 19 may be used to accommodate cap screws 20 extending through the flanged edge 21 of a secondary stage which is indicated in general at 22. The secondary stage 22 may either be secured in place as illustrated, or may be movable on the primary stage and readily removable therefrom. In the particular arrangement illustrated, the secondary stage 22 includes an internally threaded vertical sleeve 23 designed to engage the external threads of a cooperable sleeve 24 extending downwardly from the disklike platform 25. The platform 25 is preferably provided with an axial opening 26 therethrough to permit

light to be directed upwardly through the secondary stage 22.

As is indicated in FIGURES 2 and 3 of the drawings, the arms 16 are recessed as indicated at 27 to accommodate a disk 29 provided with an integral radially extending arm 30. The recess 27 is of sufficient size to permit angular adjustment of the disk 29 about its axis. A spring 31 is recessed into the arm on one side of the notch 27, and an adjustment screw 32 having a rounded end 33 is engaged in a suitable notch 34 on the other side of the arm 30. The arm 30 may be pivoted in a counter-clockwise direction as viewed in FIGURE 3 by threading the adjustment screw 32 inwardly while return movement is accomplished by the spring 31. The upper surface of the disk 29 is provided with a radially extending notch 35 for a purpose which will be later described.

A rotary mounting table 36 overlies the disk-shaped end 29 and is rotatable with respect thereto. The disk 29 and table 36 are rotatably supported for rotation about the axis of a pivot bolt 37 equipped with a head 39 which is recessed into the upper surface of the table 36, and which is provided with a stop shoulder 40 for limiting the distance to which the pivot may be threaded into the arm 16. The upper surface of the table 36 is preferably provided with threaded sockets 41 to accommodate bolts for securing the lower portion of the micromanipulator mount to the table.

As indicated in FIGURE 9 of the drawings, the micromanipulator housing 42 is supported by supporting mount 43 which includes a lower block 44 which is adapted to be secured to the turntable 36 by means of mounting bolts 45 which extend into the threaded sockets 41. One vertical edge of the block 44 is provided with the wedge-shaped slot 46 into which is dovetailed a corresponding wedge-shaped projection 47 on a downwardly extending flange 49 on one end of the upper block 43. In other words, the flange 49 is dovetailed with respect to the lower block and the upper block is vertically adjustable. Rack teeth 50 in the edge of the projection 47 are engageable with a pinion 51 mounted in the lower block 44 and the pinion 51 may be rotated by a suitable coaxial adjusting knob 52 projecting from a side of the block 44.

In a similar manner, the upper horizontal surface of the upper block 43' is provided with a wedge-shaped groove 53 designed to accommodate a wedge-shaped projection 54 in the lower horizontal surface of the micromanipulator housing 42. If preferred, the wedge-shaped projection 54 may be mounted upon a plate detachably connected to the under surface of the housing 42. The projection 54 is provided along its under surface with rack teeth 55 which are in mesh with a pinion 56 rotatably supported in the upper block 43'. An adjustment knob 57 projects from a side of the block 43' to permit the adjustment of the housing 42 in a horizontal direction.

As may be noted in FIGURE 2 of the drawings, a detent ball 59 is supported in a recess 60 in the under surface of the turn table 36, and is urged by a spring 61 against the upper surface of the disk 29. As a result, once the position of the micromanipulator has been adjusted to a certain area of the microscope field, the turntable 36 may be rotated out of the way and returned to the same position by merely rotating the turntable until the detent ball 59 drops into the groove 35 in the upper surface of the disk 29.

FIGURES 10, 11, and 12 of the drawings show the micromanipulator B in its simplest form. The housing 42 includes a bottom wall 62, upwardly extending parallel side walls 63 on opposite sides of the bottom panel 62, and a horizontal top panel 64 connecting the upper edges of the side walls 63. The housing 42 also includes parallel end walls 65 and 66, at least one of which is preferably detachable and which are normally held in place by bolts or other means, not illustrated in the drawings. The end walls 65 and 66 are provided with aligned apertures 67 and 69 therethrough in which are

positioned aligned bearings 70. The bearings 70 slidably support a sleeve 71 for axial movement relative to the housing. The ends of the sleeve 71 are provided with bearing sockets 72 and 73, the inner surfaces of which are spherical surfaces. The socket 73 universally supports a ball pivot 74 on one end of a handle arm 75. The socket 72 supports the ball pivot 76 of a secondary lever 77. The ball pivot 76 is connected by a neck 79 with a lever arm 80 having an axial socket 81 therein for accommodating a microtool 82 of any suitable type, the tool being detachably supported in the socket 81 by a set screw 83. An extension of the axis of the tool-holding socket preferably extends through the center of the ball pivot 76 and is coaxial with a second lever arm 84 secured to and extending from the opposite side of the ball pivot 76.

The lever arm 84 is provided with a ball-shaped extremity 85 which extends in a cylindrical socket 86 in the ball pivot 74 and which is on the axis of the handle arm 75. The center of the ball end 85 is thus spaced but a short distance from the axis of the ball pivot, so that the handle arm 75 may be swung in any direction through a considerable angle while only swinging the secondary lever 77 through a small angle due to the difference in length of the lever arms.

The lever arm 84 is provided with an arcuate branch 87 which extends through an aperture 89 in the sleeve 71 and leads to the interior of the housing 42. A passage 90 extends through the lever branch 87 and through the extremity of the lever arm 84 including the ball end 85. A bellcrank lever 91 is pivotally connected intermediate its ends at 92 to a bracket 93 on the housing end wall 66. The bellcrank lever 91 includes a short arm 94 having a rounded extremity pivotally engaged in a socket 94 in the end of a radially extending arm 96 on the sleeve 71. Accordingly, pivotal movement of the bellcrank lever 91 in a clockwise direction will slide the sleeve 71 to the right as viewed in the drawings, and counter-clockwise pivotal movement of the lever 91 will move the sleeve 71 to the left, thus moving the micro-tool 82 in a direction parallel to the axis of the sleeve 71.

A plunger 97 is slidably supported in the axial bore 99 of the handle arm 75. A flexible connector 100 is anchored to the inner extremity of the plunger 97 and extends through the hollow handle arm 75, and through the passage 90 leading through the lever arm 84 and its branch 87. The end of the flexible member 100 is anchored at 101 to the long arm 102 of the bellcrank lever 91 to transmit movement from the plunger 97 to the bellcrank lever to pivot the same. In actual practice the flexible connecting member 100 possesses sufficient rigidity to enable the bellcrank lever 91 to be pivoted in both directions, and is supported from buckling by being enclosed within a supporting sleeve of Teflon or similar material throughout the major portion of its length. The friction between the plunger 97 and the handle arm 75, as well as the friction between the sleeve 104 and this handle arm 75 tends to move the sleeve 71 upon longitudinal movement of the sleeve 104. As a result, the movement of the connector 100 acts as a metering force to control the movement of the sleeve 71 rather than to simply act as a primary means of moving the sleeve. This is true as the sleeve 21 cannot be forced manually beyond the distance permitted by the lever 91. In other words, the connector 100 and lever 91 function to smooth axial movements of the sleeve 71.

The plunger 97 is axially connected to the closed end 103 of a sleeve 104 which is in telescoping relation with the handle arm 75. Thus by pushing or pulling slightly on the sleeve 104, the lever supporting sleeve 71 will slide to advance or retract the position of the microtool 82. As is true of any device of the type in question, the parts are precision made and operate with extreme accuracy, and also the various parts may be moved very easily and with little friction.

The operation of the apparatus is believed understandable from the foregoing description. FIGURE 10 of the drawings shows the apparatus in a generally central position between the two extremes. When the operating handle has been swung upwardly as indicated in FIGURE 11, the microtool 82 is swung upwardly to a minor degree. Similarly, when the sleeve 104 forming a part of the handle lever is moved to the left as indicated in FIGURE 12 of the drawings, the micro-tool 82 is moved a fraction of the amount. The reduction in movement of the lever supporting sleeve 71 relative to the movement of the handle sleeve 104 is dependent upon the ratio between the lengths of the arms 94 and 102 of the bellcrank lever 91. The reduction in angular movement in any direction between the handle lever and the tool is proportional to the relationship in distance between the center of the pivot ball 72 and the ball end 85 of the lever arm 84 to the distance between the center of the ball end 85 and the center of the pivot ball 74. If a smaller ratio of reduction is desired, the handle lever can be provided with a second projecting arm opposite the handle arm 75 in which the ball end 85 is pivotally supported.

In FIGURES 13, 14, and 15 of the drawings, I show a modified form of micromanipulator C which is similar to that previously described, but which includes an added movement which may be used to operate a micro-tool which may be actuated by rotation of the handle. This added action is shown in the drawings as operating a pair of forceps, the added force being used to open the forceps.

In the micromanipulator C, the housing 42, the bellcrank lever 92 for moving the sleeve 71 through the arm 96, as well as the micromanipulator support is similar to that previously described and accordingly the same identifying numerals have been used. However, in the device C, the hollow handle arm or lever 110 is provided at one end with a pivot ball 111 having a spherical outer surface. However, the surface of the ball pivot 111 is interrupted by a pair of arcuate grooves 112 which are arranged on planes through the axis of the ball and the handle lever. Pins 113 extend through the socket bearing 114 at one end of the sleeve 71 and extend into the slots 112 to hold the pivot ball 111 and handle lever 110 from rotating about its longitudinal axis.

A plug 115 is slidable within the hollow handle lever 110 and is connected to a ring 116 slidably supported on the outer surface of the handle lever 15 by a pin 117 which extends through a longitudinally extending slot 119 in the handle lever 110. The sleeve 116 is rotatably supported in a groove 120 on the inner surface of an outer sleeve 121 which is in telescoping relation to the handle lever 110. The outer sleeve 121 is preferably, but not necessarily, provided with a closed outer end 122.

The secondary lever 123 is provided intermediate its ends with a pivot ball 124 which is engaged in the socket bearing 72 at the other end of the sleeve 71. The secondary lever 123 is provided with a long lever arm 125 having a spherical end engaged in a cylindrical socket 127 extending axially of the handle 110 in the ball 111. The lever arm 125 is provided with a curved branch 129 and a passage 130 extends longitudinally through the major portion of the lever arm 125 and through the branch 129. A flexible connector 131 extends through the passage 130 and is anchored at one end to the slidable plug 115 and at its other end to the long lever arm 102 of the bellcrank 91.

From this part of the description, it will be clear that longitudinal movement of the outer sleeve 121 upon the handle sleeve 110 will slide the sleeve 116 longitudinally within the handle sleeve 110, the movement being transmitted through the connecting pin 117.

As the pivot ball 111 of the handle lever 110 is held from rotation, the plug 115 and external sleeve 116 is

also held from rotation. However, the sleeve 121 is free to rotate with respect to the sleeve 116.

A second plug 132 is slidably supported in the handle lever 110, the plug 132 being held from rotation relative to the handle lever 110 by the projecting pin 133 which extends radially from the plug 132 and into the longitudinal slot 134 in the handle lever 110. At its outer extremity, the handle lever 110 is provided with an inwardly extending annular flange 135. An internally threaded sleeve 136 extends through the internal flange 135 and is held from axial movement relative to the sleeve 110 by annular flanges 137 and 139. The annular flange 139 is beyond the end of the handle lever 110 and is slidable within the outer sleeve 121. A radially extending pin 140 on the flange 139 extends through a longitudinal slot 141 in the outer sleeve 121 to hold the sleeve 136 from rotation relative to the outer sleeve. The plug 132 is provided with an axial externally threaded shank 142 which is threaded into the sleeve 136.

A short arm 143 projects from the pivot ball 124 in axial alignment with the long arm 125 of the secondary lever 123. A nipple 144 is supported upon the short arm 143 by friction or other means and includes an axial bore 145 which slidably supports a plunger 146. A plunger 148 is slidably supported in the enlarged diameter end of a passage 149 which extends longitudinally through the secondary lever. This plunger 148 is secured to the end of a flexible connecting member 147 which extends through the passage 149, through the pivot ball 111 and through an aperture 150 in the slidable plug 115. The other end of the flexible member 147 is anchored to the plug 132. Upon longitudinal movement of the flexible member 147, the plunger 148 is moved toward or away from the plunger 146 to move the plunger 146. With this arrangement, the nipple 144 and its attached tool may be removed in its entirety and replaced with some other accessory. When a standard tool holder is used, the plunger 148 may be retracted.

A pair of flexible resilient tapered forcep blades 151 are secured in any suitable way to the nipple 144 and are normally biased so that the pointed ends 152 are spring urged together. A spring metal link 153 is provided between the blades 151, the link 153 being connected to the blades 151 in any suitable way, and being normally curved or bowed inwardly at its center toward the nipple 144. Axial movement of the plunger 146 will straighten out the spring 153, separating the blades in the manner illustrated in FIGURE 15 of the drawings.

The plunger 146 is actuated through the flexible connector 147 by rotation of the outer handle sleeve 121. Rotation of this sleeve about its axis causes the rotative movement to be transmitted through the pin 140 to the flange 139 at one end of the sleeve 136. As the sleeve 136 is restrained from axial movement with respect to the handle lever 110 by the flange 135, this rotation acts to thread the threaded shank 142 into or out of the sleeve 136 causing axial movement of the plug 132. This axial movement is transmitted through the connecting member 147 to the plunger 148, which in turn actuates the plunger 146. This movement may act either to spread the blades 151 apart, or permit them to spring together.

The drawings in the present case are somewhat diagrammatic in that certain of the elements are shown in one integral piece rather than as a plurality of assembled pieces. For example, the sleeve 136 with its flanged ends 137 and 139 are shown as an integral unit whereas in practice either the internal flange 135 or one of the external flanges 137 or 139 must actually be removable in order to assemble the structure. However, the drawings show these parts in their simpler form to eliminate the necessity for many enlarged detailed views.

FIGURES 4-7 illustrate the manner in which the micromanipulators may be varied in position by depending upon whether one or both micromanipulators are to be

used and to illustrate the manner in which the space between the microscope A and its table may be cleared to simplify the insertion or removal of slides and the like. The microscope body has been removed in these views to better illustrate the location of the micromanipulators with respect to the primary stage or table. In FIGURE 4 of the drawings, both of the supporting arms 16 have been pivoted back toward the microscope support 12, and the micromanipulator housings have been rotated upon the supporting table 36 so that the heads are folded for storage. In FIGURE 5 of the drawings, both of the supporting arms 16 have been swung into diametrically opposed relation so that both tools may be operated in the optical field. FIGURE 6 illustrates the left hand arm 16 swung back against the microscope support, and the micromanipulator pivoted to clear the left side of the stage. In this position, only the right hand micromanipulator B is in use. In FIGURE 7 of the drawings, both of the arms 16 are swung into position for use, but the right hand micromanipulator B has been pivoted so that the microtool 32 is swung forwardly so that the tool may be changed or replaced.

In addition to the various movements which are provided through operation of the control handles, it should be noted that the rotation of the arms 16 about the axis of the base plate provides a fourth degree of control. By adjustment of the arms about their axis, the angle of attack may be varied between the tool and the work.

While the arms 16 have been described as mounted on the base plate 11, it should be understood that these arms could also be mounted on the microscope itself to rotate about the optical axis. In such an event, the micromanipulators would be mounted on the under side of the arms instead of the upper surfaces thereof. The operation would otherwise be similar to that described.

In accordance with the patent statutes, I have described the principles of construction and operation of my improvement in micromanipulator, and while I have endeavored to set forth the best embodiment thereof, I desire to have it understood that changes may be made within the scope of the following claims without departing from the spirit of my invention.

I claim:

1. A micromanipulator including,
 - a handle lever and a secondary tool supporting lever each having ball pivots intermediate their ends,
 - a bearing support including a pair of spaced sockets universally supporting said ball pivots in predetermined spaced relation,
 - said handle lever including a handle arm extending radially from its ball pivot and having a socketed portion in axially aligned diametrically opposed relation to said handle arm,
 - said secondary lever including a pair of radially extending diametrically opposed arms thereon,
 - one of said secondary lever arms including an end portion engaged in said axially aligned socket portion, the distance between the center of the ball pivot of said secondary lever and said end portion of said one secondary lever arm being materially greater than the distance between the center of the ball pivot of the handle lever and the portion of the axially aligned socket engaging said end portion, and a micro tool connected to other of said secondary lever arms.
2. The structure of claim 1 and means slidably supporting said bearing support in a direction parallel to a line through the centers of said ball pivots.
3. The structure of claim 1 and in which said bearing support comprises a sleeve having its axis extending through the centers of said ball pivot, and including,
 - means for slidably supporting said sleeve for axial movement.
4. A micromanipulator including,
 - a handle lever and a secondary tool supporting lever each having ball pivots intermediate their ends,

- a bearing support including a pair of spaced sockets universally supporting said ball pivots in predetermined spaced relation,
- said handle lever including a handle arm extending radially from its ball pivot and having a socketed portion in axially aligned diametrically opposed relation to said handle arm,
- said secondary lever including a pair of radially extending diametrically opposed arms thereon,
- one of said secondary lever arms including an end portion engaged in said axially aligned socket portion, the distance between the center of the ball pivot of said secondary lever and said end portion of said one secondary lever arm being materially greater than the distance between the center of the ball pivot of the handle lever and the portion of the axially aligned socket engaging said end portion and means slidably supporting said bearing support for movement in a direction parallel to a line through the centers of said ball pivots,
- a bell crank lever pivotally supported by said last named means and having an end engaging said bearing support to move the same upon pivoted movement of said lever,
- a micro tool connected to the other of said secondary lever arms whereby large angular movements of said handle lever produce relatively small movement of said micro tool on said secondary lever, and means on said handle lever for actuating said bell crank lever.
5. The structure of claim 4 and including a flexible connector forming a part of said means for actuating said bellcrank lever.
6. The structure of claim 4 and including a flexible connector connecting said bellcrank lever and said means on said handle lever for actuating said bellcrank lever, said flexible connector extending through a portion of said secondary lever.
7. The structure of claim 4 and in which said means on said handle lever for actuating said bellcrank lever includes a handle portion slidably supported on said handle lever, and a flexible connector connecting said bell crank lever and said handle portion for actuation thereby.
8. A micromanipulator including,
 - a handle lever and a secondary tool supporting lever, universal pivot supports intermediate the ends of said levers supporting said levers in spaced relation,
 - said secondary lever including a lever arm and said handle lever including a socket in which the end of said lever arm is pivotally engaged, the distance between the center point of universal pivot of said secondary arm and the said secondary lever arm end being substantially greater than the distance between the point of engagement of said secondary lever arm end in said socket and center point of universal pivot and said handle lever,
 - means supporting said universal joint supports, and a micro-tool supported on said secondary tool supporting lever.
9. The structure of claim 8 and in which said means supporting said universal joint supports slidably supports said universal joint supports for movement in a direction parallel to a line through the center points of said universal pivots.
10. The structure of claim 9 and including means for sliding said means supporting said universal joint supports, and
 - means on said handle lever for actuating said last named means.
11. The structure of claim 9 and including a bellcrank lever having a short end engaging said universal joint supports to slide the same,
 - said bellcrank lever having a long arm, and

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means connecting said long arm and means on said handle lever for pivoting said bellcrank lever.

12. A micromanipulator including,

a handle lever and a secondary tool supporting lever each having ball pivots intermediate their ends,

a bearing support including a pair of spaced sockets universally supporting said ball pivots in predetermined spaced relation,

said handle lever including a handle arm extending radially from its ball pivot and having a socketed portion in axially aligned diametrically opposed relation to said handle arm,

said secondary lever including a pair of radially extending diametrically opposed arms thereon,

one of said secondary lever arms including an end portion engaged in said axially aligned socket portion, the distance between the center of the ball pivot of said secondary lever and said end portion of said one secondary lever arm being materially greater than the distance between the center of the ball pivot of the handle lever and the portion of the axially aligned socket engaging said end portion, and

means slidably supported on said handle lever arm,

means slidably supporting said bearing support for movement in a direction parallel to a line through the centers of said ball pivots,

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lever means engageable with said bearing support for sliding the same,

means connecting said means slidably supported on said handle lever arm and said last named lever means to slide said bearing support.

13. The structure of claim 12 and including a second means slidably supported on said handle lever arm,

means for sliding said second means relative to said handle lever arm upon rotation thereof,

a micro-tool supported by said secondary tool supporting lever, and

flexible means connecting said micro-tool and said second means for actuating said micro-tool upon slidable movement of said second means.

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