Oct. 14, 1969 R. M. HALL 3,472,323

PNEUMATICALLY DRIVEN SURGICAL INSTRUMENT

Filed Oct. 24, 1967 3 Sheets-Sheet 1

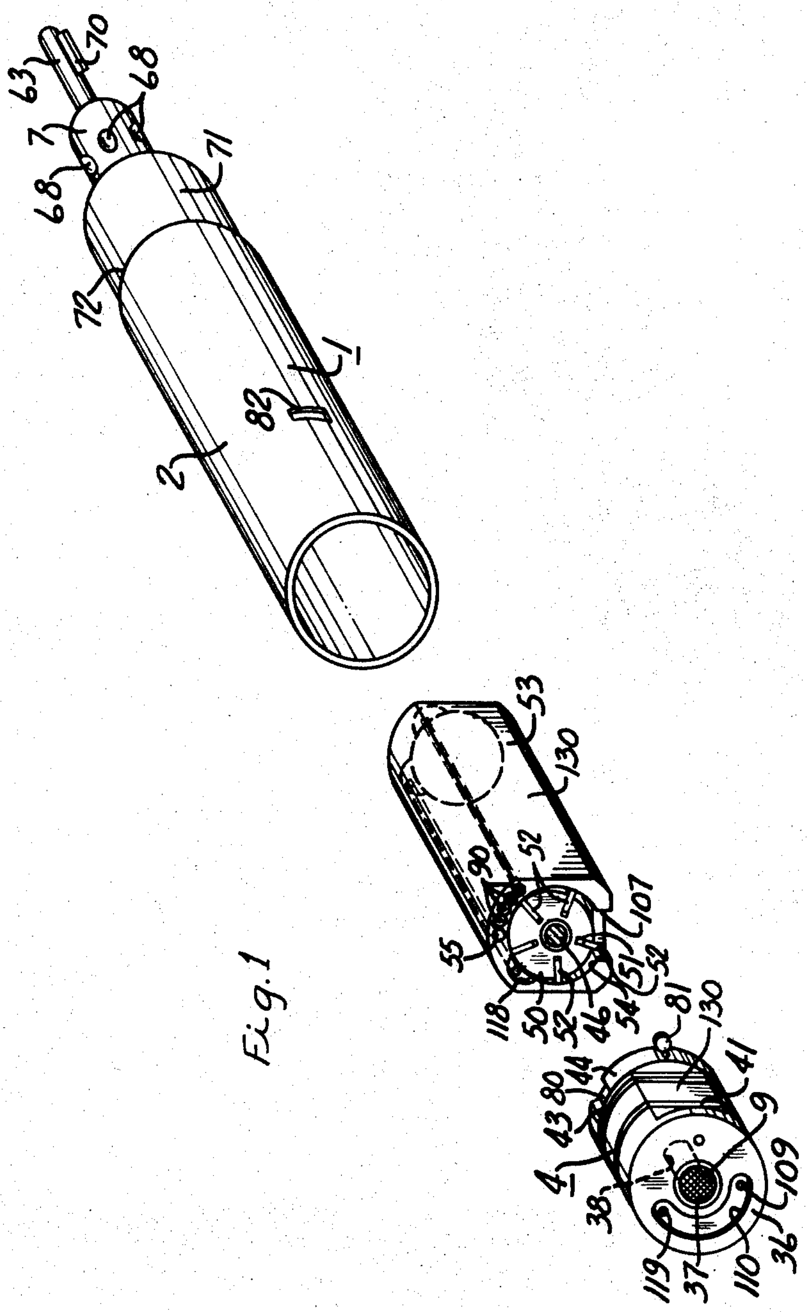

Fig. 1

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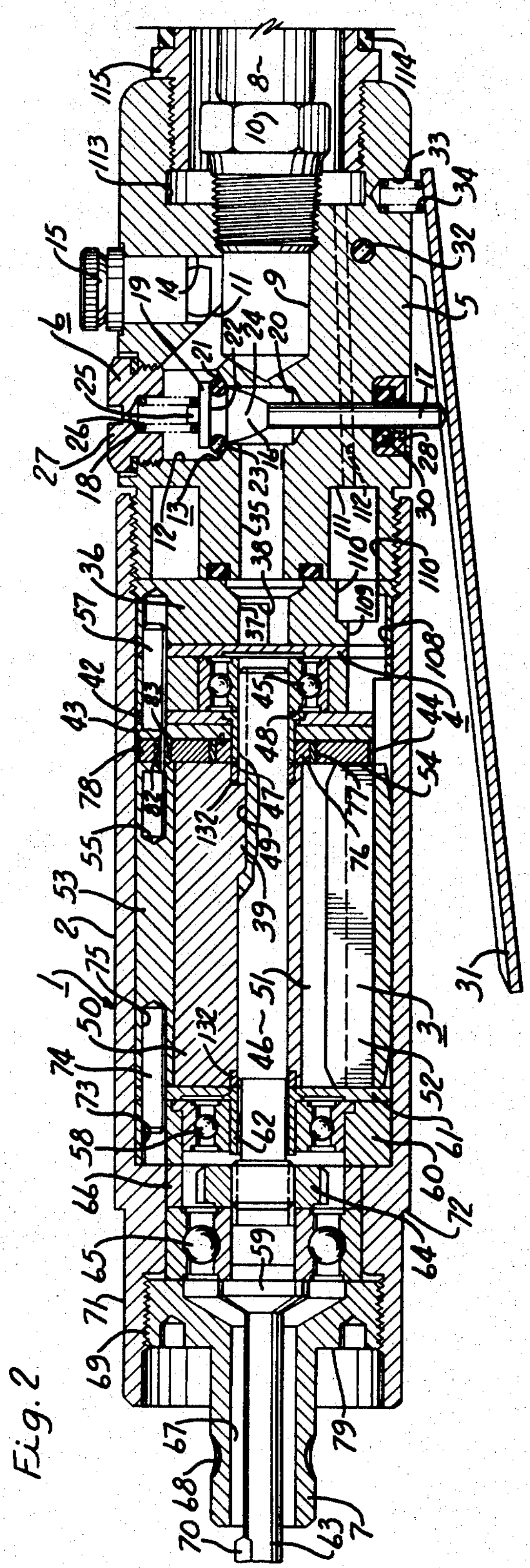

Fig. 2

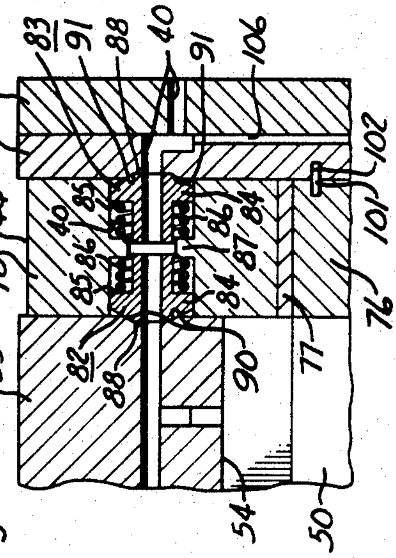

Fig. 4

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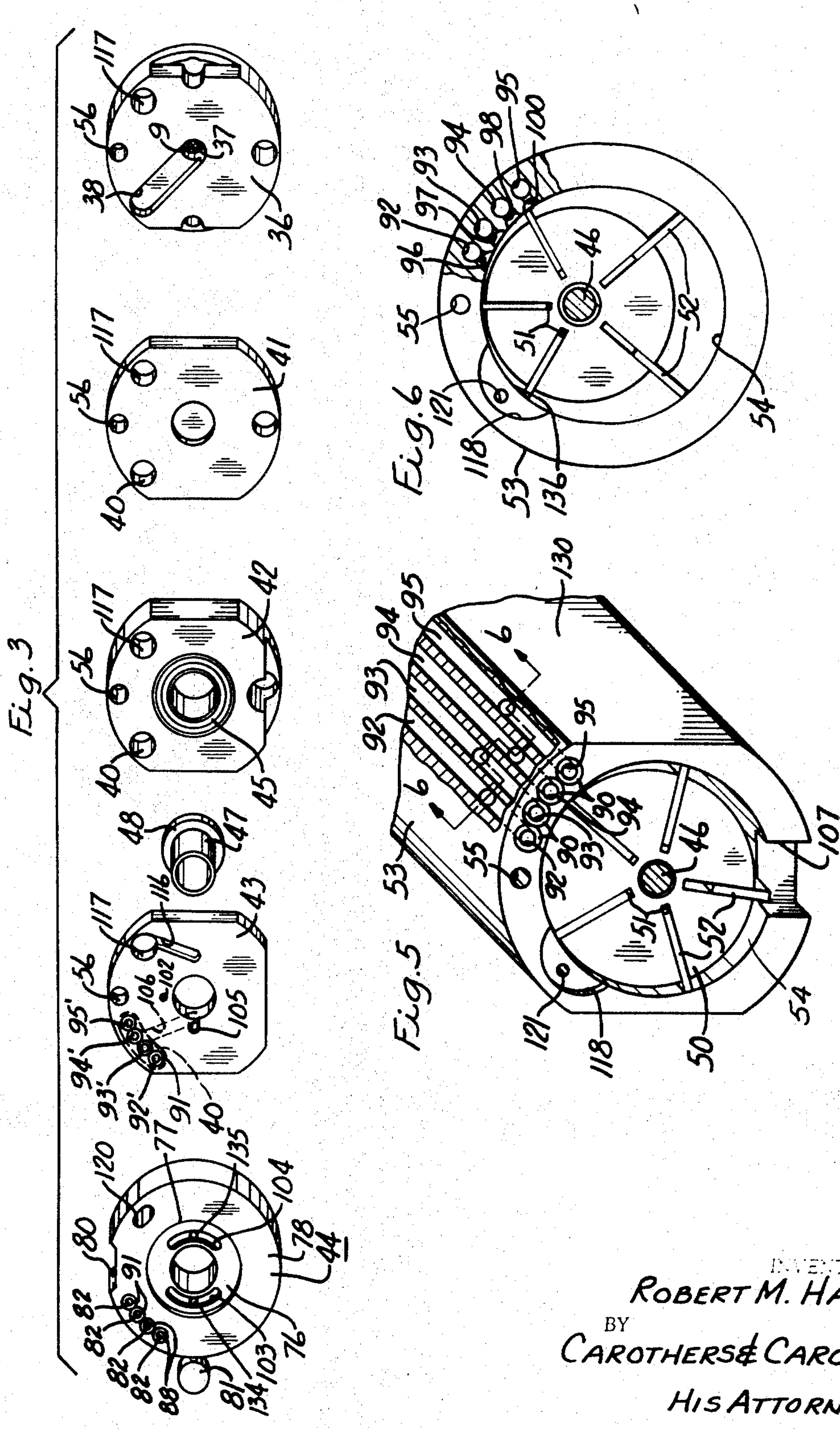

Fig. 3

Fig. 5

Fig. 6

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3,472,323

PNEUMATICALLY DRIVEN SURGICAL INSTRUMENT

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U.S. Cl. 173—163 7 Claims

ABSTRACT OF THE DISCLOSURE

A pneumatically driven surgical instrument having a rotor motor within a housing shell with valve means to selectively control the pneumatic supply to the rotor motor. An output spindle is supported on the forward end of the housing shell and rotatably connected to the rotor motor. Adapter means are provided on the forward end of the housing shell to various types of auxiliary surgical appliances of different manufacture and torque requirements. Means are provided in the surgical instrument to selectively vary the developed torque and speed of the rotor motor to meet those torque requirements in the form of (a) a specially constructed valve body in the rotor motor valve means and (b) means to vary the actual location of entry of the pneumatic supply input to the rotor motor.

BACKGROUND OF THE INVENTION

Field of invention

This invention pertains to surgical instrument devices designed for use in operative surgery together with auxiliary devices used in operations.

Description of prior art

The use of pneumatically operated surgical instruments in surgery was long ago conceived with practical fluid operated surgical devices beginning to appear in the 1940's. Since 1957, there has been unprecedented increase in the design and practical utilization of pneumatically operated instruments exclusively for surgical application. These new high speed operated instruments have no overheat problems and eliminate possible explosion problems in the operating room now possibly present with electrical operated surgical devices. Such pneumatically operated instruments also provide precision bone cutting and shaping during surgery in a fraction of the time it takes in using hand tools, such as hand drills and saws, which are rapidly being replaced by the high speed pneumatically operated surgical instrument.

Although the pneumatically operated surgical instruments are a blessing to surgery, there has erupted a whole new field of problems accompanying the ultimate practical use of these instruments in the surgical field. This invention is directed to the solving of one of those problems.

Automatically driven surgical instruments of the past which have been electrically driven bring a potential danger to the operating room since there is a risk of explosion due to the highly volatile and inflammable nature of anesthetic agents. At the same time, such electrical driven instruments were connected to a flexible drive cable controlled by a foot switch, the former making it cumbersome to properly operate and surgically apply the instruments and the latter being a potential obstruction for tripping over or accidentally stepping upon by persons present in the operating room. These potential hazards are eliminated by the pneumatically driven surgical instrument comprising this invention.

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SUMMARY OF INVENTION

The present invention is directed to a pneumatically operated surgical instrument similar to the type now known in the pneumatic surgical art but particularly directed to a pneumtically operated surgical instrument capable of being utilized with various types of surgical appliances, such as surgical saws, drills, an impactor and extractor, and dermatomes.

Various types of pneumatically operated surgical instruments have been developed with adequate torque characteristics depending upon the particular application to which the instrument is to be ultimately applied. Thus, in the case of an orthopedic screw driver the torque requirements are set within the instrument by designing the desired torque rating of the rotor motor. On the other hand, it is necessary to provide a different value of torque rating for the surgical oscillating saw since the application of this instrument is quite different than the orthopedic screw driver.

The present invention provides an instrument wherein the value of torque rating developed by the rotor motor may be selectively varied to permit the use of a single surgical instrument of the pneumatic type for many different types of surgical appliances requiring different surgical applications.

The surgical instrument of the present invention has a unique quality not known in the prior art, in being versatile in a multitude of surgical applications. This versatility not only rests in the ability to selectively vary the applied torque of the rotor motor but also rests in connection with the adaptor means provided at the forward end of the surgical instrument housing shell. The adaptor means of the present invention permits the utilization of not only newly developed surgical appliances that may be driven by the present pneumatic surgical handpiece or instrument but also by those appliances previously found in the art which are adapted to be driven by the conventional electric motor drive adapted for surgical use.

Another feature of the present invention resides in the valve means used for supplying pneumatic pressure to the rotor motor. The valve means of the present invention is provided to give uniform control in the desired amount of pneumatic pressure to be applied to the pneumatically operated rotor motor. This is brought about by the particular design of the valve body of the valve means wherein it takes the form of a parabolic sector.

The pneumatically driven surgical instrument comprising this invention comprises an elongated housing shell within which is mounted a rotor motor comprising a rotor eccentrically mounted within a cylindrical motor housing. The eccentricity of the rotor relative to its rotor housing forms a crescent-shaped expansion chamber. Rotation of the rotor permits radial movement of the rotor blades from within the rotor, when passing through the crescent-shaped expansion chamber, and, conversely, their withdrawal within the rotor upon their passing a point wherein the rotor surfaces comprising the expansion chamber converge to a point substantially tangent relative to the inner annular surface of the rotor housing. Valve means, as above mentioned, is provided in the housing shell to selectively control the pneumatic supply to the rotor motor. The speed and developed torque of the rotor motor may be varied by operation of the valve means.

A second valve means may be provided in connection with the rotor motor in order to vary the developed torque of the rotor. This second valve means may take the form of a series of inlet ports arcuately positioned along the inner surface of the cylindrical rotor housing commencing from the point of divergent of the side walls of the crescent-shaped expansion chamber. One may select the desired inlet port in order to vary the actual position or location of entry of the pneumatic pressure supply into the rotor expansion chamber. The further the supply of inlet pneumatic pressure is provided away from the point of divergence of the expansion chamber sidewalls, the greater the rotary speed, but with a corresponding reduction in the developed torque. Conversely, the closer the inlet port of the pneumatic supply to the point of divergence of the crescent-shaped expansion chamber side walls, the greater the developed torque of the rotor motor with a corresponding decrease in speed. Thus, the present invention provides means to readily selectively adjust the developed torque rating of the rotor motor to a desired value in order to meet and satisfy the torque requirements of a number of surgical appliances that may be attached on the forward end of the housing shell through the use of adaptor means provided thereon.

The adaptor means may take the form of a coaxially aligned member, being coaxial relative to the output drive spindle of the rotor motor. The adaptor means is provided with a series of detent means thereon to receive and removably secure the above mentioned appliances for operation through the output drive spindle. The detent means may take the form of an appliance mounting shoulder formed on the outer forward surface of the housing shell or may comprise a series of ball detent dimples or recesses positioned circumferentially around the outer surface of the adaptor means to receive and detachably retain an auxiliary surgical appliance to be driven by the output drive spindle.

Thus, the purpose of the present invention is the provision of a pneumatically driven surgical instrument having universatility and being capable of being used with a number of many different types of auxiliary surgical appliances, no matter their particular design or manufacture in combination with the capability of providing a means to selectively vary the torque of the motor drive in order to meet the torque requirements of any of the auxiliary surgical appliances that may be used in connection with the instrument.

Other objects and advantages appear hereinafter in the following description and claims.

The accompanying drawings show for the purposes of exemplification, without limiting the invention thereto certain practical embodiments illustrating the principles of this invention wherein:

FIG. 1 is an exploded view of the pneumatic supply and exhaust assembly, pneumatically operated rotor motor and its housing shell of the surgical instrument comprising this invention.

FIG. 2 is a longitudinal cross-section of the pneumatically driven surgical instrument comprising this invention.

FIG. 3 is an exploded view of the pneumatic pressure supply and exhaust assembly.

FIG. 4 is a detail cross-section of the structure in the supply and exhaust assembly to operate the variable pneumatic input to the rotor motor.

FIG. 5 is a perspective view of an end of the rotor motor housing with a cross-sectional detail of the pneumatic pressure input ports.

FIG. 6 is a cross-sectional view of the detailed section taken along the line 5—5 of FIG. 4.

As shown in FIGS. 1 and 2 the pneumatically driven surgical instrument **1** is provided with a housing shell **2** to support the rotor motor **3**, the pneumatic pressure supply and exhaust assembly **4**, the head **5** housing the valve means **6** and the adaptor means **7** at the forward end of the housing shell **2**.

The input pneumatic supply line **8** has the coupling **10** which is threadably secured to the rearward end of the head **5** to permit the passage of the pneumatic supply into the head chamber **9**, thence through the diagonal chamber **11** into the enlarged chamber **12** of the valve chamber **13**. A transverse entry **14** is provided in the head **5** to permit the insertion of the oiler **15** to introduce lubrication into the pneumatic supply to provide continual lubrication to the rotor motor **3**.

The valve means **6** comprises the valve body **16**, valve stem **17** and valve spring **18**. The valve body **16** is housed within the valve chamber **13** which consists of the enlarged chamber **12**, previously mentioned, and the smaller cylindrical valve chamber **20**. Due to the differences in the size of the enlarged valve chamber **12** and the smaller valve chamber **20** there is provided a shoulder **21** therebetween to form a valve seat.

The valve body **16** in reality consists of two sections. As will be noted in FIG. 2, the upper section **19** of the valve body **16** is provided with an annular groove **22** which receives the elastomer O-ring **23** which rests in position, biased by the valve spring **18** on the valve seat **21** and thus forms a valve seating surface for the valve body **16**. The lower or other body section of the valve body **16** consists of a parabolic sector section **24** which is receivable within the bounds of the smaller valve chamber **20**. The particular form of this valve section is important in that it provides proportional and uniform control of the desired quantity of pneumatic pressure supply to be provided to the rotor motor **3**.

The spring **18** maintains the valve body **16** in its normal seated position and is biased against the stud **25** of the upper valve body section **19** with the other end is housed within the aperture **26** provided in the valve chamber seal nut **27**.

The valve stem **17** extends outwardly through the head **5** through the gland **28** and its captive O-ring **30** where the outer end of the stem engages the control lever **31** of the pneumatically driven surgical instrument **1**. The control lever **31** is pivotally secured to the head **5** of the surgical instrument **1** at **32**. An aperture **33** may be provided in the head **5** in order to permit the insertion of the spring member **34** to bias the control lever **31** against the end of valve stem **17** and toward the body or housing shell **2**.

The parabolic shape of the valve section **24** is an important feature of the present invention. Most valves of this type are circular or trapezoidal in cross-section and, as such, do not permit the direct and even proportional control of the pneumatic pressure supply relative to incremental valve movement. The application of a valve body employing a parabolic sector in the valve chamber opening permits evenly distributed and applied pneumatic supply pressure with corresponding incremental movement of the valve **16** through the control lever **31**.

Upon operation of the valve means **6**, the pneumatic pressure supply is permitted to pass through the chamber **13** into the head passage **35** wherein the supply is thence directed to the pneumatic pressure suply and exhaust assembly **4**.

As shown in FIG. 2, the pneumatic pressure supply enters the distributor **36** of the pressure supply and exhaust assembly **4**. As shown in FIG. 3 as well as FIG. 2, the supply is permitted to pass through the central opening **37**, thence diagonally through the transverse opening **38** to the inlet supply vein or corridor **40**, the latter of which, as can be seen from FIG. 3, is made up of a number of openings in the various parts comprising the assembly **4**, each part being aligned relative to one another by the alignment pin **57** when assembly **4** is properly assembled.

A screen **9** may be provided in the passage or opening **37** to filter the incoming pressure supply and prevent the passage of any contaminating dirt or foreign matter.

As shown in FIG. 3 the pneumatic pressure supply and exhaust assembly **4** comprises the distributor **36**, the cover plate **41**, the bearing plate **42**, the vent plate **43** and the end plate **44**, the latter of which forms an important structure comprising an important feature of this invention.

The cover plate **41** of the assembly **4** functions as a separator for the distrbuitor **36** and the bearing plate **42**. As shown in FIG. 2 the bearing plate **42** centrally supports the bearings **45** which bearing supports one end of the axle **46** of the rotor motor **3**. The axle **46** passes through a central opening provided in the end plate **44** and the vent plate **43** and is housed in the spacer **47** which has the lip **48** abutting the inner race of the bearing **45**. The spacer **47** performs the function of a sleeve bearing relative to the vent plate **43** and the end plate **44**.

The rotor motor **3** consists of the rotor **50** having a series of radial slots **51** longitudinally disposed for receiving the rotor blades **52**. The rotor blades **52** are generally made of a fiber type material and are permitted to move radially relative to the central axis of rotation of the rotor **50** upon high rotational movement of the same. The rotor motor **3** is provided with its own rotor housing **53** and as shown in FIG. 1, the rotor housing **53** is positioned eccentrically relative to the central axis of the rotor **50**. This positioning forms the crescent-shaped expansion chamber **54** as clearly illustrated in FIG. 6. The rotor blades **52** are readily permitted to extend into the chamber **54** from their respective blade slots **51**.

The rearward end of the axle **46** is provided with the longitudinal grooves **49** to receive the rotor keys **39** to enable the rotor **50** to rotatably drive the axle **46** as well as the output spindle **63**.

As can be seen in FIG. 1, the eccentricity of the housing **53** relative to the rotor **50** is such that the rotor **50** is tangent to its housing **53** at one position which is generally in the vicinity of the alignment pin hole **55**. The rotor blades **52** of the rotor **50** when passing this position relative to the rotor housing **53** are maintained by the rotor housing wall within their radial slots **51**.

A series of alignment pin openings **56** are provided in the parts making up the supply and exhaust assembly **4** and form the alignment pin hole of the assembly **4** as assembled. Thus, the alignment pin **57** properly positions each of the various parts comprising the assembly **4** and assemblies them in proper relationship relative to the cylindrical rotor housing **53**, the pin **57** extending from the opening **56** of the assembly **4** into the alignment hole **55** in the housing **53**. Also, the sides of the housing **53** and the assembly **4**, as shown in FIG. 1, are flattened at **130** to fix their position within the shell housing **2**.

The other end of the rotor axle **46** is supported for rotational movement in the bearing **58** supported in the bearing plate **60**. The end plate **61** provides the forward end cover for the rotor motor **3** and also pneumatically seals that end of expansion chamber **54**. With the components of FIG. 1 assembled, the expansion chamber **54** is relatively defined by the eccentric positioning of the housing **53** relative to the rotor **50** together with the rearward and forward end plates **44** and **61**. A spacer **62** is provided for rotatably supporting the axle **46** relative to the inner race of the bearing **58** and, as such, necessarily acts as a sleeve bearing for rotational movement of the axle **46** relative to the end plate **61**. End seals **132** are provided at the ends of the rotor **50** to provide pneumatic sealing for chamber **54** where axle **46** enters into the chamber area.

The output spindle **63** has a shoulder abutment **59** and a bearing lock nut **64** to secure the position of the inner bearing race of the spindle bearing **65**. The spindle bearing **65** rotatably supports the output spindle **63** for driven movement by the rotor motor **3**. An annular spacer **66** is provided between the outer races of the bearings **65** and **58** in order to maintain the same in their proper spaced relation as well as their proper position within the forward end of the housing shell **2**.

The adaptor means **7** is threadably secured to the forward end of the housing shell **2** at **69** and is coaxially aligned relative to the output spindle **63**, the latter passing through the central bore **67** of the adaptor means **7**. The adaptor means **7** is provided with a series of ball detent dimples or recesses **68** which are positioned annularly around the outer surface of the same. A multiple number of detent dimples in the adaptor means **7** permits the selection of a number of possible positions for a mounting attachment or appliance, thus allowing

for the desired location of the control lever **31** relative to the auxiliary appliance to be attached to the adaptor means to be used in a surgical procedure. The adaptor means **7** provides a means for readily attaching an auxiliary surgical appliance to the instrument **1** by visually aligning the output spindle **63** with alignment key **70** when inserting the spindle **63** into the appliance to assemble the same on the instrument **1**. The appliance will be mounted against the mounting surface **79** of the adaptor means **7**. At this time, the appliance may be readily turned about on the adaptor means **7** and the surgeon may select the most comfortable or convenient lever location for the particular attached auxiliary appliance relative to the surgical instrument **1**. This location depends upon the intended application of the appliance being used and the employment of the control lever **31** relative to the operation of that attached surgical appliance. For example, in the use of an attached reciprocal impactor, extractor appliance, the control lever **31** is preferably positioned beneath the instrument **1** as shown in FIG. 2. On the other hand, when using an attached oscillating bone saw, it is preferable to position the control lever **31** above the instrument, that is, 180° from the position shown in FIG. 2.

When an auxiliary appliance is assembled to the handpiece or instrument **1**, a spring-loaded ball in the attaching collet of the appliance (not shown) will drop into any selected one of the selected dimples or recesses **68** depending upon the desired lever location. The attached appliance is securely attached for surgical use and when such use has been made, the appliance may be readily withdrawn from the adaptor means **7**.

Reference is again made to the support bearing ring **60** together with the end plate **61** which are provided with an opening in their upper portion generally indicated at **73** in FIG. 2 for insertion of the alignment pin **74** to align and maintain these parts in their proper position relative to the rotor housing **53**, the latter of which is provided with the alignment hole **75** receiving the alignment pin **74**.

Referring to the end plate **44** as shown in FIGS. 2 and 3 and 4, the end plate **44** comprises a central annular support member **76** and a controllable valve port ring **78** supported on the sleeve ring bearing **77**, made of Teflon or other suitable material and mounted on the support member **76**. The valve port ring **78** is permitted to rotate on the sleeve bearing **77**. The valve port ring **78** is provided with a cut-out section **80** in its upper portion to permit the passage of the alignment pin **57**. The alignment pin **57** also acts as a stop for limiting the extent of annular rotational movement of the valve port ring **78**.

The control arm **81** is threadably secured into the valve port ring **78** and, as shown in FIG. 1, extends outside the surgical instrument **1** through the slot **82** of the housing shell **2**.

The valve port ring **78** provides a portion of the pneumatic supply inlet vein **40** as shown in the detail of FIG. 4. The end plate **44** is provided with the spring biased pilots **82** and **83** housed within that portion of the inlet vein **40** found in the end plate **44**. Each of the pilots **82** and **83** are provided with a head section **84** which has a shoulder **85** against which the spring **86** is forcibly applied to outwardly bias the pilots **82** and **83**. The other end of the springs **86** rest against the annular shoulder member **87**. Thus the pilots **82** and **83** are always urged outwardly from within the inlet vein **40** found in the end plate **44** in order that the nose **88** of the pilots **82** and **83** will recessively cooperate with port countersinks **90** located in the end of the rotor housing **53**, as shown in FIG. 1 as well as the port countersinks **91** found in the vent plate **43** as shown in FIG. 3. The pilots **82** and **83** may be constructed of any suitable material, one such material being Teflon.

As shown in detail in FIGS. 5 and 6, the rotor housing **53** of the present invention is provided with four separate inlet port veins indicated as 92, 93, 94 and 95, each provided with a port countersink 90. Each of the veins 92, 93, 94 and 95 are provided respectively with a radially disposed inlet port 96, 97, 98 and 100. The vent plate 43 is also provided with a series of vents 92′, 93′, 94′ and 95′ in respective aligned relation with the veins 92, 93, 94, and 95, each vent provided with a port countersink 91.

As noted in FIG. 6, the inlet ports 96 through 100 enable one to selectively vary the exact location of the input pneumatic pressure supply into the expansion chamber 54 and, thus, effecting a desired rating of the developed speed and torque of the rotor 50. Thus, if the inlet port 96 is chosen as the desired entrance or location of the pneumatic supply input by rotating the valve ring 78, the developed speed of the rotor 50 will be reduced and there will be a great amount of developed torque which can be used in matching the torque requirements necessary for an attached auxiliary surgical appliance. Rotor motors of the type disclosed in FIGS. 1, 2 and 5 develop rotational speeds from 20 r.p.m. up to 20,000 r.p.m. and, conversely, torque ratings from 3 in pounds to 90 in pounds or more.

If one chooses to direct the input supply through the inlet port 100, an increase in the developed rotational speed of the rotor 50 will be obtained with a corresponding reduction in developed torque. Thus, it may be desired, for example, to adjust the valve port ring 78 to the inlet port 96 wherein an attached auxiliary appliance to the surgical instrument 1 is to be a surgical screw driver attachment for orthopedic procedures, in which case, a large amount of torque is necessary in order for this appliance to perform its job adequately. On the other hand, it may be desired to select the inlet port 100 through adjustment valve port ring 78 in order to develop a greater amount of output speed rather than developed torque as in the case of a surgical bone drill appliance.

The spring biased pilots 82 and 83, as shown in FIG. 4, prevent the unauthorized passage of the pneumatic supply between the adjacent surfaces of the vent plate 43, end plate 44 and the rearward end of the rotor housing 53.

From the foregoing it will be evident that the end plate 44 is an important feature comprising the present invention and actually is a valving means used to selectively vary the location for entrance of the pneumatic supply into the expansion chamber 54 of the rotor motor 3.

In FIG. 4 it will be noted that in order to prevent the valve support 76 from rotating with the valve port ring 78, the pin member 101 of the former is provided to be received in the opening 102 of the vent plate 43. It is important that the valve port support 76 does not rotate relative to the valve plate 43 since the rotor vent lanes 103 and 104, as shown in FIG. 3, must be positioned as shown in that figure to correspond with the opening 105 and passage 116 provided for in the vent plate 43.

The vent lane 103 in the valve support 76 is arcuate in shape around the central opening of the end plate 44 and is positioned to supply pneumatic pressure to the end of the rotor 50 in the area of the base of the rotor slots 51. The purpose of the vent lane 103 is to permit pneumatic pressure to enter into the bottom of the rotor slots when each successive slot with its rotor blade enters into the area of the expansion chamber 54 to insure positive outward radial movement of the rotor blades within the rotor slots at that time. There is no tendency for the rotor blade, therefore, to stick within the rotor slot 51 when the blade should be in an extended position from the rotor 50, as shown in FIG. 2.

From FIG. 3 it will be noted that the opening 105 in the vent plate 43 is aligned with the vent lane 103 of the end plate 44 and its opening 134 therethrough, pneumatic pressure supply being channeled along the vein 40 will be generally directed to the ports 92′, 93′, 94′ and 95′ with a small portion of the same supply being diverted along the transverse channel 106 through the opening 105, the opening 134 and thence to the arcuate vent lane 103.

As can be seen in FIGS. 1, 2 and 5, the pneumatic supply within the expansion chamber 54 is exhausted from the chamber through the lateral opening 107 in the housing 53, thence along the exhaust corridor 108 through the pneumatic supply and exhaust assembly 4, thence through the opening 109 into the arcuate exhaust chamber 110 of the distributor 36. Part of the chamber 110 is in the head 5 as shown in FIG. 2, and a series of eccentric passageways 112 are provided in the transverse wall 111 of the chamber 110 for the expended gas to be exhausted and carried away from the surgical instrument 1 as fast as conveniently possible. For purposes of illustration, only one such passageway 112 is shown leading from the annular exhaust chamber 110 to the annular exhaust chamber 113 where the expended gas is then directed through the outer coaxial flexible tubing 114 to a remote area for diffusion into the atmosphere. In providing several passageways such as 112 in the head 5, the expended gas from the pneumatically driven motor 3 is permitted to exist from the surgical instrument 1 as efficiently as possible and prevents any possibility of any gas build-up in the encased motor 3. This reduces the possibility of gas leakage through the internal parts of the instrument 1 to an external point resulting in contamination of the sterile operative field of surgery.

The flexible tubing 8 and 114 together form a coaxial hose. The tubing 114 is secured to the head 5 through the use of the fitting 115 and, as previously mentioned, the fitting or coupling 10 secures the inner tubing 8 to the head 5.

The lateral opening 107 represents the main exhaust from the chamber 54. However, the rotor motor 3 must also be provided with a secondary exhaust means in order to eliminate compression of the gases contained behind adjacent rotor blades passing on the diverging exhaust chamber side of the rotor 50 in an area designated at 136 in FIG. 6. Also, there must be means provided for the rotor blades to readily move inwardly into their respective slots without the gases present behind each of the blades resisting the inward movement of the same. The vent lane 104 is provided to bleed off any of the gases present in the bottom of the slot 51 as the blades are moved radially therein. As shown in FIG. 3, the gases present behind the rotor blades are drawn off through the vent lane 104 and the opening 135 in the end plate 44 and thence through the diagonal passage 116 in the vent plate 43 and thence discharged through the exhaust vent or corridor 117. The exhaust corridor 117 is also present in the bearing plate 42; the cover plate 41 and the distributor 36. In the distributor 36, the expended gases in the corridor 117 are directed through the opening 119, as shown in FIG. 1, into the arcuate exhaust chamber 110, previously mentioned.

The gases entrapped between adjacent rotor blades 52 as the same are progressing through the diverging side illustrated at 136 of the expansion chamber 54 are permitted to exhaust through the port 118, thence through the arcuate opening 120 in the valve port ring 78 of the end plate 44. The arcuate port 120 is part of the exhaust corrdor 117 and thus the expended gases are directed along the vent 117 to the distributor 36. The exhaust port 118, thus, represents a secondary exhaust means present in the expansion chamber 54.

It should be noted that, although not specifically illustrated in the drawings, the input supply lines 92, 93, 94 and 95 extend through to the other end of the rotor housing 53 and have corresponding inlet ports aligned relative to the inlet ports 96, 97, 98, 100, respectively. Thus, the pneumatic supply is provided on both sides of the expansion chamber 54 for uniform operation of the rotor 50. In the same manner, an exhaust passage 121, as shown in FIGS. 5 and 6, is provided in the rotor housing **53** to a secondary exhaust port aligned with and similar to port **118** at the opposite end of the housing **53** to permit uniform escape of the expended gases from between adjacent rotor blades on the diverging side of the exhaust chamber **54**.

It is not necessary to provide vent lanes in the end plate **61** since the vent lanes **103** and **104** are sufficient to supply and remove the gases within the blade slots **51** from behind each of the rotor blades **52**.

From the foregoing it should be apparent that the pneumatic driven surgical instrument of the present invention provides a unique means for varying the developed torque rating of the rotor motor in order to meet the various torque requirements necessary to operate efficiently various surgical appliances readily attachable to the forward end of the instrument. As previously mentioned, some of the appliances now present in the operating room of hospitals have been formerly electrically driven and thus adapted to torque requirements developed by electrical motors. With the ability in the present pneumatically driven surgical instrument to vary the torque requirements to be developed by the rotor motor **3**, the present surgical instrument lends itself to universatility in use in the surgical field, since this pneumatic instrument can be used to drive those surgical appliances previously driven by an electrical motor.

The operation of the valve ring **78**, as previously explained, permits unique selective control of the developed torque of the rotor motor **3** in order to match the torque requirements of an attached auxiliary surgical appliance. Although the selective positioning of the valve ring **78** will also change the output rotational speed inversely relative to the developed torque, the valve means **6** can be used in cooperation with the valve ring **78** to maintain the output rotational speed of the rotor motor substantially constant while changing the developed torque thereof, if it is desired to maintain a constant and specific output speed for a given surgical application. The opposite may be true wherein the developed torque is to be maintained at substantially the same value while changing the output rotational speed of the instrument. An example of the latter condition would be the insertion of bone screws in an orthopedic procedure with the aid of a screwdriver appliance attached to instrument **1**. The torque to be applied to the screw should not be over 25 inch-pounds while the surgeon may desire to vary the rotational speed of the screw when driving the same into the bone.

I claim:

1. A pneumatically driven surgical instrument having an elongated graspable housing shell, a pneumatically driven rotor motor mounted within said housing shell comprising a rotor eccentrically mounted within a cylindrical rotor housing forming a crescent-shaped expansion chamber, valve means in said housing shell to selectively control the pneumatic supply to said rotor motor to vary the speed of said rotor, said valve means comprising an operable valve stem secured to a valve body, a valve chamber having an enlarged chamber and a smaller chamber with a shoulder therebetween to form a valve seat, an annular groove in one body section of said valve body to receive an elastomer O-ring having a valve seating surface, the other body section of said valve body within said smaller chamber and having the form of a parabolic sector to variably and uniformly control the quantity of pneumatic pressure supply through said valve chamber to said rotor motor.

2. In a pneumatically driven surgical instrument, an elongated graspable housing shell, a pneumatically driven rotor motor mounted within said housing shell, valve means in said housing shell to selectively control the pneumatic supply to said rotor motor to vary the speed and developed torque of the same, an output spindle rotatably supported from the forward end of said housing shell and connected in driving relationship to said rotor motor, means on the outer end portion of said spindle to interengage and drive a surgical appliance, adapter means on the forward end of said housing shell coaxially aligned relative to said output spindle having detent means thereon to receive and removably secure said appliance driven by said output spindle, said valve means including means to vary the location of the input for the pneumatic pressure supply applied to said rotor motor to selectively adjust the speed and developed torque of said rotor motor, said rotor motor includes a rotor mounted eccentrically within a cylindrical rotor housing to form a crescent-shaped expansion chamber, said variable means comprising a series of inlet ports arcuately positioned along the inner surface of said rotor housing starting from one end of said crescent-shaped expansion chamber, and a rotatable valve means to direct the pneumatic supply to a selected one of said inlet ports.

3. In the pneumatically driven surgical instrument of claim **2** characterized in that said detent means is an appliance mounting shoulder formed on the outer forward surface of said housing shell.

4. In the pneumatically driven surgical instrument of claim **2** characterized in that said detent means comprises a series of ball detent dimples positioned circumferentially around the other surface of said adaptor means to receive and detachably retain an auxiliary surgical appliance to be driven by said output spindle.

5. A pneumatically driven surgical instrument having an elongated graspable housing shell, a pneumatically driven rotor motor mounted within said housing shell comprising a rotor eccentrically mounted within a cylindrical rotor housing forming a crescent-shaped expansion chamber, valve means in said housing shell to selectively control the pneumatic supply to said rotor motor to vary the speed and developed torque of said rotor, an output spindle with adapter means mounted on the forward end of said housing to engageably receive and drive auxiliary surgical appliances having different torque requirements, said output spindle rotatably driven by said rotor motor, said valve means including means to vary the location of entry of the pneumatic supply input to said rotor motor to selectively adjust the developed torque of said rotor motor to meet the torque requirements of said appliances, said variable means comprises a series of inlet ports arcuately positioned along the inner surface of said rotor housing commencing from the end of said expansion chamber, and rotatable valve means to direct the pneumatic supply to a selected one of said inlet ports.

6. The pneumatically driven surgical instrument of claim **5** characterized in that said rotatable valve means includes a controllable valve port ring, a spring biased pilot in said port ring having a centtral opening for passage of inlet pressure supply through said port ring, a port countersink for each of said inlet ports, a nose on said pilot receivable in any of said port countersinks upon rotation of said port ring.

7. In a pneumatically driven surgical instrument, an elongated graspable housing shell, a pneumatically driven rotor motor mounted within said housing shell, valve means in said housing shell to selectively control the pneumatic supply to said rotor motor to vary the speed and developed torque of the same, an output spindle rotatably supported from the forward end of said housing shell and connected in driving relationship to said rotor motor, means on the outer end portion of said spindle to interengage and drive a surgical appliance, cylindrical adaptor means on the forward end of said housing shell coaxially aligned relative to said output spindle having detent means thereon to receive and removably secure said appliance driven by said output spindle, said detent means comprises a series of ball detent dimples positioned circumferentially around the other surface of said adaptor means to receive and detachably retain an auxiliary surgical appliance to be driven by said output spindle, an annular recess provided in the forward end of said housing shell around said adaptor means, the bottom of which forms a mounting surface to receive in secure relation said appliance and removably fix said appliance in one of a selected number of set positions relative to the surgical instrument determinative by said ball detent dimples.

References Cited

UNITED STATES PATENTS

978,086	12/1910	Weinland	91—121
1,758,760	5/1930	Price et al.	173—163

3,205,873	9/1965	Renshaw	91—76 X

FOREIGN PATENTS

1,174,751	3/1959	France.

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