Nov. 23, 1965 V. H. AMES 3,219,379

SEALING MEANS FOR A VACUUM GRIPPING DEVICE

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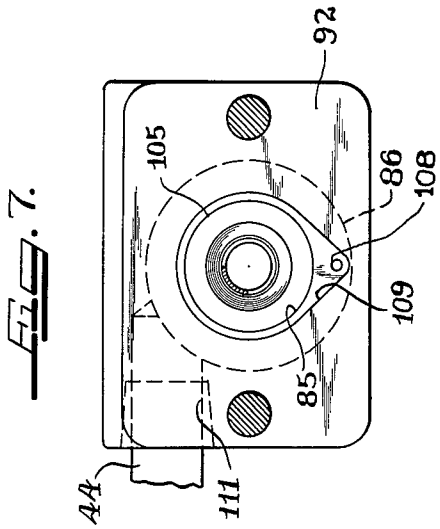


FIG. 7.

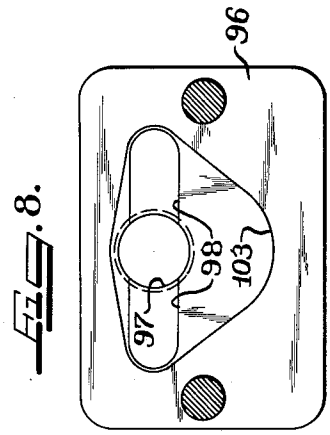


FIG. 8.

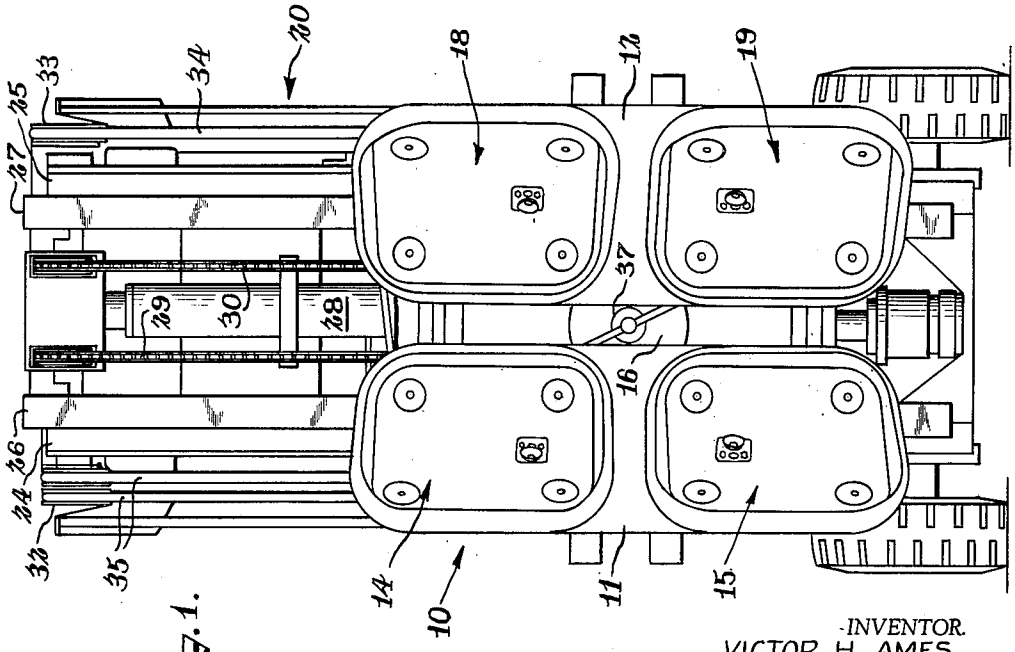


FIG. 1.

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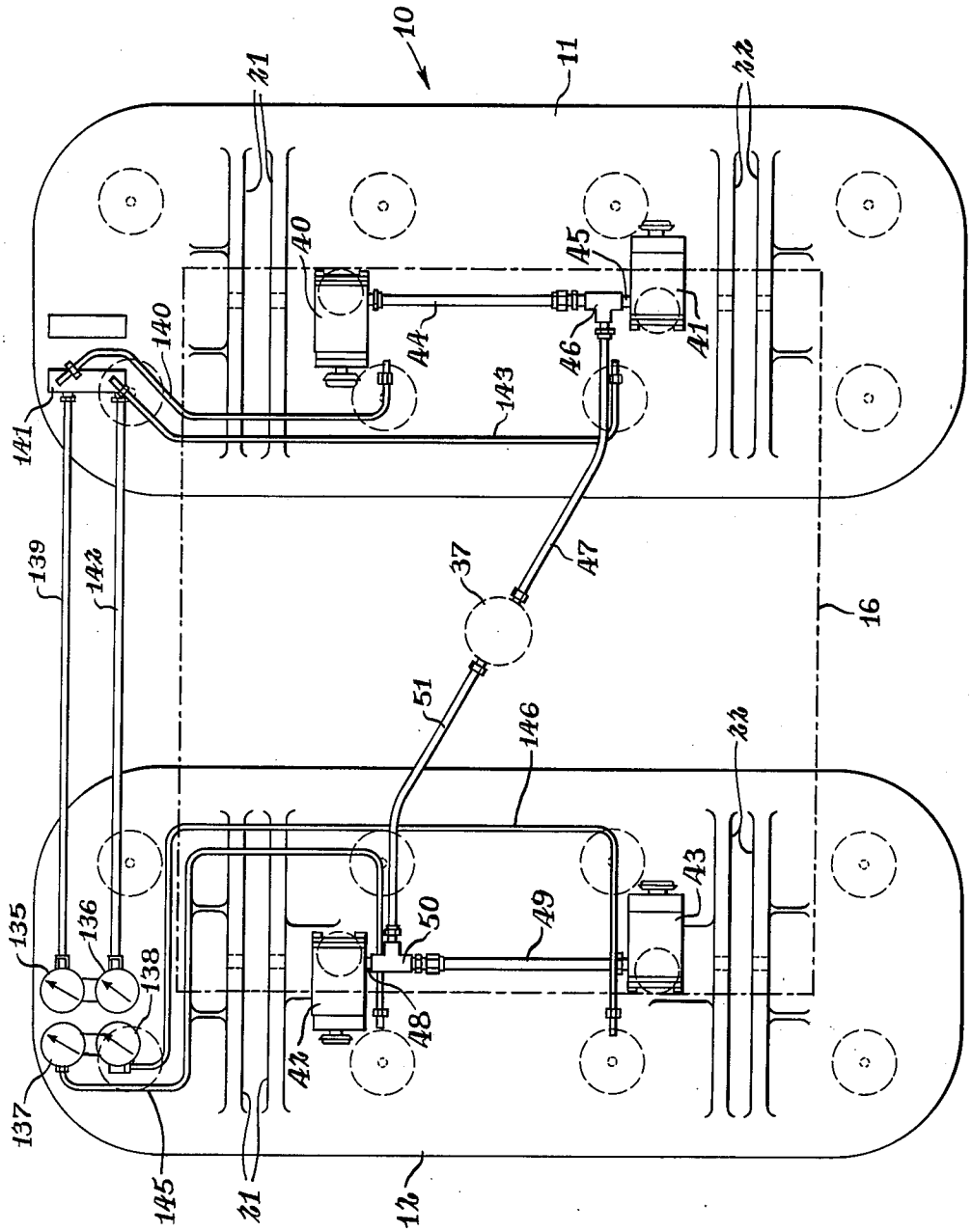


Fig. 2.

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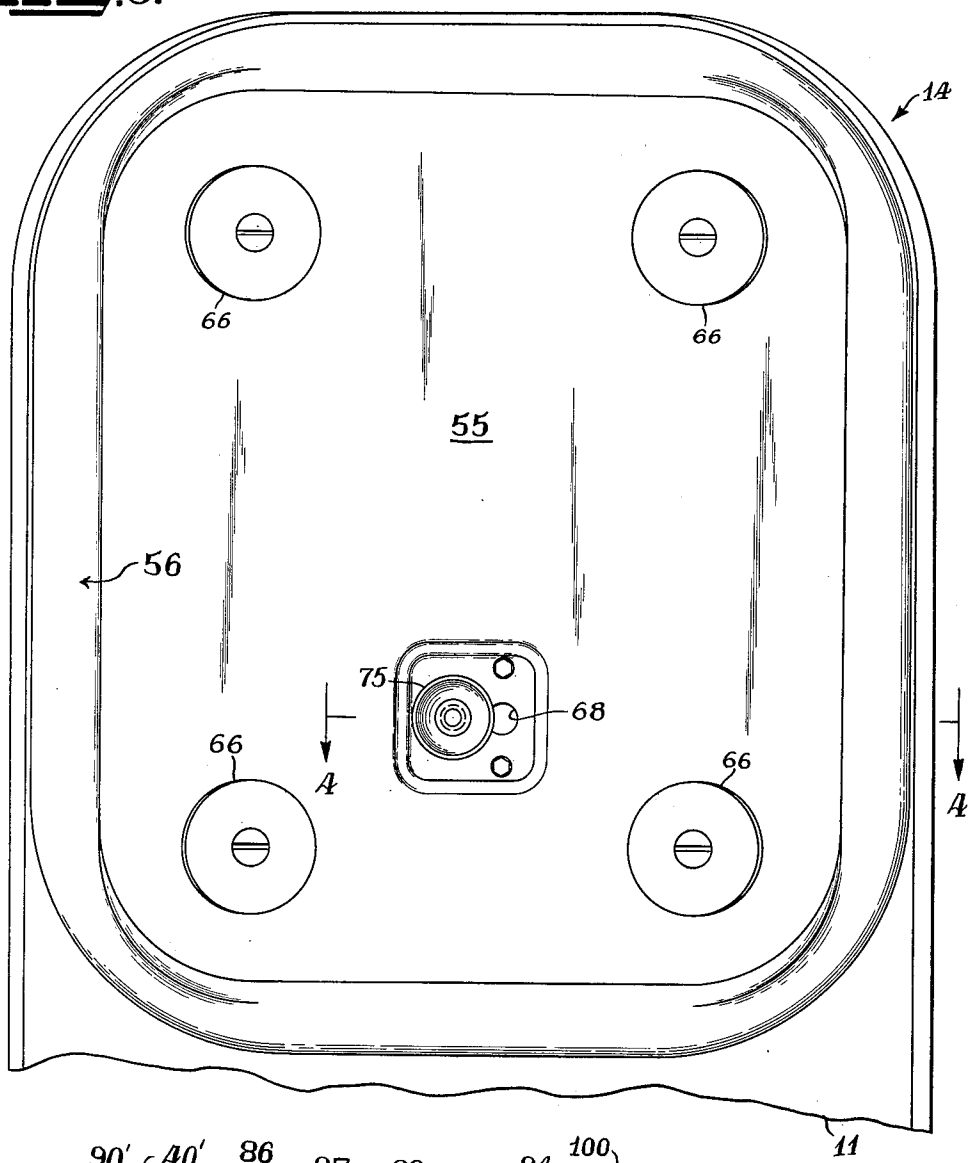
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SEALING MEANS FOR A VACUUM GRIPPING DEVICE

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Fig. 3.



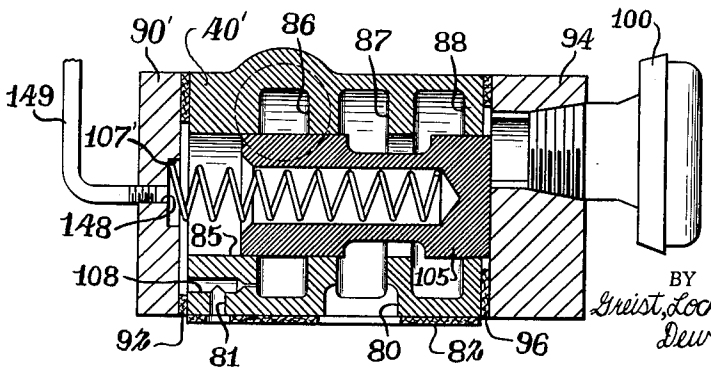


Fig. 11.

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SEALING MEANS FOR A VACUUM GRIPPING DEVICE

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FIG. 4.

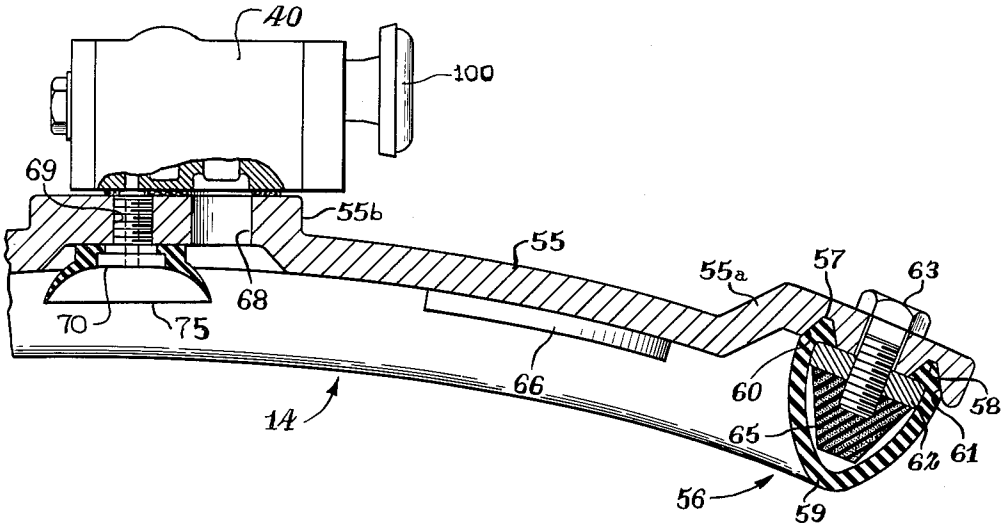


FIG. 5.

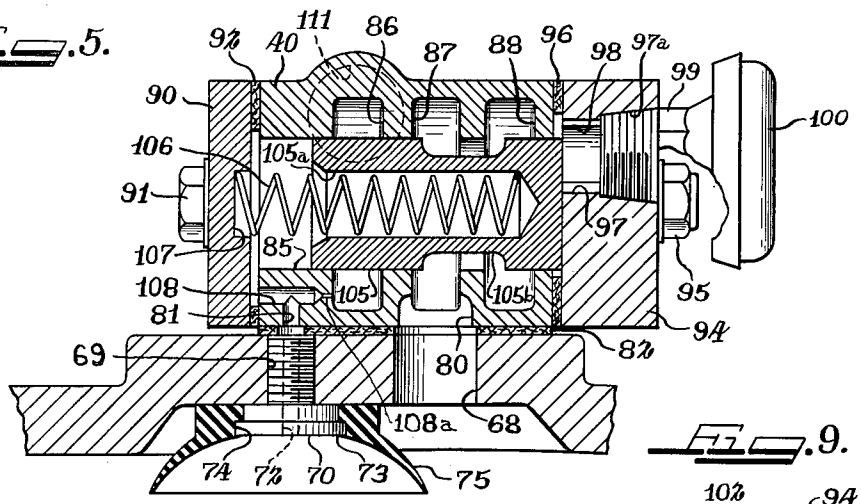


FIG. 9.

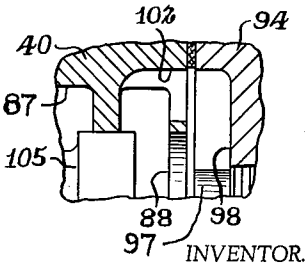
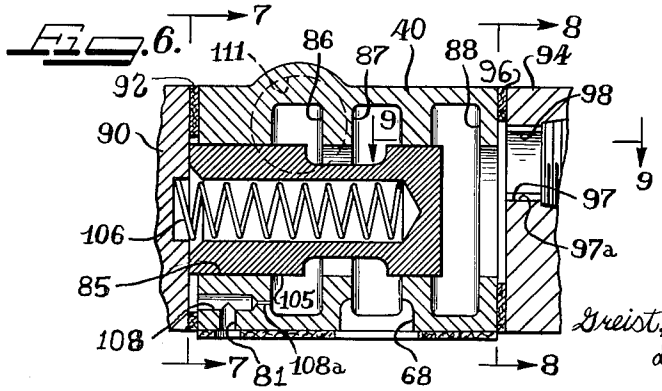


FIG. 6.



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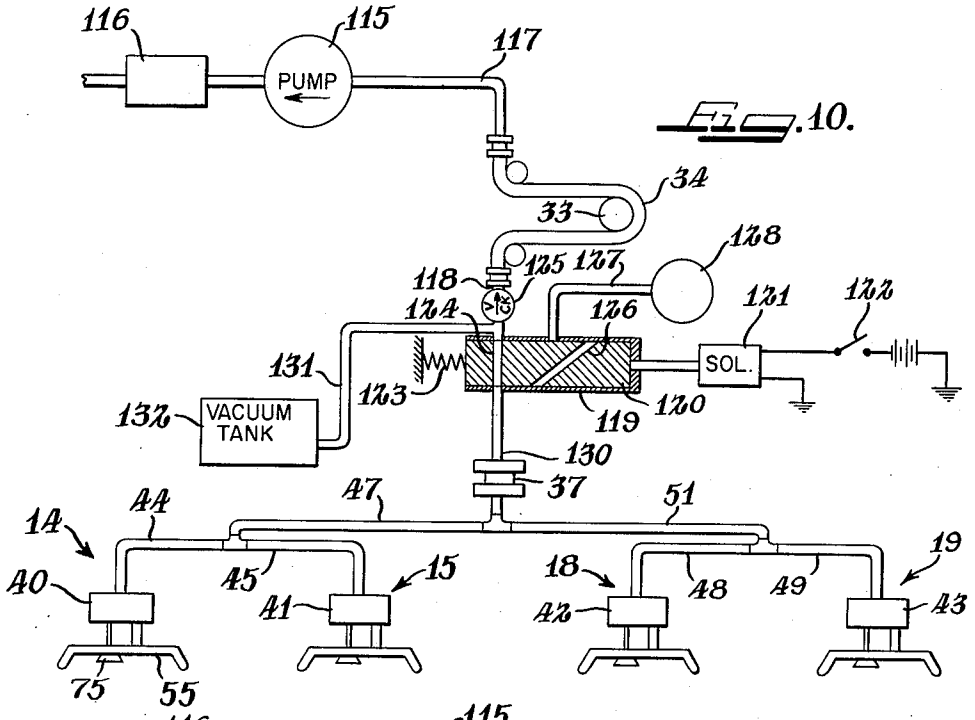


FIG. 10.

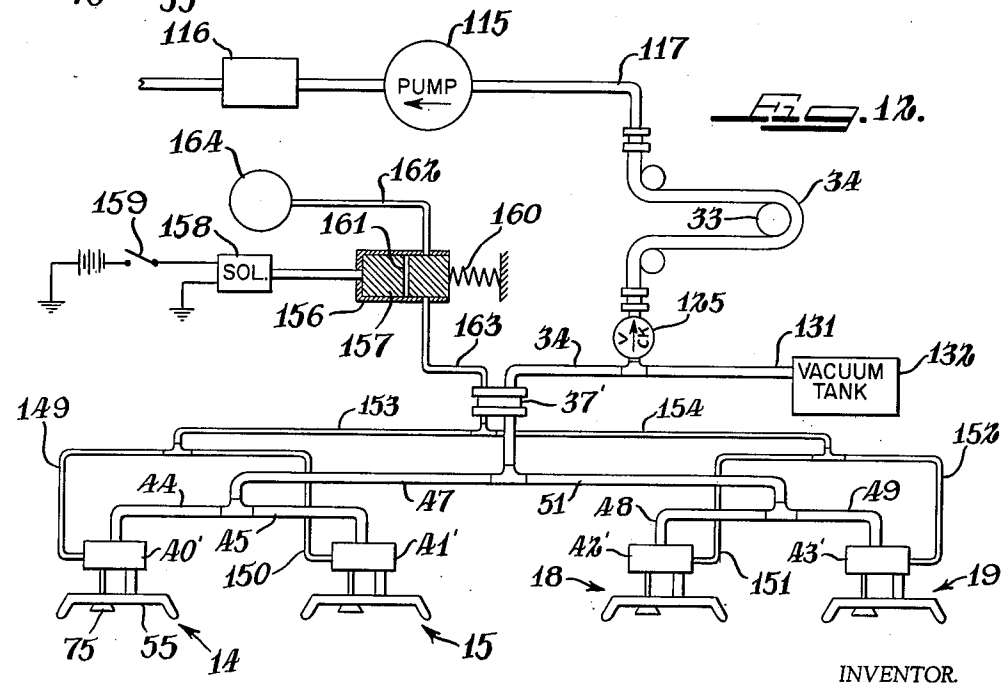


FIG. 12.

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SEALING MEANS FOR A VACUUM GRIPPING DEVICE

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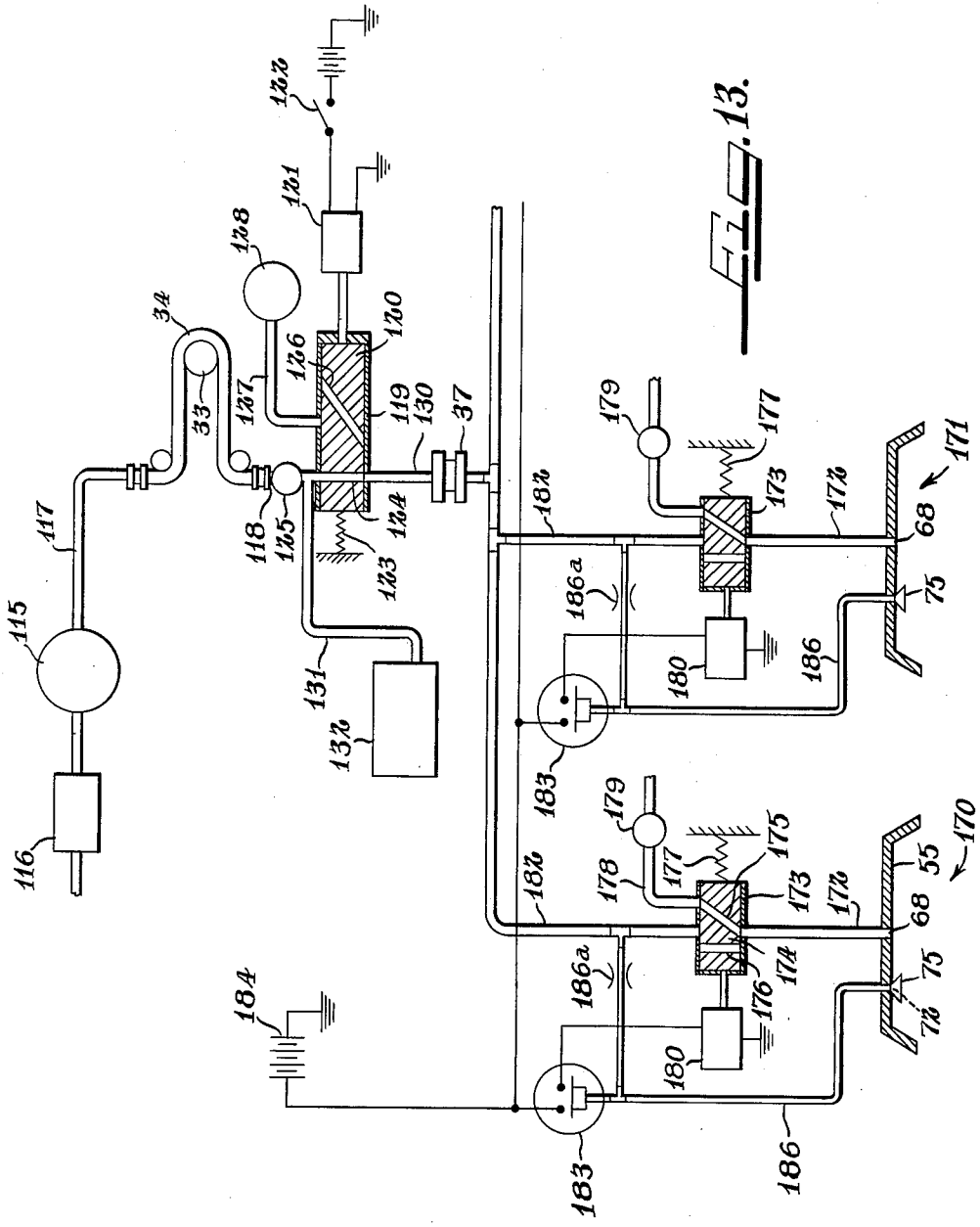


Fig. 13.

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United States Patent Office 3,219,379 Patented Nov. 23, 1965

3,219,379

SEALING MEANS FOR A VACUUM GRIPPING DEVICE

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Filed July 1, 1963, Ser. No. 291,654
6 Claims. (Cl. 294—64)

This invention relates to material handling equipment and more particularly to a new and improved vacuum gripping device for lifting an object by application of one or more vacuum pads to the surface of the object.

Known vacuum gripping and lifting devices of the type including one or more vacuum pads mounted on a movable support have been provided with means adapting the pads to grip a surface automatically upon engagement with the same. Such means have included devices in the nature of mechanically operating feeler arms located adjacent the vaccum pads for detecting the presence of a surface to be gripped. This invention provides a vacuum gripping device including one or more vacuum gripping pads wherein each pad is provided with pneumatic means adapting each pad for automatically gripping a particular surface upon contact of the pad itself with the surface.

A primary object of the present invention is the provision of a vacuum gripping device including a new and improved vacuum gripping pad assembly having pneumatic means adapting the pad to grip a particular surface automatically upon contact with the same.

Another object of the present invention is the provision of a vacuum gripping device including a plurality of separate vacuum gripping pad assemblies wherein each assembly has pneumatic means adapting the pad to grip a particular surface independently and automatically upon contact with the same.

Still another object of the present invention is to provide a vacuum gripping device for a lift truck, which device includes a plurality of separate vacuum pad assemblies in communication with a source of vacuum carried by the truck, wherein each vacuum pad assembly has pneumatic means adapting the pad to grip a particular surface independently and automatically upon contact with the same and wherein means are provided for simultaneously breaking communication with all of the vacuum pad assemblies and the source of vaccum.

Even another object of the present invention is the provision of a vacuum gripping device including a plurality of vacuum pad assemblies each of which assemblies is adapted to grip a particular surface automatically upon contact with the same, wherein each vacuum pad assembly includes improved means for quickly releasing the surface gripped.

Another object of the present invention is to provide a vacuum gripping device including at least one vacuum pad assembly, wherein each pad assembly includes a vacuum pad and improved sealing means therefor for effecting a seal between the pad and a surface to be gripped, which sealing means is adapted to accommodate wrinkles or irregularities in the surface gripped.

Yet another object of the present invention is the provision of a vacuum gripping device including at least one vacuum pad assembly adapted for effectively gripping curved surfaces.

These and other objects and advantages of the invention will become apparent from the following specification wherein like numerals refer to similar parts throughout.

In the drawings:

FIG. 1 is a front elevation of one embodiment of the vacuum gripping device of this invention showing the same mounted on the carriage at the front end of an industrial lift truck;

FIG. 2 is an enlarged rear elevation of the pair of elongated dual vacuum pad plates of the vacuum gripping device of FIG. 1, the support for the plates being shown in phantom lines;

FIG. 3 is an enlarged fragmentary front elevation of one of the vacuum pad plates showing one of the vacuum pad assemblies;

FIG. 4 is an enlarged partial section and partial elevation taken along line 4—4 of FIG. 3;

FIG. 5 is an enlarged central longitudinal section taken through one of the separate valve members associated with each vacuum pad assembly showing the valve member in its condition before a surface is gripped;

FIG. 6 is a fragmentary section similar to FIG. 5 showing the valve member in its condition after a surface has been gripped;

FIG. 7 is a section taken along line 7—7 of FIG. 6;

FIG. 8 is a section taken along line 8—8 of FIG. 6;

FIG. 9 is a fragmentary section taken along line 9—9 of FIG. 6;

FIG. 10 is a schematic view of a vacuum producing and control system for the embodiment of the invention shown in FIG. 1;

FIG. 11 is a section similar to FIG. 5 showing a modified valve member;

FIG. 12 is a schematic view of a vacuum producing and control system employing the modified valve members; and

FIG. 13 is a schematic view of a modified vacuum pad assembly.

Briefly, and by way of introduction, the vacuum gripping device of this invention includes at least one vacuum pad assembly mounted on a movable support. The vacuum pad assembly, which is specially designed for gripping a curved surface, includes a vacuum pad having a main vacuum port, a separate pilot vacuum port adjacent the main port and a valve arrangement associated with the pad and in communication with both ports, the valve arrangement being adapted to be placed in communication with a source of vacuum. The pilot vacuum port has a pilot cup member associated therewith providing for closing of the pilot vacuum port by a particular surface to be gripped upon contact of the rim of the cup with the surface. The rim of the pilot cup is preferably inwardly offset within the pad sealing ring for being contacted by a surface to be gripped after the pad sealing ring has made its initial contact with the surface. Closing of the pilot vacuum port results in actuation of a valve member for applying a vacuum to the vacuum pad and thereby gripping the surface contacted. In other words, the vacuum pad assembly of this invention, includes penumatic means adapting the pad to grip a surface automatically upon contact of only the pad assembly itself with the surface. This invention also includes the provision of mounting a plurality of vacuum pad assemblies in generally co-planar relationship on a movable support member. Separate valve members and pilot cups are provided for each vacuum pad assembly adapting each assembly for independently and automatically gripping a particular surface upon contact with the same. Means are also provided for simultaneously breaking communication between the source of vacuum and all vacuum pad assemblies for release of the surface or surfaces gripped, and the invention includes means for accomplishing this release in a quick manner.

The embodiment of the invention shown for purposes of illustration is associated with an industrial lift truck of known type and is especially designed for handling large rolls of newsprint. It will be realized that the vacuum gripping device of this invention may be mounted on any type of material handling equipment, such as a crane,

for example. The vacuum gripping device shown is in the form of a plurality of separate vacuum pad assemlies mounted on a support which is in turn movably mounted on the carriage of the industrial lift truck. Two vacuum pad assemblies are provided on each of a pair of parallel elongated vacuum pad plates, and each plate is transversely curved and pivotally mounted on the support for limited swinging movement about the longitudinal axis of the plate for accommodating the curvature of the paper roll to be gripped. The entire support is adapted for rotation about a horizontal, front-to-rear central axis, and the carriage mounting the support is adapted for vertical reciprocatory movement. The arrangement is such that a roll of paper may be gripped by the vacuum device and handled or manipulated as desired by any combination of movements of the support, carriage and lift truck. By virtue of the automatic operation of the vacuum pad assemblies of this invention an article to be handled, such as a paper roll, will be automatically gripped by contact of the vacuum pad assemblies with the surface of the article. By reason of the independent operation of each vacuum pad assembly, a vacuum is applied to a particular vacuum pad assembly only when that assembly is brought into contact with the surface of the article. Therefore, if only two vacuum pad assemblies in the embodiment of the vacuum gripping device illustrated should be brought into contact with a paper roll, for example, a vacuum would be applied only to these two assemblies. The invention also includes improved means for simultaneously breaking communication between the source of vacuum and all of the vacuum pad assemblies for release of a surface or surfaces gripped, and the invention includes improved sealing means for the vacuum pad assemblies for forming an effective seal with the surface of an object, such as a paper roll, which object may have wrinkles or irregularities in its surface.

Now referring to the drawings and more particularly to FIGS. 1 and 2, an embodiment of the vacuum gripping device, generally designated **10**, will be seen to include primarily a pair of elongated dual vacuum pad assembly plates **11** and **12**, each of which plates is slightly curved in transverse cross-section for gripping the curved surface of a cylindrical object. Plate **11**, which includes two vacuum pad assemblies generally designated **14** and **15**, is pivotally mounted to a generally square support member **16** for limited swinging movement about the longitudinal axis of the plate. Similarly, plate **12**, which includes two vacuum pad assemblies generally designated **18** and **19**, is pivotally mounted to support **16** for limited swinging movement about the longitudinal axis of the plate. In the embodiment of the invention shown for purposes of illustration, the vacuum griping device of this invention is movably mounted on a known type of industrial lift truck, generally designated **20**, for gripping and handling large rolls of paper of the type use in printing newspapers. Plates **11** and **12** are pivotally mounted on support **16** for accommodating the curvature of a paper roll which varies to some degree depending on, of course, the size of the roll. While each plate may be pivotally mounted to support **16** by any suitable means, each plate is preferably provided with upper and lower pairs of integral apertured ear plates **21** and **22**, respectively. It will be understood that the pairs of ear plates are adapted to receive pins held in lugs or the like (not shown) extending from support **16** for providing pivotal mounting of the plates to the support. Support **16**, which of itself forms no part of the present invention, may be of any suitable construction for mounting plates **11** and **12** on a carriage (not shown) on lift truck **20** for swinging movement in a vertical plane, i.e. support **16** is adapted for rotation about a central horizontal axis extending longitudinally of the truck allowing a vertically extending paper roll, for example, to be gripped by vacuum gripping device **10** and swung or rotated in a vertical plane. Preferably, hydraulic means are provided for rotating or swinging support **16**.

It will be understood that lift truck **20**, which forms no part of the present invention and may be of any known type, includes stationary parallel upright members **24** and **25** slidably supporting movable parallel upright members **26** and **27**, respectively. Uprights **26** and **27** support a carriage (not shown) and vertical reciprocatory movement is imparted to uprights **26** and **27** by means of a hydraulic ram **28** having a pair of lifting chains **29** and **30** associated therewith. A number of pulleys **32** and **33** are suitably supported by a head member attached to the stationary uprights for supporting various vacuum and hydraulic lines **34** and **35**, respectively, extending to support **16**. Vacuum line **34** has one end thereof in communication with a swivel **37** of known construction for communicating a source of vacuum carried by the truck with all of the vacuum pad assemblies.

As best seen in FIG. 2, vacuum pad assemblies **14**, **15**, **18** and **19** include valve members **40**, **41**, **42** and **43**, respectively. Valve members **40** and **41** are in respective communication with vacuum lines **44** and **45**, which vacuum lines communicate with a T-member **46**. T-member **46** communicates with swivel **37** by means of a vacuum line **47**. Similarly, valve members **42** and **43** communicate with vacuum lines **48** and **49**, respectively, which lines connect with a T-member **50**. T-member **50** is in communication with swivel **37** by means of a vacuum line **51**. It will be understood that swivel **37** provides constant communication between line **34** and lines **47** and **51** regardless of the disposition of support **16** with respect to the lift truck carriage. As will be explained in greater detail hereinbelow, the valve members, among other things, serve to communicate all vacuum pad assemblies with a common source of vacuum and adapt each vacuum pad assembly for independent and automatic gripping of a surface. As each vacuum pad assembly is of identical construction, it will suffice for purposes for understanding the invention to describe only on vacuum pad assembly in detail herein.

Referring to FIGS. 1, 3 and 4, vacuum pad assembly **14** includes a vacuum pad **55** defined by a sealing member generally designated **56**, which sealing member extends continuously around the periphery of the pad. By virtue of the curvature of plate **11**, pad **55** has its front or gripping face curved to receive the curved surface of a cylindrical object to be gripped. As seen in FIG. 4, pad **55** includes a rearwardly offset marginal portion **55***a* having continuous, parallel, inner and outer grooves **57** and **58** formed therein. Sealing member **56** includes a generally U-shaped flexible sealing ring **59** having inner and outer lip portions **60** and **61** adapted to be received in respective grooves **57** and **58** and held therein by means of a retainer ring **62**, which retainer ring is secured to pad portion **55***a* by means of a plurality of bolt means **63** spaced apart around the periphery of pad **55**. Sealing ring member **59** is preferably made of neoprene. A continuous resilient ring member **65** is disposed within flexible ring member **59** and held therein in contact with retaining ring **62** by means of a suitable adhesive. Resilient ring member **65** is preferably made of a closed cellular sponge-like material having a degree of resiliency somewhat firmer than that of sponge rubber. As noted in FIG. 4, the bight portion of flexible ring member **59** is in spaced relation with the outermost portion of resilient ring member **65** for defining a continuous clearance space therebetween.

As is known to those skilled in the art, it is quite difficult to form an effective seal between a vacuum pad and a curved surface to be gripped, e.g., a roll of a material or a pipe section, because of leakage at the marginal portions of the pad. The vacuum pad of this invention provides an extremely effective seal with a curved surface by means of the curved or arcuate pad and the sealing member secured to the marginal portion thereof. Sealing mem-

ber 56 has been found to be quite effective in forming a secure seal between pad 55 and the curved surface of an object to be gripped thereby, such as the surface of a roll of paper of the type used in printing newspapers. Frequently, such paper rolls have slight irregularities or wrinkles in the contour of the surface thereof. Curved pad 55, which is curved along one axis thereof, allows the sealing ring to accommodate the curved surface, and sealing ring 56 readily adapts itself for forming a seal along any wringles or irregularities in the curved surface. Flexible ring member 59 readily flexes and conforms to the contour of the surface of a paper roll to be gripped for forming a seal between the surface and pad 55 shortly after initial contact between ring member 59 and the paper roll. As pad 55 is vacuumized drawing the same into closer contact with the surface of the paper roll to be gripped, flexible ring member 59 continues to flex or deform after it is brought into contact with resilient ring member 65. The latter ring member acts as a backup or resilient support for ring member 59. Continued vacuumizing of pad 55 results in both ring members being squeezed or compressed until the surface of the paper roll is brought into contact with friction pads 66, which friction pads are spaced one at each corner of pad 55. Further, sealing ring 56 readily adapts itself to accommodate the shape of the marginal portion of pad 55 to which it is attached. Because of the curvature of pad 55 along one axis thereof, two opposite marginal portions of the pad are straight, two other marginal portions of the pad are curved at a certain radius and the four corners of the pad are curved at a different curvature for smoothly joining the marginal portions of the pad. Ring members 59 and 65 readily conform to these surfaces of the pad. The clearance space between these two ring members is sufficient for insuring their spaced relationship with each other along the entire lengths of the members.

Vacuum pad 55 will be seen to include a generally centrally disposed, inwardly offset portion 55*b* in which is formed a main vacuum port 68 and a pilot vacuum bore 69, which bore is internally threaded for threading engagement with the external threads of an insert member 70. Insert 70 is centrally bored defining a pilot vacuum port 72, and the insert includes an annular flange portion 73 adapted to be received within an annular recess 74 formed in the base portion of a centrally apertured pilot cup 75 for holding the latter in sealing engagement with pad portion 55*b* around bore 69 therein. The purpose and function of pilot cup 75, which is preferably made of a flexible material such as gum rubber, will be explained hereinbelow.

Referring now to FIGS. 5 and 6, it will be seen that valve member 40 having a main vacuum opening 80 and a pilot vacuum opening 81 is secured to the backside of pad portion 55*b* with openings 80 and 81 in respective alignment with ports 68 and 72. A gasket member 82 having a pair of openings adapted for respective alignment with openings 80 and 81 is provided for forming an air-tight seal between the openings in the valve member and the ports in the pad. Preferably, a flat screen (not shown) is held in place against one face of the gasket for covering openings 80 and 81 to prevent entry of foreign matter into the various bores and passageways in valve member 40. Valve member 40 includes a central bore 85 having annular passageways 86, 87, and 88 opening into the bore and spaced-apart along the longitudinal axis of the same. Bore 85 is closed at one end thereof by means of a cover plate 90 secured to one end of the body member by a plurality of bolts 91. The cover plate is in sealing engagement with the body member by means of a gasket 92. A second cover plate 94 is secured to the other end of the body member by a plurality of bolts 95, which cover plate is in sealing engagement with this end of the body member by means of a gasket 96. Cover plate 94 includes an aperture 97 having an internally threaded tapered portion 97*a* and a transversely extending recess 98 communicating with aperture 97. Aperture portion 97*a* is adapted for threadingly receiving a threaded stud portion 99 of an air breather member 100. Air breather 100, which is of known construction, includes suitable screened openings (not shown) for communicating the interior of hollow stud portion 99 with the atmosphere. In other words, the end of bore 85 adjacent cover plate 94 is always open to atmosphere through aperture 97 and breather 100. Valve member 40 includes a pair of side bores 102 (FIG. 9) adapted for registry with opposite ends of recess 98, which side bores are in communication with annular passageway 88. As noted in FIG. 8, gasket 86 includes an opening 103 shaped for allowing communication between opposite ends of recess 98 and side bores 102. It will be realized that annular passageway 88 is always open to atmosphere by means of side bores 102, recess 98, opening 97 and air breather 100.

A valve spool 105 is adapted to be slidably received within bore 85 for axial reciprocatory movement therein, and the valve spool is normally biased away from the end of the bore defined by cover plate 90 by a coil spring 106 for defining a chamber in the bore. One end of spring 106 is adapted to be received in a central bore 105*a* formed within the valve spool, and the other end of the spring is adapted to be received in a centrally disposed recess 107 formed on the inside face of cover plate 90.

An axially extending passageway 108 having a constricted portion 108*a* opening into annular passageway 86 is provided in valve member 40. Passageway 108 opens along the length thereof into opening 81, and the end of passageway 108 remote from the constricted portion opens at the end of valve member 40 adjacent cover plate 90. Gasket 92 maintains cover plate 90 in spaced relation with the end of the valve member adjacent this cover plate, and gasket 92 is provided with a central opening 109 (FIG. 7) shaped for exposing the end of passageway 108. Accordingly, this end of bore 85 adjacent cover plate 90 is always in communication with pilot vacuum port 72 and annular passageway 86 by means of passageway 108 as long as valve spool 105 is held in its normal position by spring 106, i.e., held out of contact with cover plate 90 by the spring. As noted in FIG. 7, a passageway 111 is formed in valve member 40 for communicating vacuum line 44 with annular passageway 86.

Referring again to FIG. 5, valve spool 105 includes a reduced in diameter annular portion 105*b* along the length thereof for placing annular passageways 87 and 88 in communication with each other when valve spool 105 is in its spring biased position, i.e., to the right as seen in FIG. 5. As annular passageway 87 communicates with opening 80 which in turn communicates with main vacuum port 68, the latter opens to atmosphere through breather 100 when spool 105 is in the position shown in FIG. 5.

The operation of vacuum pad assembly 14 is as follows:

Vacuum line 44 is placed in communication with a suitable source of vacuum which results in a flow of air from atmosphere through pilot vacuum port 72, opening 81, passageway 108 including constricted portion 108*a*, annular passageway 86 and passageway 111. As constricted portion 108*a* of passageway 108 has a relatively small diameter, this flow of air from atmosphere is not substantial. Constricted portion 108*a* performs a very important function during this stage of operation of valve 40. Because of the relatively small diameter of portion 108*a*, a substantial vacuum is maintained in annular passageway 86 notwithstanding the fact that passageway 86 is opened to atmosphere by means of passageway 108 including portion 108*a*, opening 81 and pilot vacuum port 72. Also, by reason of the relatively small diameter of passageway portion 108*a*, the chamber in bore 85 adjacent the forward end of the valve spool is maintained at substantially atmospheric pressure notwithstanding the

communication of this chamber with vacuumized chamber **86** via passageway **108** including constricted portion **108***a*. Or in other words, because of the relative sizes of constricted portion **108***a* and opening **81** which has a much greater diameter than portion **108***a* and which communicates with the pilot vacuum port, the chamber in bore **85** adjacent the front end of the valve stem remains substantially at atmospheric pressure when a vacuum is being drawn through annular passageway **86**. By reason of the size and construction of constricted portion **108***a* and the associated passageways, there is a substantial pressure drop or pressure variance between annular passageway **86** and the chamber defined in bore **85** between cover plate **90** and the valve spool. Accordingly, when cup **75** is closed with the surface of an object to be gripped thereby closing the pilot vacuum port and closing bore **85** from the atmosphere, this pressure drop causes the valve spool to be quickly and smartly snapped to the left as seen in FIG. 5. It is desirable to provide constricted portion **108***a* with the smallest diameter possible to achieve the greatest possible pressure drop between bore **85** and annular passageway **86**. On the other hand, constricted portion **108***a* should not be made so small that clogging is possible or that an unacceptable length of time will be required for vacuumizing the chamber in bore **85** for initiating movement of the valve spool.

In the normal or spring biased position of valve spool **105**, i.e., the position of FIG. 5, there is no flow of air through the main vacuum port due to operation of the source of vacuum as annular passageways **86** and **87** are prevented from communicating with each other by the valve spool. As vacuum pad **55** is brought into contact with the surface of an object to be gripped, flexible ring member **59** flexes allowing the surface of the object and pad **55** to be brought together until the surface of the object is contacted by the rim portion of pilot cup **75**. The rim portion of the pilot cup readily conforms to the surface of the object to be gripped resulting in closing the pilot vacuum port thereby preventing the flow of air through this port to the source of vacuum and breaking communication between bore **85** and the atmosphere. As explained above, closing of the pilot vacuum port results in vacuumizing of the chamber in bore **85** adjacent the forward end of the valve spool by virtue of the communication of this portion of the bore with the source of vacuum by means of passageway **108** including the constricted porton **108***a*, annular passageway **86** and passageway **111**. When the pressure in this chamber of bore **85** drops sufficiently for allowing atmospheric pressure acting on the end of the valve spool adjacent cover plate **94** (it will be recalled that this end of the valve spool is open to atmosphere through breather **100**) to overcome the force of spring **106**, valve spool **105** will be moved in bore **85** until the spool contacts cover plate **90** as seen in FIG. 6. As explained above, movement of the valve spool is quite rapid because of the pressure drop across constricted portion **108***a* of passageway **108**. When valve spool **105** is in this position just mentioned, communication between annular passageways **87** and **88** is prevented while communication between annular passageways **86** and **87** is permitted by means of annular valve portion **105***b*. It will now be apparent that main vacuum port **68** is in communication with the source of vacuum through opening **80**, annular passageways **87**, **86** and passageway **111**. As the marginal portion of vacuum pad **55** is in sealing engagement with the surface of the object to be gripped during this actuation of valve member **40**, vacuum pad **55** is vacuumized through the main vacuum port for securely gripping the object. When it is desired to release the object, vacuum line **44** is opened to atmosphere by suitable means. This results in a flow of air into annular passageways **86**, **87**, opening **80** and the main vacuum port **68** for breaking the vacuum in the vacuum pad thereby releasing the object gripped. Valve spool **105** returns to the position illustrated in FIG. 5 under the force of spring **106** again placing the main vacuum port in communication with the atmosphere through breather **100**. Additional air may be quickly drawn through the main vacuum port from breather **100** to aid in releasing the grip by vacuum pad **55**. Return of the valve spool and separation of the rim of pilot cup **75** from the surface of the object again allows the source of vacuum to cause a small flow of air through the pilot vacuum port, thereby adapting the vacuum pad assembly for automatically gripping the surface of an object upon contact of the vacuum pad assembly with the surface of the object.

It will be realized that valve member **40** operates in a very rapid manner for automatically vacuumizing the vacuum pad. Movement of the valve stem is almost instantaneous upon engagement of pilot cup **75** with the surface of the object for closing the pilot vacuum port. As explained above, this action communicates the main vacuum port with the source of vacuum for vacuumizing the vacuum pad assembly. Release of the object gripped is also accomplished in a quick and effective manner by valve **40**. It will be appreciated that the above described pneumatic means adapting the vacuum pad for automatically gripping a surface upon contact with the same will function equally well with a flat or planar vacuum pad.

FIG. 10 illustrates in schematic form a preferred vacuum and control system for the embodiment of the vacuum gripping device shown in FIG. 1. A motor powered vacuum pump **115** of suitable construction is mounted on industrial lift truck **20**, which pump discharges to the atmosphere through a muffler **116**. Suitable air conduit means **117** are provided for communicating the intake port of vacuum pump **115** with flexible air conduit **34**, which flexible conduit is trained over pulley **33** supported by the upright members of the lift truck. Further conduit means **118** are provided for communicating flexible air conduit **34** with a release valve **119**, which valve includes a slidable member **120** adapted to be actuated by a solenoid **121** controlled by a switch **122**. Switch **122** is located in a convenient location on the lift truck for manipulation by an operator of the truck. A spring **123** is provided for returning member **120** to its normal position, i.e., the position of FIG. 10. Valve member **120** includes a first bore **124** communicating conduit means **118** with a check valve **125**, and valve member **120** includes a second bore **126** adapted to communicate the check valve with a conduit **127** when the valve member is actuated by solenoid **121**. Conduit **127** opens to atmosphere through a filter **128**. A conduit **130** communicates check valve **125** with swivel **37**, and a conduit **131** communicates a vacuum tank **132** with conduit **130**. The location of vacuum tank **132** is important for at least two reasons. First, the tank should be located between the vacuum pad assemblies and flexible conduit **34**. If breakage should occur in any of the various conduits communicating the vacuum pad assemblies with the vacuum pump, such breakage would most likely occur in the flexible conduit which is subjected to frequent flexure and wear because of movement of the carriage to which the flexible conduit connects. If breakage should occur in flexible conduit **34** when a load is being gripped, vacuum tank **132** will maintain all vacuum pad assemblies in their vacuumized condition for securely holding the load. The second factor to be considered in mounting the vacuum tank is the length of conduit extending between the tank and the vacuum pad assemblies. By having the vacuum tank mounted as close as possible to the vacuum pad assemblies, the length of the conduits extending between the tank and the vacuum pad assemblies is kept to a minimum. This reduced length of conduit makes it easier for the vacuum tank to maintain a vacuum in the vacuum pad assemblies upon failure of the vacuum pump or breakage in the conduits extending between the tank and the pump.

The operation of the vacuum and control system of FIG. 10 is as follows:

Pump **115** is operated resulting in vacuumizing tank **132** and causing a small flow of air through the pilot cups of the vacuum pad assemblies. As explained above, upon engagement of one of the pilot cups with the surface of an object to be gripped, the corresponding vacuum pad assembly automatically grips the object. As each vacuum pad assembly includes a pilot cup and valve member, each assembly independently and automatically grips a particular surface upon contact with the same. It will be apparent that if one of the pilot cups is not contacted by the surface of an object to be gripped, the valve member of the corresponding vacuum pad assembly will not be actuated. When an operator desires to release a load gripped by one or more of the vacuum pad assemblies, switch **122** is closed thereby energizing solenoid **121** to actuate valve member **120** for simultaneously placing the various conduits in communication with the vacuum pad assemblies in communication with the atmosphere through filter **128**.

Indicating means are provided for indicating to an operator of the industrial lift truck the pressure in each of the vacuum pad assemblies when the latter are gripping the surface of an object. Such means are in the form of four pressure gauges **135**, **136**, **137** and **138**. Pressure gauge **135** is placed in communication with the vacuum pad of vacuum pad assembly **14** for indicating the pressure therein by conduits **139** and **140**, which conduits communicate with each other through a junction block **141**. Pressure gauge **136** is in communication with the vacuum pad of vacuum pad assembly **15** for indicating the pressure therein by means of conduits **142** and **143**, which conduits communicate with each other through junction block **141**. It will be understood that conduits **140** and **143** each have one end thereof communicating with small openings (not shown) in the vacuum pads of respective vacuum pad assemblies **14**, **15**. Similarly, pressure gauge **137** is in communication with the vacuum pad of vacuum pad assembly **18** by means of a conduit **145**, and pressure gauge **138** is in communication with the vacuum pad of vacuum pad assembly **19** by means of a conduit **146**. It will be understood that conduits **145** and **146** each have one end thereof in communication with small apertures (not shown) located in the vacuum cups of respective vacuum pad assemblies **18** and **19**. Pressure gauges **135–138** are mounted on the backside of plate **12** for easy viewing by an operator of the lift truck during operation of the latter. The pressure gauges provide a ready indication for indicating the vacuum pad assemblies being vacuumized upon contact with the surface of an object to be gripped. Further, the pressure gauges serve as a ready means for indicating to an operator of the lift truck whether the various vacuum pad assemblies are operating properly.

FIG. 11 shows a modified valve member **40** for use with the vacuum pad assemblies of the vacuum gripping device of this invention. The construction of modified valve is the same in all respects with valve member **40** previously described with the exception of cover plate **90** at one end of the valve member. In the modified form of valve member, designated **40'**, a cover plate **90'**, is provided, which cover plate has a central aperture **148** opening into recess **107'**. Aperture **148** is internally threaded for threading engagement with one end of a line or conduit **149**. As will be explained further hereinbelow, vacuum line **149** extends to a release valve. The release valve is normally closed for closing aperture **148**, and the release valve is adapted to open line **149** to atmosphere for admitting air to the end of bore **85** adjacent cover plate **90**. If line **149** is opened when valve member **40'** is in its gripping position, air will be admitted to the end of the bore adjacent cover plate **90** for quickly releasing the valve spool to its non-gripping or normal position. In the modified valve, the main vacuum line is not opened for releasing the surfaces gripped. It will be noted that when valve spool **105** of valve member **40'** returns to its normal position, all air admitted to vacuum pad **55** for breaking the vacuum therein is drawn in through breather **100**. The releasing action of the vacuum pad assembly having the modified form of valve member **40'** associated therewith is very quick in operation as conduit **149** is rather small in diameter providing a conduit of rather small volume extending between valve member **40'** and the release valve. Because of this small volume a reduced amount of air is required to pass through conduit **149** for being admitted to the modified valve member to release the valve spool therein for return to its normal or non-gripping position.

FIG. 12 schematically shows a preferred vacuum and control system for the embodiment of the invention shown in FIG. 1 and employing the modified valve members. In FIG. 12 all components of the main vacuum line are the same except a release valve is not located in the main vacuum line. Modified valve members **41'**, **42'** and **43'**, which valve members are identical to valve member **40'**, have respective conduits **150**, **151** and **153** corresponding with conduit **149**, Conduits **149** and **150** communicate with each other and with a conduit **153**, the latter conduit being in communication with a modified swivel **37'**. Conduits **151** and **152** communicate with each other and with a conduit **154**, which last mentioned conduit also communicates with the modified swivel. A small release valve **156** has a valve member **157** slidable therein, which valve member is adapted to be actuated by a solenoid **158** energized by a switch **159**. A spring **160** engages one end of the valve member for urging the same into the position shown in FIG. 12. Valve member **157** includes a bore **161**, which bore is adapted to communicate a conduit **162** with a conduit **163** when the valve member is actuated by solenoid **158**. Conduit **162** communicates with the atmosphere through a filter **164**, and conduit **163** extends to swivel **37'** for communication with conduits **153** and **154**. In the vacuum and control system illustrated in FIG. 12, the operation of the various vacuum pad assemblies is the same as described above for gripping the surface of an object to be handled. However, release of the load is accomplished by actuation of valve **156** by closing switch **159**. Actuation of this valve opens conduit **163** to atmosphere which results in opening the ends of the modified valve members adjacent cover plate **90** to atmosphere for quick actuation of the valve members. As will be apparent from FIG. 12, it is not necessary to open the main vacuum line extending to the various vacuum pad assemblies for releasing a load. It is only necessary to open the relatively small diameter conduits which communicate with release valve **156**, which release valve itself may be much smaller in size than the release valve of FIG. 10. As explained above, release of an object gripped by the vacuum pad assemblies having the modified valves associated therewith is much quicker because of the smaller conduit volume that must be filled with air for actuation of the valve members to their normal or non-gripping position.

FIG. 13 schematically illustrates a vacuum gripping device employing a modified vacuum pad assembly. The modified vacuum pad assembly differs from the vacuum assembly of FIGS. 1 through 12 in that the former does not employ valve member **40** or **40'** for communicating the main vacuum port with a source of vacuum when the pilot vacuum port is covered by the surface to be gripped. The modified vacuum pad assembly of FIG. 13 utilizes, in lieu of valve member **40** or **40'**, a valve arrangement including a conventional valve adapted to be actuated by a solenoid for alternately communicating the main vacuum port with atmosphere and with a source of vacuum. A vacuum switch

of conventional design is provided for energizing the solenoid. Passageway means in the form of a vacuum line communicates the pilot vacuum port with the source of vacuum, and this vacuum line has a section of relatively small diameter along the length thereof, this section generally corresponding to constricted portion **108***a* of valve member **40**. The vacuum switch is connected in the vacuum line between the pilot vacuum port and the section of relatively small diameter. When the pilot vacuum port is covered by a particular surface to be gripped, the vacuum line and vacuum switch are vacuumized thereby energizing the solenoid for actuation of the valve. When the valve is actuated, the main vacuum port is placed in communication with the source of vacuum pad for gripping the surface.

Referring now to FIG. 13, the vacuum gripping device employing the modified vacuum pad assemblies will be seen to be identical in construction, between muffer **116** and swivel **37**, to the vacuum gripping device illustrated in FIGS. 1 through 10. In FIG. 13 only two modified vacuum pad assemblies are illustrated. However, it will be understood that any suitable number of modified vacuum pad assemblies may be employed depending on the size and shape of the gripping device. The vacuum gripping device illustrated in FIG. 13 is shown with two modified vacuum pad assemblies, generally designated **170** and **171**. As both of the modified vacuum pad assemblies are of identical construction, only one will be described in detail.

Modified vacuum pad assembly **170** includes vacuum pad **55** having main vacuum port **68** and pilot vacuum port **72** with pilot cup **75** associated therewith. A conduit **172** communicates the main vacuum port with a valve **173**, which valve may be of conventional design including a slidable member **174** having through passageways **175** and **176**. The slidable member is normally held by a spring **177** for communicating conduit **172** with a conduit **178** via passageway **175**. Conduit **178** opens to atmosphere through a filter or breather **179**. A solenoid **180** is provided for sliding member **174** against spring **177**. When solenoid **180** is energized, member **174** is moved for communicating conduit **172** with a conduit **182** via passageway **176**. Conduit **182** communicates the modified vacuum pad assembly with swivel **37** and the source of vacuum. A vacuum switch **183** of conventional construction is provided for energizing solenoid **180**. The vacuum switch receives electrical power from a suitable source, such as battery **184**.

The modified vacuum pad assembly includes passageway means in the form of a vacuum line **186** extending between the pilot vacuum port and conduit **182** for communicating the pilot vacuum port with the source of vacuum. Vacuum line **186** includes a section **186***a* of relatively small diameter, which section generally corresponds to constricted portion **108***a* of valve member **40**. Section **186***a* may be formed in any suitable manner. For example, vacuum line **186** may be crimped or squeezed to provide a relatively small diameter portion or a suitable fitting may be connected in vacuum line **186**, which fitting is provided with a relatively small diameter bore. Vacuum switch **183** opens into vacuum line **186** between pilot vacuum port **72** and section **186***a*. Because of relatively small diameter section **186***a*, the flow of air from atmosphere through pilot vacuum port **72** is not substantial. By reason of section **186***a*, pump **115** is not burdened to any extent in maintaining the main vacuum conduits substantially vacuumized when the system is opened to atmosphere at the pilot vacuum ports, i.e., when one of the pilot cups is not in contact with a surface to be gripped. Vacuum line **186** itself is preferably of small diameter and has the shortest possible length for providing a space of minimum volume that must be vacuumized when the pilot cup is covered for actuating the vacuum switch, thereby insuring rapid operation of the modified vacuum pad assembly.

The operation of the vacuum gripping device employing the modified vacuum pad assemblies is as follows:

Pump **115** is operated thereby resulting in vacuumizing tank **132** and conduits **182** and causing a small flow of air through the pilot vacuum cups of the modified vacuum pad assemblies. When one of the pilot cups is closed by a particular surface to be gripped upon contact with the latter by the vacuum pad, vacuum line **186** is quickly vacuumized thereby vacuumizing and actuating vacuum switch **183**. Actuation of the vacuum switch energizes solenoid **180** thereby actuating valve **173** for sliding movable member **174** to a position where passageway **176** communicates conduits **172** and **182**. This movement of the valve results in communicating the main vacuum port **68** with the source of vacuum thereby vacuumizing the vacuum pad itself for gripping the object having its surface covering pilot cup **75**.

When it is desired to release the object, switch **122** is closed thereby actuating release valve **119** for communicating simultaneously all modified vacuum assemblies with the atmosphere through filter **128**. When this occurs, the pilot cup is again uncovered thereby allowing resumption of the small flow of air through vacuum line **186** which in turn results in opening of the vacuum switch. Opening of the vacuum switch results in deenergizing solenoid **180** thereby allowing movable member **174** to be returned by spring **177** for again communicating the main vacuum port with the atmosphere through breather or filter **179**.

The modified vacuum pad assembly has the marked advantage of being positive in operation. When the pilot vacuum port is covered for vacuumizing line **186** and vacuum switch **183**, solenoid **180** is energized thereby positively moving the movable member of the valve for communicating main vacuum port with the source of vacuum.

From the foregoing description it is believed to be apparent that this invention provides an improved vacuum gripping device having at least one vacuum pad assembly adapted for automatically gripping a particular surface upon contact with the same. Further, it will be apparent from the foregoing that this invention provides vacuum gripping means including a plurality of separate vacuum pad assemblies wherein each vacuum pad assembly is adapted to grip independently and automatically a particular surface upon contact with the same. It will also be apparent that the invention provides an improved vacuum pad for gripping curved surfaces.

While the invention has been shown in only several forms it will be obvious to those skilled in the art that it is not to be so limited, but on the contrary the invention is susceptible of various changes and modifications without departing from the spirit and scope of the appended claims. For example, while only one pilot vacuum port and associated pilot cup are shown with each vacuum pad, it will be realized that, if desired, a number of pilot vacuum ports and pilot cups could be operatively associated with the vacuum pad. If a number of pilot vacuum ports are used, they may be equally spaced around the periphery of the vacuum pad closely adjacent the sealing ring thereof and placed in communication with a source of vacuum by suitable passageways, conduits, etc. By such construction, the vacuum pad would not grip a particular surface until the sealing ring and the surface were in substantial co-extensive contact. As a further modification coming within the scope of the appended claims, the pilot cups might be formed as an integral part of the sealing ring for the vacuum pad.

I claim:

1. Vacuum gripping means comprising, at least one vacuum gripping pad assembly including a vacuum pad having sealing means extending around the periphery of the pad, said sealing means including a flexible ring member secured to said pad and extending continuously

around the periphery of the same, which flexible ring member is generally U-shaped in cross-section having inner and outer lips each being in sealing engagement with said pad, a resilient ring member secured to said pad and extending continuously around the periphery of the same within said flexible ring member, said flexible ring member having the bight portion thereof in spaced relation with said resilient ring member, whereby said flexible ring member readily conforms to the contour of a surface to be gripped upon initial contact with the same and said resilient ring member limits flexing of the flexible ring upon vacuumizing of the gripping pad. assembly.

2. The structure according to claim 1 wherein said flexible ring member is formed of neoprene and wherein said resilient ring member is formed of a sponge-like material.

3. Vacuum gripping means comprising, at least one vacuum gripping pad assembly including a vacuum pad having a gripping face curved to receive the curved surface of a cylindrical object to be gripped, sealing means extending around the periphery of said face, said sealing means including a flexible ring member secured to said pad and extending continuously around the periphery of said face, which flexible ring members is generally U-shaped in cross-section having inner and outer lips each being in sealing engagement with said pad, a resilient ring member secured to said pad within said flexible ring member and extending continuously aroung the periphery of said face, said flexible ring member having the bight portion thereof in spaced relation with said resilient ring member, whereby said sealing means readily conforms to the shape of the curved surface of said object and to the shape of said face at the periphery thereof for forming an effective seal between said pad and said surface.

4. The structure according to claim 3 wherein said flexible ring member is formed of neoprene and wherein said resilient ring member is formed of a sponge-like material.

5. Sealing means for a vacuum gripping pad comprising, a flexible ring secured to the gripping face of said pad and extending continuously around the pad adjacent the periphery thereof, said ring being generally U-shaped in cross section thereby defining inner and outer continuous lips, which lips sealingly engage said face of the pad thereby defining a closed generally annular space within said ring, a resilient ring secured to said face of said pad and extending continuously around the periphery thereof within said space, said flexible ring having the bight portion thereof in spaced relation with said resilient ring, whereby said flexible ring readily conforms to the contour of a surface to be gripped upon initial contact with the same and said resilient ring limits flexing of the flexible ring upon vacuumizing of the gripping pad.

6. In combination, a vacuum gripping pad having a gripping face including spaced, inner and outer grooves extending continuously around the pad adjacent the periphery thereof, a flexible ring having a U-shaped cross section defining inner and outer continuous lips received in said grooves, respectively, said lips each having continuous portions extending toward each other, a substantially rigid retaining ring secured to said face of the pad within said flexible ring, which ring has its marginal portions engaging said continuous portions thereby to secure said flexible ring to said pad, a resilient ring substantially coextensive with said retaining ring and secured to the latter, said flexible ring having the bight portion thereof in spaced relation with said resilient ring, whereby said flexible ring readily conforms to the contour of a surface to be gripped upon initial contact with the same and said resilient ring limits flexing of the flexible ring upon vacuumizing of said gripping pad.

References Cited by the Examiner

UNITED STATES PATENTS

2,347,491	4/1944	Lente	294—64
2,578,220	12/1951	Billner	294—65
2,665,013	1/1954	Socke.	
2,887,849	5/1956	Lytle.	
2,893,581	7/1959	Cushman	214—651
2,899,088	8/1959	Corbin	214—651 X
2,934,086	4/1960	Blatt	294—64 X
2,942,745	6/1960	Horton	214—650
2,999,715	9/1961	Firestone	294—64
3,089,723	5/1963	Fortson et al.	294—65

FOREIGN PATENTS

396,668	3/1923	Germany.
845,835	8/1960	Great Britain.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,219,379 November 23, 1965

Victor H. Ames

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 52, for "griping" read -- gripping --; column 4, line 40, for "on" read -- one --; column 5, line 10, for "wringles" read -- wrinkles --; column 11, line 15, before "pad" insert -- thereby vacuumizing the vacuum --; line 48, after "as" insert -- a --; column 13, line 25, for "members" read -- member --.

Signed and sealed this 20th day of September 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents