United States Patent [19]

Hutson

[11] **3,843,183**

[45] **Oct. 22, 1974**

[54] **VACUUM PICK-UP INSTRUMENT**

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[22] Filed: **Aug. 16, 1972**

[21] Appl. No.: **281,139**

[52] **U.S. Cl.**..... **294/64 R,** 137/625.25, 251/344

[51] **Int. Cl.**..... **B66c 1/02**

[58] **Field of Search**..... 294/64 R, 64 A; 74/417, 74/416, 553; D74/17 B; 116/124 R, 124.1 R; 269/21

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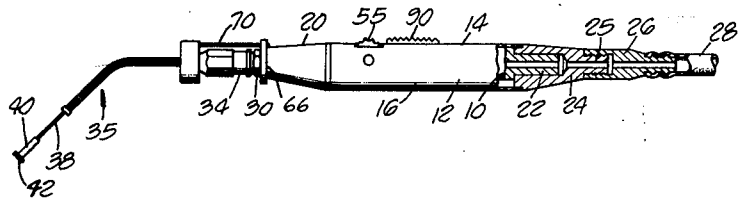
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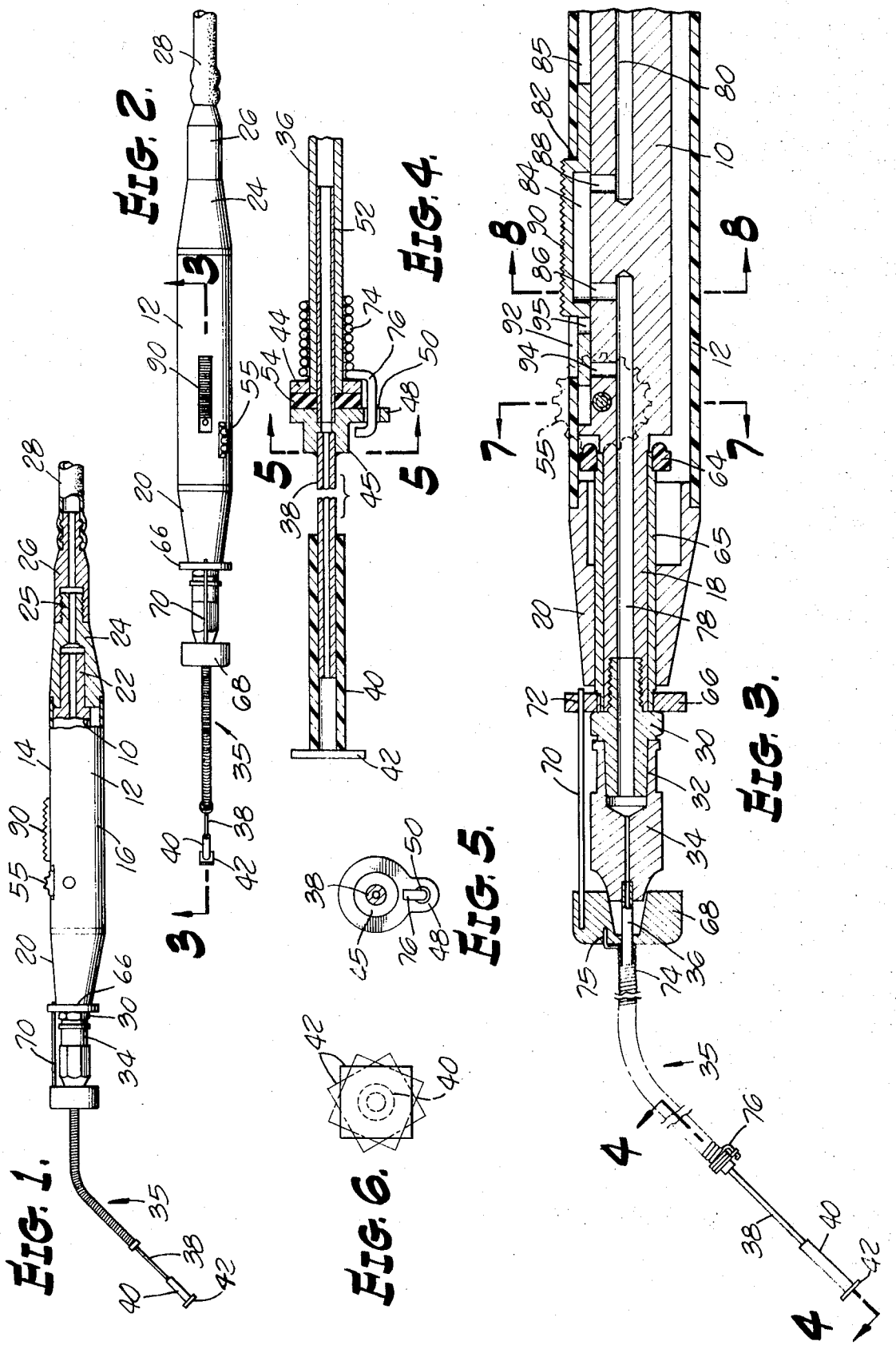
Primary Examiner—Evon C. Blunk
Assistant Examiner—James L. Rowland
Attorney, Agent, or Firm—Paul A. Weilein

[57] **ABSTRACT**

An instrument generally similar to a pencil in size and configuration has a vacuum-actuated nozzle to pick up small objects. A slide valve movable by the index finger has one position to connect the nozzle to a vacuum source, a second position to cut off the nozzle from the source to maintain a vacuum in the nozzle, and a third position to vent the nozzle to the atmosphere for the purpose of releasing the small object. A small wheel on the body of the instrument is manipulated by a finger to rotate the nozzle to control the orientation of a small object on the nozzle tip.

17 Claims, 32 Drawing Figures




FIG. 1.
FIG. 2.
FIG. 3.
FIG. 4.
FIG. 5.
FIG. 6.

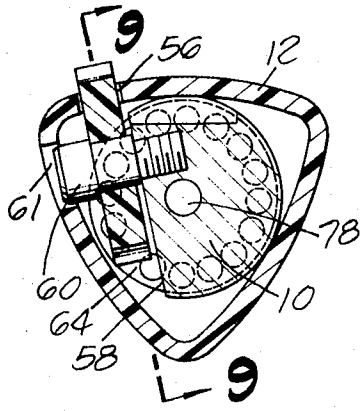


FIG. 7.

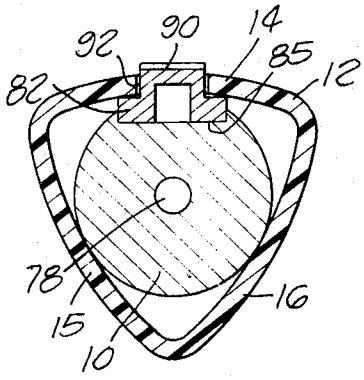


FIG. 8.

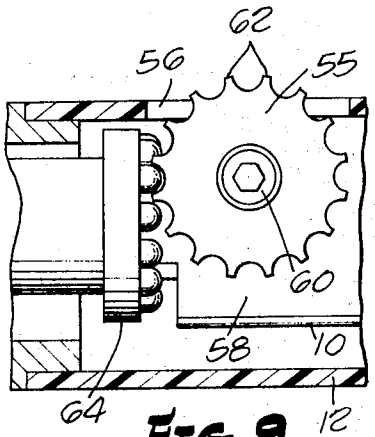


FIG. 9.

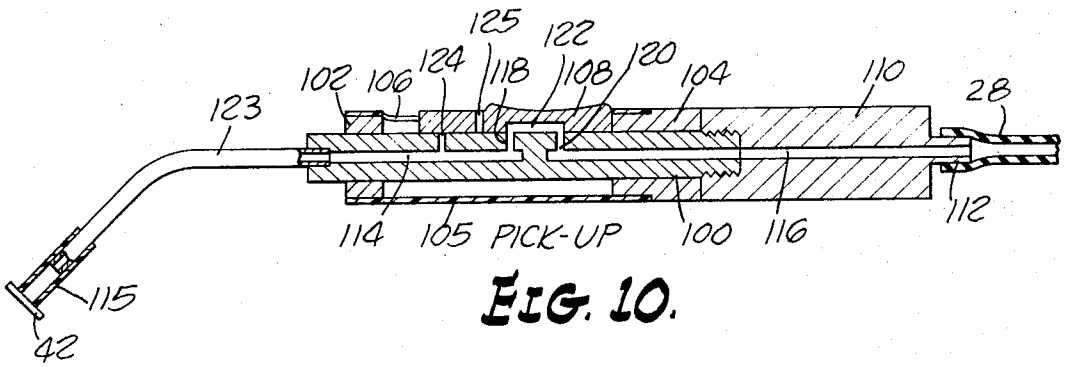


FIG. 10.

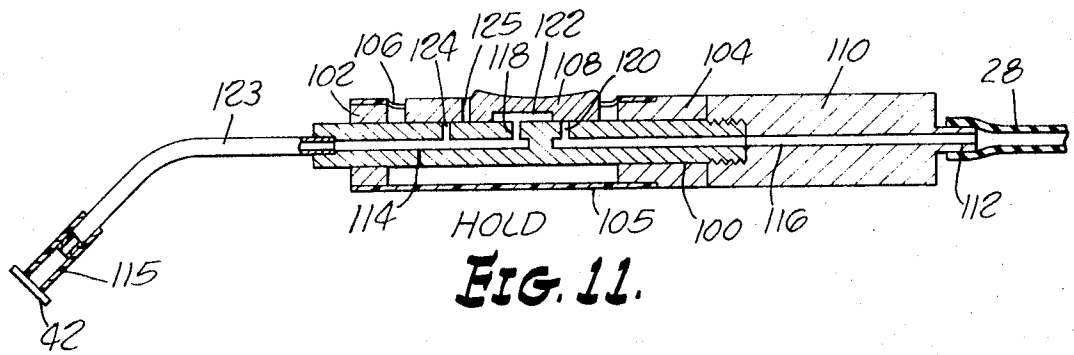


FIG. 11.

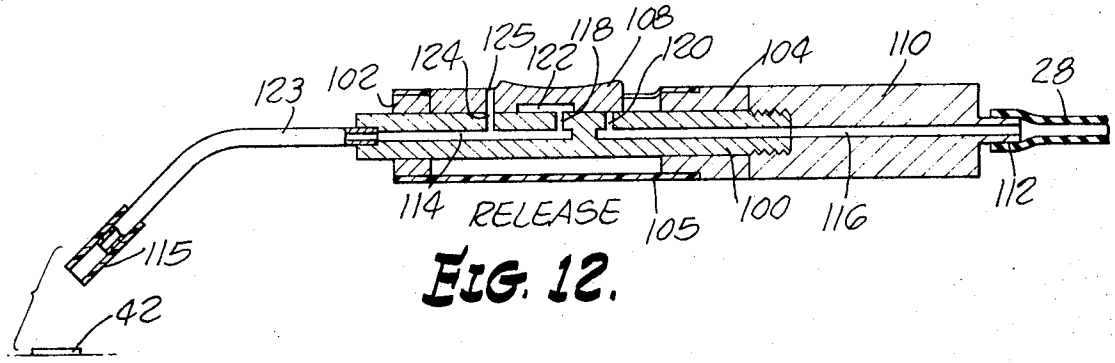


FIG. 12.

FIG. 13.

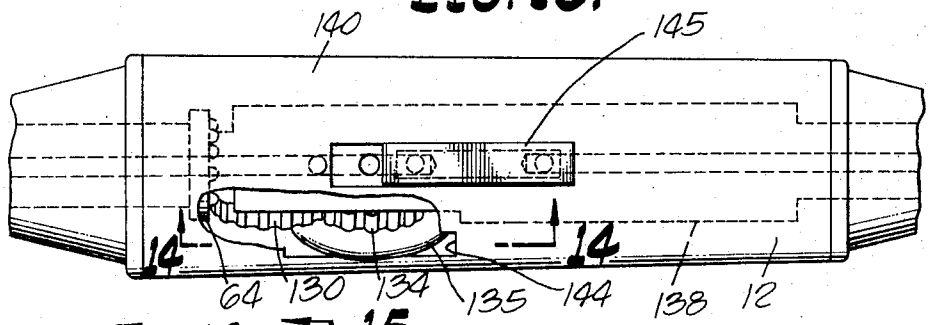


FIG. 14.

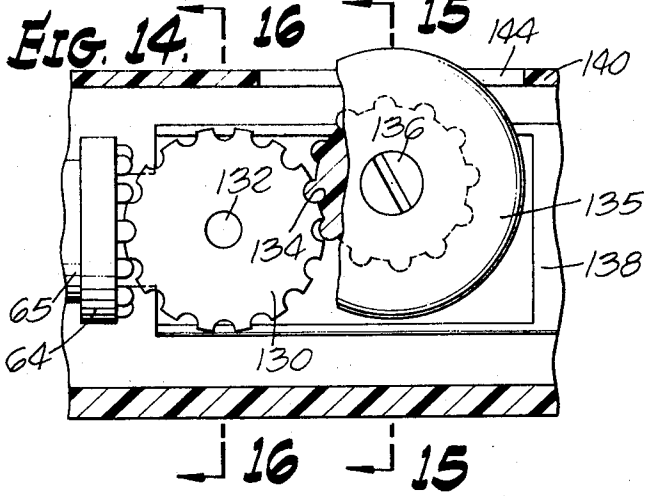
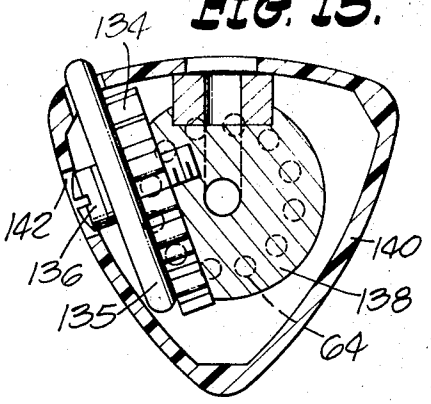


FIG. 15.



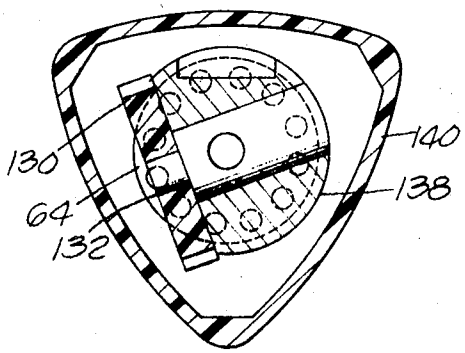


FIG. 16.

FIG. 18.

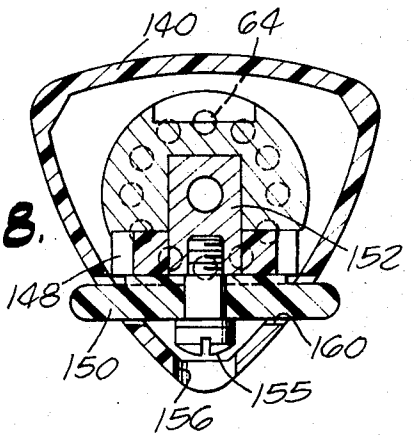
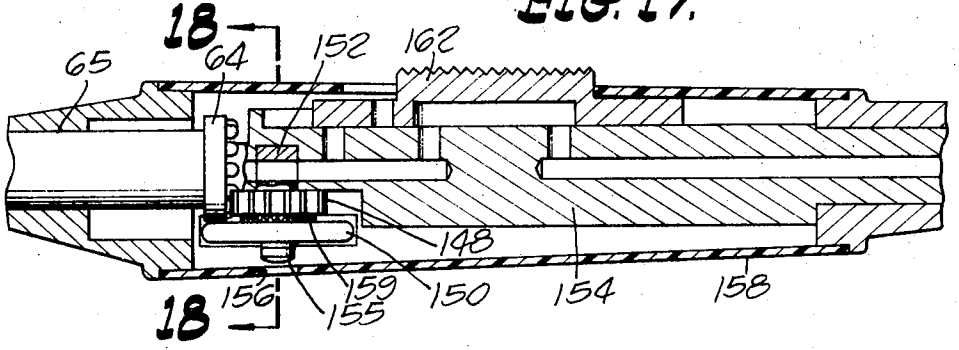


FIG. 17.



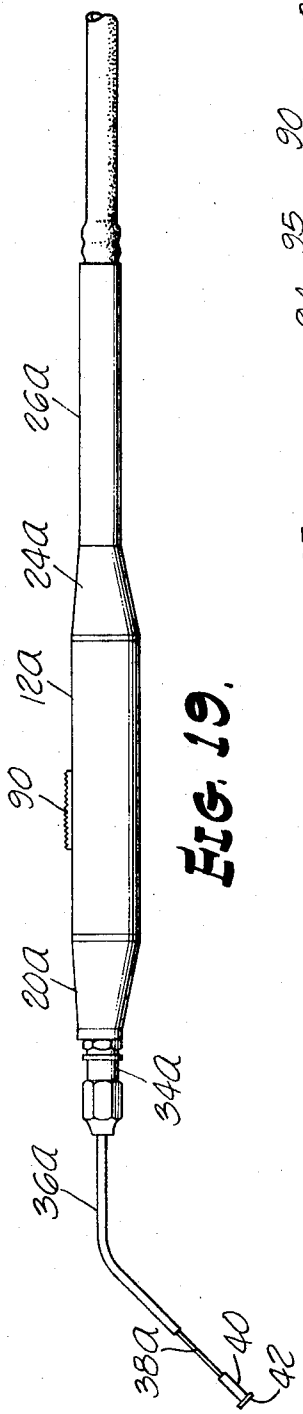


Fig. 19.

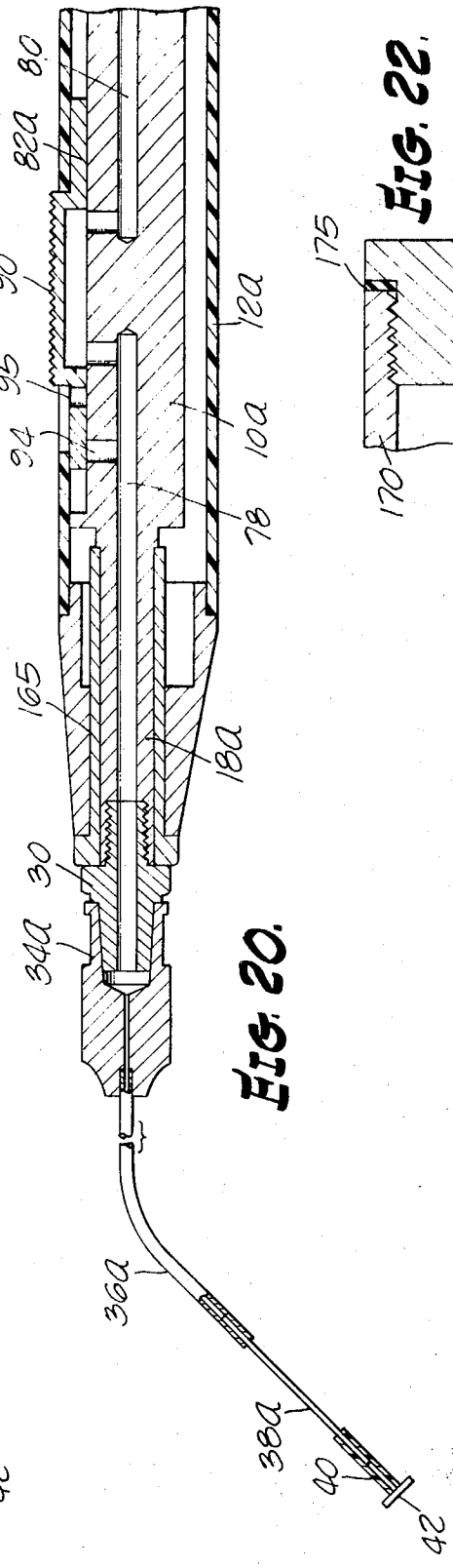


Fig. 20.

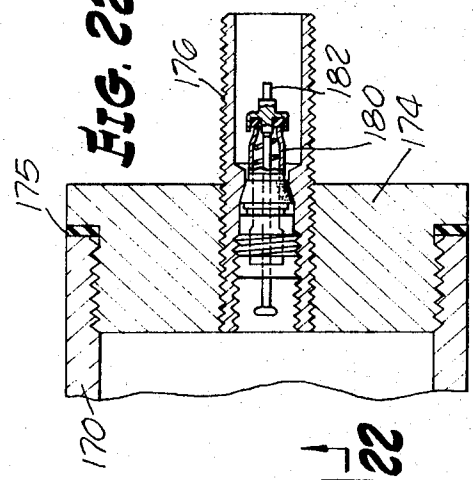


Fig. 22.

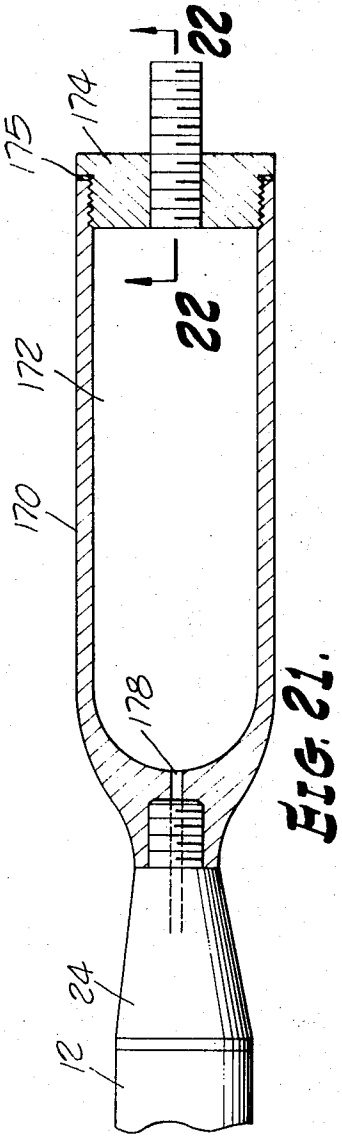


Fig. 21.

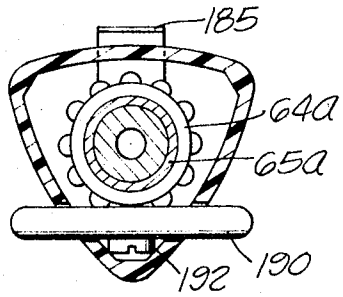


FIG. 24.

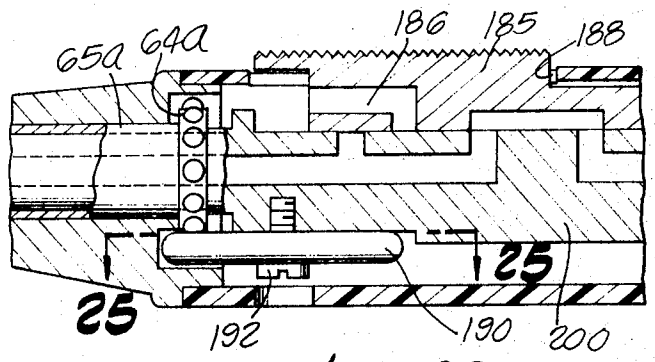


FIG. 23.

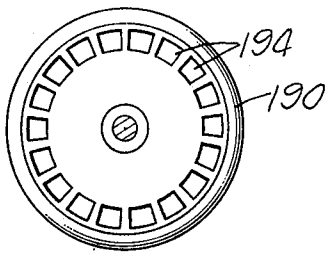


FIG. 25.

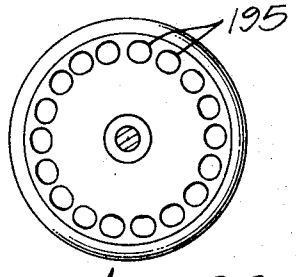


FIG. 26.

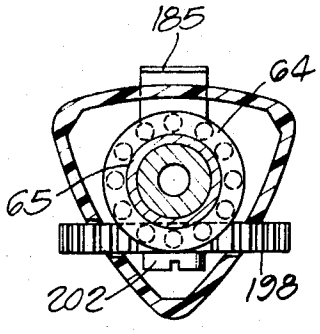


FIG. 28.

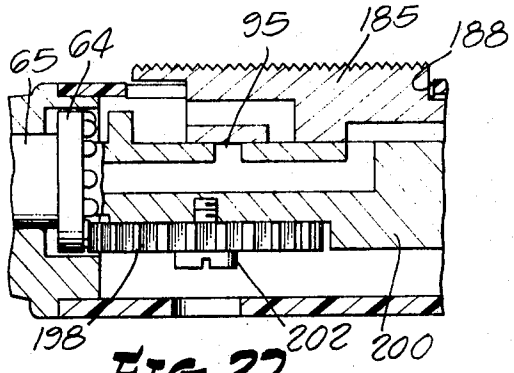


FIG. 27.

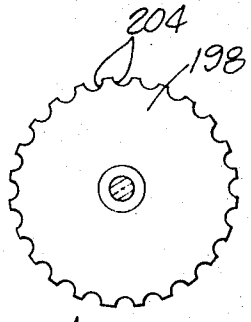


FIG. 29.

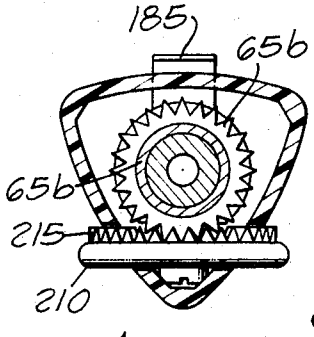


FIG. 31.

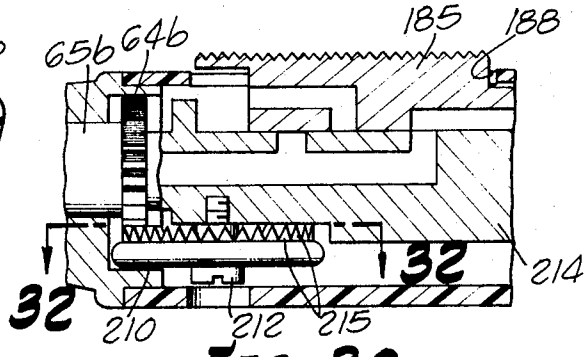


FIG. 30.

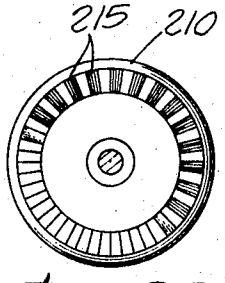


FIG. 32.

VACUUM PICK-UP INSTRUMENT

BACKGROUND OF THE INVENTION

It is exceedingly difficult to use the fingers to pick up, handle, and precisely position small objects that are of only a small fraction of an inch in cross dimension. In the first place, an operator's fingers are awkward instruments for picking up such small objects. In the second place, when a small object is picked up by the thumb and index finger, the thumb and index finger overshadow the object to cut off adequate observation of the object. In the third place, the thumb and forefinger are much too awkward for rotating such a small object precisely to a predetermined orientation and especially so if the object is flat and thin. These difficulties are compounded if it is necessary to handle the small object under a microscope where small movements are magnified and where the fingers interfere with observation of the small object.

Accordingly, there has been a growing need for a suitable instrument to pick up and maneuver exceedingly small parts, the need being felt in such fields as electronics, dentistry, jewelry, cameras and watches. There is an especially pressing need for such a tool in the fabrication of miniaturized electronic devices where complex photochemical processes are employed to provide a multiplicity of integrated circuits on silicon chips or wafers which may be of a size ranging downward from one-tenth inch square to microscopic sizes. Such silicon chips are vulnerable to damage by contamination, dust particles, and scratches and are much too delicate to be handled by mechanical forceps. With even the best pick-up devices heretofore available, a large percentage of silicon wafers must be rejected.

One prior art expedient for handling an exceedingly small silicon wafer is to use a toothpick that is dipped in alcohol to cause the wafer to adhere temporarily to the toothpick. Such a procedure minimizes mechanical damage to the wafer, but is unsatisfactory for a number of obvious reasons including poor control over the position of the wafer and poor control over the disengagement of the wafer from the toothpick.

Another prior art device is a pencil-size device which employs a vacuum to pick up a silicon chip, the device having a short pick-up nozzle at the end of an air passage in communication with a suitable vacuum source. The air passage has a radial vent port and when the vent port is closed by the index finger or by a leaf spring which is depressed by the index finger, a vacuum is created to cause the small object to adhere to the nozzle. The small object is released by lifting the finger to vent the air passage to the atmosphere. Unfortunately, relieving the instrument of the pressure of the index finger for the purpose of terminating the vacuum tends to destroy the stability of the instrument, the nozzle tending to swing upwardly. A further disadvantage is that too often the small object continues to adhere to the nozzle after the vacuum is destroyed.

SUMMARY OF THE INVENTION

The objects of the invention include: to provide a vacuum-actuated pencil-size instrument of a cross sectional configuration that is conducive to stability of the device when it is gripped by the fingers; to provide such an instrument in which a forwardly extending pick-up nozzle is of substantial length to keep the fingers from interfering with observation of a small object on the nozzle tip and with the nozzle curved downwardly in a vertical plane through the axis of the instrument to place the end of the nozzle near to the line of sight of the operator; to provide such an instrument with quickly interchangeable nozzles for different specific tasks; to provide interchangeable nozzles that are relatively inexpensive and are of various diameters including extremely small diameters; to provide such a nozzle with a plastic pick-up sleeve on its end that is yieldable to avoid damage to delicate objects and to make airtight engagement with small objects; to provide such an instrument in which the nozzle tip may be manually rotated by a finger wheel on the instrument body for the purpose of turning a small object to a desired orientation or for the purpose of screwing a small object into its assembled position; to provide a satisfactory degree of rotational responsiveness of the nozzle to a given increment of rotation of the finger wheel, the ratio of rotation of the nozzle tip to rotation of the finger wheel being high enough for rapid initial rotation of a small object to approximately a desired orientation and the ratio being small enough to facilitate precise final orientation of the object; to provide efficient mechanical means for transmitting motion from the finger wheel to the relatively remote tip of the curved nozzle; to provide a vacuum-actuated instrument without the necessity of connecting the instrument to a vacuum source, thus eliminating a flexible hose that might interfere with free maneuvering of the instrument; to control the vacuum in the pick-up nozzle by means of a valve member in the form of a slide that may be easily and quickly operated by the index finger; to provide such an arrangement in which the finger wheel may also be actuated by the index finger; to provide such an instrument in which the slide valve may be actuated by the index finger and the finger wheel may be independently actuated by the third finger of the hand; to provide such an instrument which may be employed either as a left hand instrument or a right hand instrument with actuation of the finger wheel in both instances by the third finger of the hand; to provide a valve means that is effective to eliminate the tendency for small objects to adhere to the nozzle after the vacuum is broken; to provide such an instrument wherein not only nozzles may be employed interchangeably, but also tail pieces may be employed interchangeably to enable the instrument to be employed either with a vacuum hose or with an independent vacuum reservoir built into the instrument; and to provide novel functions for the vacuum in the instrument, the functions including: to form effective seals at various points of the instrument; to tend to hold parts of the instrument in their assembled positions; and to serve the purpose of spring means to maintain a valve member in frictional contact with a fixed guide surface.

The various objects, features and advantages of the invention may be understood from the following detailed description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which are to be regarded as merely illustrative:

FIG. 1 is a side elevation of a first rotary-nozzle embodiment of the invention with a portion of the instrument broken away;

FIG. 2 is a top plan view of the instrument;

FIG. 3 is an enlarged fragmentary longitudinal section taken as indicated by the line 3—3 of FIG. 2;

FIG. 4 is a greatly enlarged fragmentary section of the nozzle assembly as seen along the line 4—4 of FIG. 3;

FIG. 5 is a transverse section along the line 5—5 of FIG. 4;

FIG. 6 is a diagram showing how a flat silicon chip or wafer adhering to the tip of the nozzle may be rotated to various orientations by the finger wheel on the body of the instrument;

FIG. 7 is an enlarged transverse section along the line 7—7 of FIG. 3 showing the finger wheel and associated gearing;

FIG. 8 is an enlarged transverse section along the line 8—8 of FIG. 3 showing how the slide valve is positioned in a longitudinal guideway;

FIG. 9 is a fragmentary section along the line 9—9 of FIG. 7 showing how the finger wheel meshes with a driven gear on the rear end of a forwardly extending tubular drive shaft for rotation of the nozzle tip;

FIG. 10 is a longitudinal sectional view of a fixed-nozzle embodiment, the slide valve being shown in a position for connecting the fixed nozzle to a vacuum hose that extends rearwardly to a suitable vacuum source;

FIG. 11 is a sectional view of the same embodiment similar to FIG. 10 showing the slide valve in a position to cut off the nozzle from the vacuum hose in a manner to maintain the vacuum in the nozzle for the purpose of causing a small object to adhere to the tip of the nozzle;

FIG. 12 is a similar sectional view showing the slide valve in its third forward limit position at which the slide valve vents the nozzle to the atmosphere for the purpose of releasing a workpiece from the tip of the nozzle;

FIG. 13 is a fragmentary plan view of a second rotary-nozzle embodiment of the invention, a portion of the body of the instrument being broken away to reveal gearing associated with the finger wheel;

FIG. 14 is an enlarged fragmentary longitudinal section taken along the line 14—14 of FIG. 13 showing gearing associated with the finger wheel;

FIG. 15 is a transverse section along the line 15—15 of FIG. 14 which shows the structure of the finger wheel;

FIG. 16 is a transverse section along the line 16—16 of FIG. 14 showing in section an idler gear that meshes with a driven gear on the rear end of a forwardly extending tubular drive shaft;

FIG. 17 is a fragmentary longitudinal horizontal section of a third rotary-nozzle embodiment of the invention;

FIG. 18 is an enlarged transverse section along the line 18—18 of FIG. 17 showing how a finger wheel protrudes at opposite sides of the body of the instrument;

FIG. 19 is a side elevation of another fixed-nozzle embodiment of the invention;

FIG. 20 is an enlarged fragmentary longitudinal vertical section of the instrument shown in FIG. 19;

FIG. 21 is a longitudinal sectional view of a detachable tail piece for a vacuum type instrument wherein the tail piece serves as a vacuum reservoir;

FIG. 22 is an enlarged fragmentary longitudinal section taken as indicated on the line 22—22 of FIG. 21 to show the structure of a check valve for the vacuum reservoir;

FIG. 23 is a fragmentary longitudinal section of a fourth rotary-nozzle embodiment of the invention;

FIG. 24 is a cross section of FIG. 23 with internal structure removed for clarity of illustration to show how the finger wheel engages a driven gear on the rear end of a tubular drive shaft;

FIG. 25 is a fragmentary section taken along the line 25—25 of FIG. 4 showing how the face of the finger wheel is provided with a circumferential series of recesses for engaging the driven gear on the rear end of the tubular drive shaft;

FIG. 26 is a view similar to FIG. 25 showing a different configuration for the circumferential series of recesses in the face of the finger wheel;

FIG. 27 is an enlarged fragmentary longitudinal section of a fifth rotary-nozzle embodiment of the invention;

FIG. 28 is a transverse section of FIG. 27 with internal structure omitted for clarity of illustration showing how the finger wheel engages the driven gear on the rear end of the tubular drive shaft;

FIG. 29 is a side elevation of the finger wheel in FIG. 27 showing how the finger wheel is formed with peripheral teeth for engagement with the driven gear on the rear end of the tubular drive shaft;

FIG. 30 is an enlarged fragmentary sectional view of the sixth and presently preferred rotary-nozzle embodiment of the invention;

FIG. 31 is a transverse section of FIG. 30 with internal structure removed for clarity showing how the finger wheel is related to the driven gear on the rear end of the tubular drive shaft; and

FIG. 32 is a side elevational view of the finger wheel as seen along the line 32—32 of FIG. 30.

DESCRIPTION OF THE SELECTED EMBODIMENTS OF THE INVENTION

FIGS. 1–9 illustrate the first of the rotary-nozzle embodiments of the invention. As shown in FIGS. 3 and 8, the main body portion of the instrument that is grasped by the operator's fingers has a core 10 of circular cross sectional configuration and a surrounding plastic sleeve 12 that is of generally triangular configuration, the configuration providing a top longitudinal surface 14 that extends across the full width of the instrument and two downwardly convergent longitudinal side surfaces 15 and 16.

Referring to FIG. 3, the core 10 has a forward tubular extension 18 which is surrounded by a forward nose section 20 of the body. The nose section 20 is of triangular cross section at its rearward end where it is embraced and supported by the forward end of the plastic sleeve 12, the nose section tapering forwardly and being circular at its forward end.

As shown in FIG. 1, the rear end of the core 10 has a rearwardly extending tubular portion 22 on which a rear section 24 of the body is fixedly telescoped to engage and support the rear end of the triangular plastic sleeve 12, the forward end of the rear section 24 being of trinagular cross sectional configuration with the rear section tapering rearwardly to a reduced circular configuration. The rear end of the rear section 24 of the body forms a reduced nipple 25 onto which a tail fitting 26 is releasably threaded to serve as an adapter for connecting the instrument to a flexible hose 28 that is con-

nected to a suitable vacuum source such as a vacuum pump.

In the construction shown in section in FIG. 2 a nose fitting 30 is screwed into the forward end of the tubular extension 18 of the core 10 and this nose fitting forms a tapered nose 32 to receive the socket end 34 of a nozzle assembly that is generally designated 35. Thus, the nozzle assembly fits releasably onto the nose fitting 30 in the same manner as the socket end of a hypodermic needle fits releasably onto the nose of a hypodermic syringe.

The body of the instrument is comparable in size to a pencil, the vertical cross sectional dimension of the sleeve 12 being, for example, approximately one-half inch.

In the construction shown the socket end 34 of the nozzle assembly is the socket end of a tubular shank 36 that has a downwardly inclined end, the tubular shank being formed with a downward bend that is in a vertical plane, i.e., in the vertical plane that bisects the triangular cross sectional configuration of the sleeve 12. Rotatably mounted on the downwardly inclined end of the tubular shank 36 is a straight tubular nozzle extension 38 which carries a nozzle tip 40 of a suitable resiliently yieldable plastic material. The nozzle tip 40 may be simply a short piece of medical plastic tubing commonly used in blood vessel surgery, the tubing being telescoped over the nozzle extension 38 and extending forward from the nozzle extension. FIGS. 1, 2, 3, 4, and 6 show how a small rectangular silicon chip or wafer 42 is releasably held against the nozzle tip 40 by means of a vacuum inside of the nozzle tip fitting.

The rotary nozzle extension 38 may be secured to the end of the tubular shank 36 by a joint construction of the character shown in FIG. 4. In FIG. 4 the tubular shank 36 has a circular radial flange 44 on its outer end and the nozzle extension 38 is fixedly connected to a flanged fitting 45 that has a radial ear 48 with an aperture 50 therein. Fixedly mounted in the flanged fitting 45 is a piece of tubing 52 that telescopes into the tubular shank 36 in a rotatable manner to serve as a bearing for the nozzle extension 38. To provide a seal at the rotary joint between the fixed tubular shank 36 and the rotary nozzle extension 38, a gasket 54 is inserted between the faces of the radial flange 44 and the flange fitting 45, the gasket being made of suitable plastic material having a low coefficient of friction with respect to the two faces.

The nozzle extension 38 with the nozzle tip 40 thereon is operatively connected to suitable control means on the instrument body for rotating the nozzle tip 40 by remote control. AS shown in FIGS. 1, 2, 3, 7, and 9, the remote control means may comprise a finger wheel 55 which protrudes through a slot 56 in the upper wall of the plastic sleeve 12 to make the finger wheel accessible for rotation by the index finger of the operator of the instrument. The body core 10 is cut away as indicated at 58 in FIG. 7 to provide room for the finger wheel 55 inside of the plastic sleeve. The finger wheel is mounted on a suitable stud 60 that threads into the body core and is accessible through an aperture 61 in the plastic sleeve 12. In the construction shown, the finger wheel 55 functions as a drive gear, the finger wheel having outer circumferential teeth 62 that engage the teeth of a driven gear 64 which is preferably made of plastic material. The driven gear 64 is fixedly mounted on the rear end of a forwardly extending tubular drive shaft 65 which is journalled on the tubular extension 18 of the body core 10 and is surrounded by the nose section 20 of the instrument body.

A radial flange 66 on the exposed forward end of the tubular drive shaft 65 is operatively connected to a forward collar 68 that rotatably embraces the tubular shank 36. In the construction shown, the operative connection between the flange 66 and the rotary collar 68 comprises a short piece of stiff wire 70 that is permanently embedded in the collar 68. The stiff wire releasably extends through an aperture 72 in the flange 66 to permit the nozzle assembly to be withdrawn from the tapered nose 32 of the instrument.

The operative connection between the rotatable collar 68 and the nozzle extension 38 may comprise a snugly wound coil 74 of suitable spring wire that rotatably embraces the bent tubular shank 36, as best shown in FIG. 3, with one end 75 of the wire coil embedded in the rotary collar 68. As shown in FIG. 4, the other end 76 of the wire coil extends through the previously mentioned aperture 50 in the ear 48 and overhangs the flanged fitting 45.

The means for controlling the creation of a vacuum in the nozzle tip 40 may comprise, first, a forwardly extending axial passage 78 in the instrument body that communicates with the tubular shank 36, second, a rearwardly extending axial passage 80 in the instrument body that communicates with the vacuum hose 28 and, third, a slide valve 82 that is cut away on its underside to provide a short third passage 84 to interconnect the two passages 78 and 80.

The slide valve 82 is movable in a longitudinal guide channel 85 on the upper side of the body core 10 with the forward passage 78 terminating in a first port 86 in the bottom of the guide channel and with the rearward passage 80 terminating in a second port 88 in the bottom of the guide channel. A serrated portion 90 of the slide valve 82 protrudes through a longitudinal slot 92 in the upper wall of the plastic sleeve 12 to make the slide accessible for manipulation by the index finger of the operator of the instrument. The plastic sleeve overhangs the forward and rear ends of the slide valve 82 to keep the slide captive.

As may be seen in FIG. 2, the finger wheel 55 and the slide valve 82 are relatively close together with the range of longitudinal movement of the slide valve overlapping the longitudinal extent of the finger wheel. As may be seen in FIG. 8 the slide valve is in a vertical plane that bisects the top longitudinal surface 14 of the instrument and as may be seen in FIGS. 2 and 7, the finger wheel 55 is inclined from the vertical to provide clearance for the slide valve, the angle of inclination of the finger wheel being preferably approximately 12°.

In the construction shown, the forward air passage 78 has a vent port 94 in the bottom of the guide channel 85 which is under control of the slide valve 82. Preferably, the slide valve 82 is provided with an aperture 95 which may register with the vent port 94 for the purpose of placing the forward air passage 78 in communication with the atmosphere.

The slide valve 82 is movable to a rearward limit position abutting the rear end of the sleeve slot 92 at which the short passage 84 of the slide valve establishes communication between the forward air passage 78 and the rearward passage 80 as may be seen in FIG. 3. At a second intermediate position of the slide valve 82

the slide valve covers the port **88** to cut off the rearward passage **80** and the slide valve isolates the forward air passage **78** both from the rearward air passage **80** and from the atmosphere to maintain a vacuum in the forward passage and thus keep a picked up chip or wafer **42** in engagement with the nozzle tip **40.** The function of the slide valve at this second intermediate position may be understood by referring to FIG. **11.**

A third position of the slide valve **82** is a forward limit position against the forward end of the sleeve slot **92.** At this third position of the slide valve the aperture **95** of the slide valve registers with the port **86** to vent the forward air passage **78** to the atmosphere and thus terminate a vacuum in the tip fitting **40** to release the chip or wafer **42.** The third position of a slide valve is shown in FIG. **12.**

The manner in which the first embodiment of the invention functions for its purpose may be readily understood from the foregoing description. With the slide valve **82** at its first rearward limit position shown in FIG. **3,** the vacuum hose **28** is in communication with the forward air passage **78** to evacuate air from the interior of the nozzle tip **40** and when the nozzle tip is applied to a small object **42** at this time for the purpose of picking up the object, a vacuum is quickly created inside the nozzle tip **40** to cause the object to adhere to the nozzle tip. The operator may then move the slide valve **82** forward to its second intermediate position at which it cuts off the forward passage **78** both from the vacuum hose **48** and the atmosphere to maintain the vacuum in the nozzle tip **40** independently of the vacuum hose. The operator may then employ the instrument as means for transporting the small object **42** to a desired destination and the operator may manipulate the finger wheel **55** to rotate the small object **42** to any desired orientation of the destination. The operator may then push the slide valve **82** to its forward limit position to vent the forward air passage **78** to the atmosphere and thus terminate the vacuum inside the nozzle tip **40** to cause the nozzle tip to release the small object.

FIGS. **10, 11,** and **12** show the construction of a simplified embodiment of the invention that has a fixed nozzle tip **115** instead of a rotatable nozzle tip.

The body of the instrument shown in FIGS. **10, 11,** and **12** has a core **100** which is fixedly embraced by a forward collar **102** and a rearward collar **104.** A plastic sleeve **105** which is supported at its opposite ends by the two collars has a longitudinal slot through which a slide valve **108** extends for manipulation by the index finger of the operator of the instrument. A rear body section **110** that threads onto the core **100** is formed with a rearwardly extending nipple **112** for connection to a vacuum hose **28.**

The body of the instrument is formed with the usual forward axial passage **114** that communicates with a nozzle tip **115** and the body is provided with the usual rearwardly directed axial passage **116** that communicates with the vacuum hose **28.** The forward passage **114** terminates at its rear end in a port **118** under the slide valve **108** and in like manner the rear passage **116** terminates in a port **120** under the slide valve, the slide valve being cut away on its underside to provide the usual short passage **122** for placing the two passages **114** and **116** in communication with each other. A tubular nozzle shank **123** of the usual bent configuration is fixedly mounted in the forward end of the body core **100** and the nozzle tip **115** is telescoped onto the leading end of the tubular shank. The forward air passage **114** has the usual vent port **124** and the slide valve **108** has the usual aperture **125** to cooperate with the vent port.

It is apparent that the simplified instrument shown in FIGS. **10, 11,** and **12** functions in the same general manner as the first embodiment of the invention except for the fact that the nozzle tip **115** is not rotatable for the purpose of orienting a small object adhering thereto.

FIGS. **13–16** illustrate a second embodiment of a rotary-nozzle type of pick-up instrument which is largely similar to the first embodiment as indicated by the use of corresponding numerals to indicate corresponding parts. This embodiment differs from the first embodiment solely in the finger wheel and associated gearing for manually rotating the tubular drive shaft **65.** As shown in FIGS. **14** and **16,** an idler gear **130** on a stub axle **132** is in mesh with the driven gear **64** on the tubular drive shaft **65** and is also in mesh with a drive gear **134** that is integral with a smooth-rimmed finger wheel **135.** The finger wheel **135** is journalled on a stud **136** that is threaded into a body core **138.** A plastic sleeve **140** of the instrument body has an aperture **142** for access to the stud **136** and has a longitudinal slot **144** through which the smooth-rimmed finger wheel **135** protrudes for manipulation by the index finger of the user. As shown in FIG. **13,** the instrument has the usual slide valve **145** to control the vacuum in the pick-up nozzle. The instrument operates in the same manner as the first embodiment of the invention.

FIGS. **17** and **18** illustrate a third rotary-nozzle pick-up instrument that is also similar to the first embodiment, differing solely in the means of manual rotation of the tubular drive shaft **65.** In the construction shown, the driven gear **64** on the rear end of the tubular drive shaft **65** is engaged by a drive gear **148** that rotates in unison with a smooth-rimmed finger wheel **150.** The drive gear **148** is journalled on a block **152** that is inserted into a body core **154** of the instrument and the finger wheel **150** is journalled on a stud **155** that is threaded into the end of the insert and is aaccessible through an aperture **156** in a plastic sleeve **158** of the body of the instrument. The drive gear **148** and the finger wheel **150** are separate members which are interlocked by radial serrations **159** on their confronting faces.

A feature of the embodiment shown in FIGS. **17** and **18** is that the finger wheel **150** is on the bottom side of the body core **154** and protrudes by equal amounts through longitudinal slots **160** in the two convergent side walls of the plastic sleeve. Thus, with the finger wheel **150** spaced below the slide valve **162** of the instrument the finger wheel may be manipulated by the third finger of the operator's hand instead of the index finger.

FIGS. **19** and **20** show another embodiment of the invention that has a fixed or nonrotary pick-up nozzle. The body of the instrument is quite similar in construction to the body of the instrument shown in FIGS. **1–9** as indicated by the use of corresponding numerals to indicate corresponding parts. The tubular drive shaft **65** of the first embodiment of the invention is replaced by a fixed spacer sleeve **165.** The usual nose fitting **30** is threaded into the end of a tubular extension **18***a* of the body core **10***a* to receive the socket end **34***a* of the

tubular shank **36***a* of a nozzle assembly **38***a*. The nozzle extension **38***a* is fixedly mounted in the end of the tubular shank **36***a* and carries a previously described plastic nozzle tip **40**. It is apparent that a number of nozzle assemblies of different sizes may be mounted interchangeably on the nose fitting **30**.

Referring back to FIG. **1**, the tail fitting **26** that is attached to the vacuum tube **28** may be removed from the body to expose the nipple portion **25** of the rear body section **24** so that a module differing from the tail fitting **26** may be attached to the rear section **24**. By way of example, FIG. **21** shows how a module **170** may be substituted for the tail fitting **26** of FIG. **1** or the tail fitting **26***a* of FIG. **19**. The module **170** forms a chamber **172** that is closed at its rear end by a removable bushing **174** that is equipped with a sealing gasket **175**. The bushing **174** is provided with an axial threaded tubular valve body **176** that houses a check valve structure similar to the familiar check valve structure employed in automobile tires. When the tubular valve body **176** is screw threadedly engaged with means for connecting the tubular valve body to a vacuum pump, the valve member in the valve body **176** opens in response to the connection to permit the vacuum pump to evacuate the chamber **172**. When the chamber **172** is adequately evacuated the connection is removed from the tubular valve body **176** to permit the check valve to close to keep the chamber **172** evacuated. Obviously, the coiled valve spring **180** that biases the valve stem **182** to closed position must be strong enough to withstand a pressure differential as high as **15** psi. The chamber **172** has an axial passage **178** that communicates with the usual rearward air passage **80** of the body core of the instrument.

In FIGS. **23, 27,** and **30** a modified slide valve **185** is shown which differs from the previously described slide valves in the provision for venting the pick-up nozzle. Instead of providing the slide valve with an aperture therethrough to register with a vent port **95** in the body core of the instrument, the slide valve **185** is provided with an angular vent passage **186** that registers with the vent port at the forward limit position of the slide. One advantage of the modified slide valve is that there is no possibility of the operator's index finger blocking the inflow of atmospheric air into the pick-up nozzle. Another advantage is that the angular vent passage **186** communicates with the interior of the instrument body and does so when the slide is in a forward position that closes the forward end of the slot **188** in the plastic sleeve through which the slide protrudes. Thus, since the angular vent passage **186** draws atmospheric air from the interior of the plastic sleeve there is less likelihood of dust or other small particles being drawn from the atmosphere into the pick-up nozzle.

The fourth rotary-nozzle embodiment of the invention shown in FIGS. **23–25** differs from the embodiment shown in FIGS. **17, 18** solely in the above described modification of the slide valve and in the manner in which a tubular drive shaft **65***a* is rotated by a smooth-rimmed finger wheel **190**. The finger wheel **190** which is journalled on a stud **192** is formed with a concentric series of equally spaced recesses **194** on one of its faces to engage the teeth of a driven gear **64***a* that is fixedly mounted on the rear end of the tubular drive shaft **65***a*. FIG. **26** shows how a concentric series of round recesses **195** may be employed instead of the recesses **194** shown in FIG. **25**.

FIGS. **17–29** illustrate a fifth rotary-nozzle embodiment of a pick-up instrument which differs from the embodiment shown in FIGS. **23–25** solely in the manner in which a driven gear **64** on the end of a tubular drive shaft **65** is manually actuated. As shown in FIG. **27** a finger wheel **198** which is mounted on the bottom side of a body core **200** by means of a stud **202** has peripheral teeth **204** that engage the driven gear **64**, the peripheral teeth being of the profile shown in FIG. **29**.

FIGS. **30–32** illustrate a further embodiment of the rotary nozzle pick-up instrument in which a smooth-rimmed finger wheel **210** is journalled on a stud **212** on the underside of a body core **214** of the instrument. The finger wheel **210** has a concentric series of axially projecting teeth **215** on its inner face which serve as a drive gear in mesh with a driven gear **64**b on a tubular drive shaft **65**b.

EXPLANATION OF FEATURES OF THE INVENTION

The triangular cross sectional configuration of the body of the instrument enables the operator to grip the instrument by his fingers in a manner that prevents the instrument from turning on its axis and ensures that the controls that are manipulated by the index finger are on the upper side of the instrument body.

An important feature of the invention is that the triangular cross sectional configuration results in stability of the instrument because the finger pressure against each of the three longitudinal surfaces of the instrument body is balanced by finger pressure against each of the other two longitudinal surfaces. Thus, the downward pressure of the index finger on the upper side of the instrument is balanced by the opposing pressures of the thumb and the second finger against the two downwardly divergent sides respectively. With the index finger constantly pressing downward against the slide valve, the manipulation of the slide valve does not destroy the stability of the instrument. In contrast, if the index finger must be lifted from the instrument body to vent the pick-up nozzle, stability is lost and the nozzle waivers at the very moment when a small object is being released from the nozzle.

An important advantage of mounting the finger wheel horizontally on the underside of the instrument with the finger wheel accessible from both sides, as shown in FIGS. **18, 24, 28,** and **31,** is that the finger wheel may be manipulated with equal convenience by right-handed and left-handed operators.

An important feature of the invention is based on the discovery of why a previously mentioned vacuum-actuated instrument cannot be relied upon to release a small object when the finger-controlled vent port of the instrument is opened for that purpose. The vent port is in the single axial passage of the instrument which is in continuous communication with a vacuum source. The discovery is that the portion of the axial passage that extends forward from the vent port to the nozzle tip must compete for atmospheric air with the rearward portion of the passage that communicates with the vacuum source and consequently the vacuum is only partially destroyed at the nozzle tip. Actually, the open port tries to vent the vacuum source itself and therefore cannot effectively vent the nozzle tip.

The invention takes advantage of this discovery by cutting off the rearward portion of the axial passage so

that only the forward portion of the passage is vented to the atmosphere. Thus, a feature of the invention is that the slide valve cannot be shifted to the forward venting position without first cutting off the vacuum source, the result being that the vacuum at the nozzle tip is abruptly destroyed for effective release of the small object. There is also reason to believe that in the new arrangement atmospheric air enters the nozzle tip so abruptly that it gains sufficient momentum to create momentary positive pressure against the inner face of the small object to ensure prompt release of the small object.

The employment of a resiliently deformable tubular nozzle tip is advantageous on two counts. In the first place, the nozzle tip is sufficiently soft to avoid scratching a small object that is highly vulnerable to damage and, in the second place, the plastic nozzle tip yieldingly conforms to the surface configuration of the small object to form an air-tight seal at the juncture of the small object and the nozzle tip.

With the nozzle extending forward from the instrument body and curving downwardly towards the tip of the nozzle, and with the triangular cross sectional configuration of the body preventing rotation of the nozzle in the operator's hand, the curved nozzle is maintained in approximately a vertical plane with the end of the nozzle extending relatively close to alignment with the line of sight of the operator of the instrument.

With a slide valve and a finger wheel relatively close together on the upper longitudinal side of the instrument body, the index finger may be quickly shifted from one control to the other. Since the finger pressure against the finger wheel is balanced by the pressure of the thumb and second finger against the convergent lower sides of the instrument body, the instrument is held in a stable manner during the rotation of a small object to a desired orientation. In like manner, since the pressure of the index finger is balanced by the pressure against the convergent lower sides of the instrument body when the index finger moves the slide valve forward to terminate the vacuum, there is no tendency for the tip of the nozzle to waiver at the moment when a small object is being released. It is also to be noted that the heel of the operator's hand may rest on a table or counter where the assembly operation is being carried out, the support of the hand making it possible to keep the nozzle tip steady.

The provision for rotating the nozzle tip by remote control from the body of the instrument together with the provision of a relatively long nozzle makes it possible to keep the operator's fingers and the leading end of the instrument body out of the field of vision at the nozzle tip. This feature is especially important in the common practice of employing a microscope, for example, a 40 power microscope to carry out an assembly operation.

The location of a finger wheel on the underside of the instrument body as shown in FIGS. **18, 23, 27,** and **30** makes possible independent manipulation of the slide valve and the finger wheel by the operator's index finger and third finger respectively. Thus, this arrangement promotes stability of the instrument by making it unnecessary for the operator to shift his index finger back and forth between the slide valve and the finger wheel.

For the further promotion of stability of the instrument, the provision of a vacuum reservoir as illustrated by FIG. **21** frees the body of the instrument from the weight and drag of a flexible vacuum hose.

In the design of the instrument, advantage is taken of the fact that the instrument employs a vacuum to pick up small objects. In the first place, the invention utilizes the vacuum to create a vertical pressure differential across the slide valve that presses the slide valve against the bottom wall of its guideway. Thus, the arrangement makes it unnecessary to employ any kind of spring means to press the slide valve against its guideway to ensure a required degree of frictional resistance to movement of the slide valve. In the second place, the vacuum promotes sealing contact between various parts to make it possible to simplify the construction of the instrument. Thus, the vacuum promotes sealing action at the slide valve, sealing action at the rotary joint in the nozzle assembly, sealing action where the plastic tip embraces the nozzle extension **38,** and sealing action between the plastic tip and a small object that is picked up by the tip.

In the third place, the vacuum in the instrument has the effect of urging certain parts to their assembled positions. Thus, the vacuum in the forward part of the instrument tends to keep the nozzle assembly connected to the instrument body and, as may be seen in FIG. **4,** the vacuum tends to draw the nozzle extension **38** towards the tubular shank **36** of the nozzle to keep the two parts together.

The employment of a relatively long tubular drive shaft for transmitting rotation from the finger wheel to the instrument nozzle makes it possible to position the finger wheel sufficiently rearwardly to be in close proximity to the slide valve.

The provision of the coil spring makes it possible to transmit rotation from the tubular drive shaft past the bend in the nozzle to the rotatable nozzle tip and the coil spring does not interfere with the field of vision at the nozzle tip. The inclusion in the motion-transmitting means of the short rigid wire **70** as shown in FIG. **3** makes the rotary nozzle assembly detachable to permit the use of different rotary nozzle assemblies interchangeably.

The use of a finger wheel with peripheral gear teeth as in FIGS. **2** and **27** makes possible simplification of the nozzle-rotating mechanism. On the other hand, a finger wheel with a smooth surface as shown in FIGS. **15, 18, 23,** and **30** is more comfortable for the user and is highly desirable when the instrument is manipulated constantly over a period of several hours.

As heretofore stated, it is desirable on the one hand that the rotary nozzle tip be highly responsive to rotation of the finger wheel for initial rotation of a small object to approximately the desired orientation of the small object and, on the other hand, it is desirable that the rotary nozzle tip be less responsive to the finger wheel in carrying out precisely the final orientation of the small object. It has been found that a satisfactory compromise is to arrange for approximately one-eighth inch peripheral movement of the finger wheel to cause the nozzle tip to rotate through an angle of 30°–60°. In designing the instrument it is a simple matter to select the diameter of the finger wheel and the gear ratio between the finger wheel and the tubular shaft to provide any desired angular response to one-eighth inch peripheral movement of the finger wheel. In the above embodiments of the rotary-nozzle instruments the angular

response is in the range of 30°–60°, a response of approximately 40° being preferred.

Economical fabrication of the various embodiments of the invention is favored in different ways. A basic body structure is employed for the various rotary nozzle embodiments, a basic body core being cut away in various ways for various types of finger wheels and associated gearing. The same basic body structure is used for the fixed nozzle embodiment shown in FIGS. **19** and **20** wherein the fixed tubular spacer **165** is substituted for the usual tubular drive shaft **18.** Any of the described embodiments of the invention that is connected to a vacuum source by a flexible vacuum tube may be converted to a model that incorporates a vacuum reservoir by simply substituting the vacuum reservoir shown in FIG. **21** for the usual tail fitting **26.**

My description in specific detail of the selected embodiments of the invention will suggest various changes, substitutions, and other departures from my disclosure within the spirit and scope of the appended claims.

I claim:

1. In a vacuum-actuated pick-up instrument to be held in the hand of an operator for handling small objects, which instrument has an elongated body with a pick-up nozzle extending forwardly from the forward end of the body and a valve on said body for controlling vacuum at said nozzle,

the improvement comprising:

at least the tip portion of said nozzle being continuously rotatable;

a manually rotatable control member on said body adjacent said valve;

and means drivingly connecting said manually operable control member to said tip portion of the nozzle for rotation thereof by remote control from the instrument body.

2. An improvement as set forth in claim **1** in which said body has a forwardly extending tubular air passage in communication with the tip portion of the nozzle to evacuate the tip portion of the nozzle and in which said operatively connecting means includes a forwardly extending tubular shaft rotatably surrounding said air passage to transmit movement from said control member to said tip portion of the nozzle.

3. An improvement as set forth in claim **2** in which said control member is a manually operable control member oriented with its plane of rotation longitudinally of the instrument and in which said operatively connecting means includes gearing operatively connecting said wheel to the tubular shaft.

4. An improvement as set forth in claim **3** in which said gearing includes a drive gear on the rear end of the tubular shaft.

5. An improvement as set forth in claim **4** in which the gearing includes a circular series of teeth fixedly connected to the hand wheel to drive the driven gear.

6. An improvement as set forth in claim **5** which includes gear teeth on the periphery of the hand wheel for contact by the index finger of the operator, the gear teeth engaging said driven gear at the inner end of the tubular shaft.

7. An improvement as set forth in claim **5** which includes an idler gear in mesh with the driven gear and in engagement with said series of teeth.

8. An improvement as set forth in claim **5** in which the rim of the hand wheel is smooth.

9. An improvement as set forth in claim **5** in which said gear teeth are formed by recesses on one face of the hand wheel.

10. An improvement as set forth in claim **1,** in which the means operatively connecting the control means to the tip portion includes a coil spring rotatably embracing said nozzle.

11. An improvement as set forth in claim **10** in which the nozzle has a downward bend and said coil spring embraces the bend of the nozzle.

12. An improvement as set forth in claim **1** wherein said valve includes a slide on the upper side of the elongated body for manipulation by the index finger of the operator to control the creation of a vacuum in the pick-up nozzle.

13. An improvement as set forth in claim **12** in which said hand wheel is also on the upper side of the elongated body for manipulation by the index finger of the operator.

14. An improvement as set forth in claim **12** in which hand said wheel is below the top surface of the elongated body with the periphery of the wheel protruding from the two opposite sides of the body for manipulation by the third finger of either hand of the operator.

15. An improvement as set forth in claim **1** in which:

the cross sectional configuration of the body of the instrument is generally triangular with one side of the triangle uppermost to provide a top longitudinal surface extending across the width of the instrument for contact by the index finger of the operator and to provide two downwardly convergent longitudinal surfaces for contact by the thumb and second finger respectively to resist rotation of the instrument about its longitudinal axis and to cause the pressure against any one of the three longitudinal surfaces to be opposed and balanced by pressure against the other two longitudinal surfaces to promote stability of the instrument;

and in which the periphery of the hand wheel is exposed at both of the downwardly convergent longitudinal surfaces of said body.

16. In a pick-up instrument having a body to be held in the hand of an operator, wherein the body is provided with a pick-up nozzle to hold a small body by vacuum action, and wherein the body is provided with a movable vacuum control member to control the vacuum in the pick-up nozzle and the body is provided with a manually rotatable control member for rotary control of the pick-up nozzle, the improvement comprising:

said body having an elongated core with said control members mounted thereon and said vacuum control member being slidable on the outer surface thereof;

said body having a sleeve enclosing at least the portion of said core where said control members are located,

said sleeve being connected to the core and being of substantially larger cross sectional area than the core to provide clearance space between the core and the sleeve,

said sleeve being apertured to provide access to said control members;

and said vacuum control member having portions movable in said clearance space and being retained against said body by said sleeve.

17. An improvement as set forth in claim 16 in which the cross sectional configuration of said sleeve is generally triangular with one side of the triangle uppermost to provide a top longitudinal surface extending across the width of the instrument for contact by the index finger of the operator and to provide two downwardly convergent longitudinal surfaces for contact by the thumb and second finger respectively to resist rotation of the instrument about its longitudinal axis and to cause the pressure against any one of the three longitudinal surfaces to be opposed and balanced by pressure against the other two longitudinal surfaces to promote stability of the instrument.

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