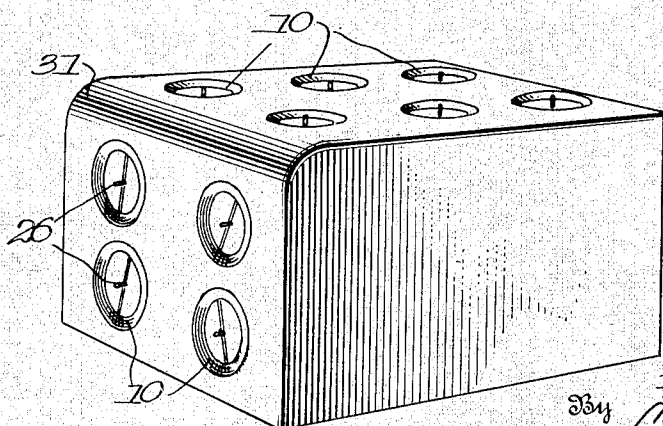
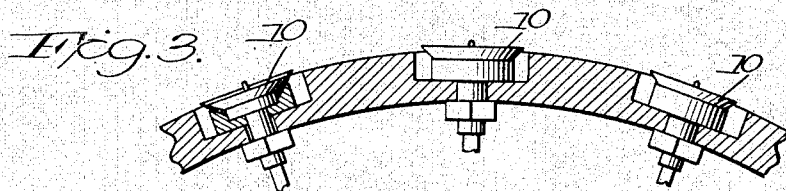
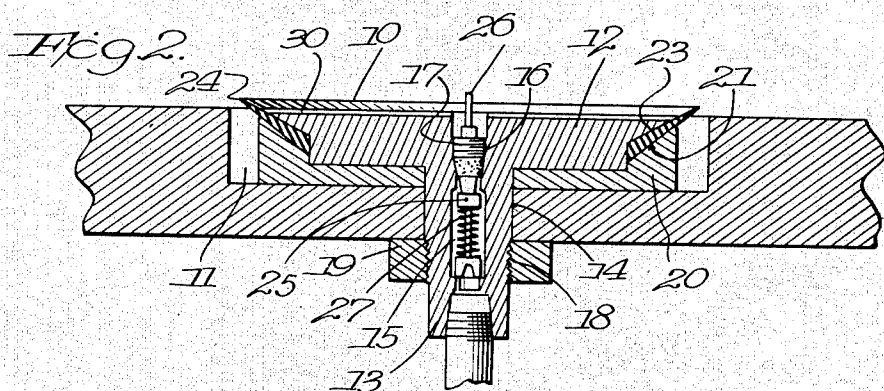
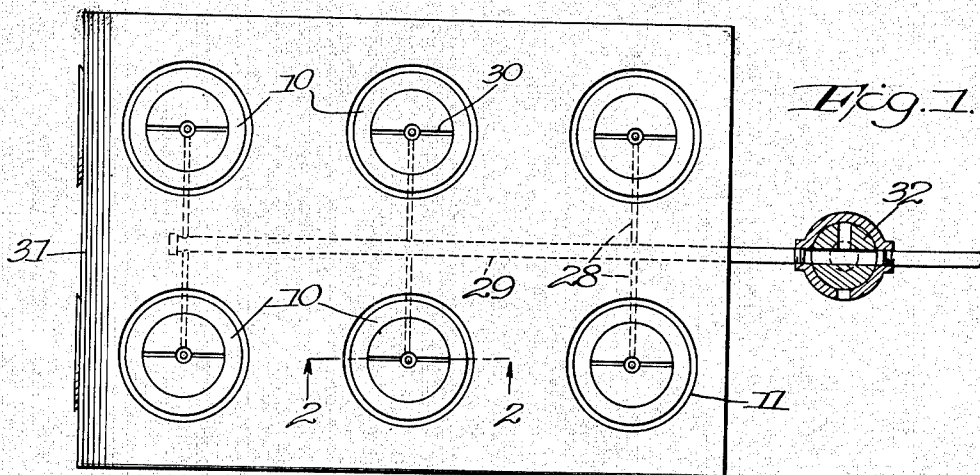


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VACUUM CUP AND VACUUM CUP SYSTEM

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VACUUM CUP AND VACUUM CUP SYSTEM

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The present invention relates to an improved form of vacuum cup and multiple vacuum cup system for holding surfaces of articles by suction and has for its principal object to provide a device of this character which remains sealed off from the source of reduced pressure except when in actual contact with a surface to be held. Another object is to greatly reduce the volume of air within the individual cups which must first be exhausted before the full working vacuum is produced. The attainment of these two ends cooperates to obtain a third important advantage by permitting the operation of a multiple system of cups such as a vacuum work table for polishing, with a great saving in the size of the vacuum pump needed for satisfactory operation. Another object is to provide a quick release upon completion of the work.

Vacuum cup appliances normally comprise one or more cup-shaped members having a pipe connection to a vacuum pump, the cup being provided with an elastic marginal lip usually made of rubber and adapted for contacting the surface to be held and sealing off leakage. Frequently, a number of such cups are inserted in the surface of a table and piped to a common source of reduced pressure. This and other forms of suction devices have been used for holding sheet materials during polishing. In the plate glass industry where a sheet of glass must be held rigidly in a perfectly flat position on the bed of the polishing table, a somewhat simpler type of suction holding device has sometimes been used. This particular method consists of using a vacuum table having a flat true bed perforated to form a grating with openings communicating to a common chamber evacuated by an air pump. A more elaborate form of vacuum table replaces the perforations with a multiplicity of rubber vacuum cups connected with a single pump.

These devices have common defects in that a comparatively large volume of air must be evacuated before a strong holding effect is obtained and also they lack adaptability for handling sheets of different sizes, since, without a pump of very large capacity, an effective action is not obtained unless the sheet covers all the individual openings or cups in the surface of the table. Even when the sheet is large enough to cover all the openings, it still requires a rather large pump to quickly evacuate the considerable volume of air which is entrapped in the individual cups or openings and the communicating passages. A further difficulty requiring excessive pump capacity is encountered when warped material is handled. The portion of the sheet which is flat is not held

firmly until the warped portion is also pressed down into a flat position on the table, because of the leakage through the openings left uncovered by the warpage. With large sheets it is often difficult to press the warped portion down into contact with the table without causing some other portion to spring up and cause more leakage. Another difficulty is a tendency for the vacuum to warp thin sheet materials by deflecting them towards the interior of the cup.

In the plate glass industry the difficulties with vacuum holding devices have caused abandonment of that system for a method of embedding the sheets in plaster of Paris to hold them firmly and without deflection during polishing. This is an expensive expedient as a fresh bed of plaster has to be provided for each side of every sheet. In the sheet metal industry magnetic tables are in use but these are expensive and also ineffective with non-magnetic metals. Furthermore, with magnetic materials the metal dust from polishing adheres strongly to the surface.

In the woodworking industry, vacuum beds theoretically could also be useful for holding plywood panels during sanding and polishing, but as nearly all plywood panels are slightly warped and tend to spring up in some other place when pressed down in the warped area, the usual vacuum table is often unsatisfactory. Ordinary plywood panels are made usually either 3-ply or 5-ply, both constructions being symmetrical so that warping tendencies are comparatively moderate, but in the case of 2-ply panels which have an unbalanced construction, a serious warping tendency makes the use of a vacuum table almost impossible. The difficulty is increased by the wide variation in the size of the plywood so that a considerable proportion of the work done on a large table is on panels which are too small to cover all of the openings.

We have now found an ideal solution of this problem by devising a system which provides for a multiplicity of vacuum cups inserted in the surface of a work table which may be of considerable size, but so arranged that a high vacuum will develop immediately in each cup as it is contacted by a sheet or panel placed on the table. This system provides means whereby additional cups come into action automatically as fast as warped portions of the sheet are pressed down in contact with the table. A distinctive feature is the provision of high vacuum and immediate action in numerous individual cups without need for a large and costly pump, the system requiring only an inexpensive small vacuum pump of low capacity.

Along with these desirable features we also provide a convenient means for quick release so that work can be handled rapidly.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described, and particularly pointed out in the claims, the following description setting forth in detail certain illustrative embodiments of the invention, these being indicative however of but a few of the various ways in which the principle of the invention may be applied.

We arrive at an effective solution of the problem by the employment of three cooperating features. These are: first, a modification of the vacuum cup construction so as to reduce the entrapped air to the absolute minimum and simultaneously support thin sheet material against inward deflection by the vacuum; second, incorporating in the cup a contact operated spring-closed air valve capable of keeping the source of vacuum tightly shut off except when the work has been brought against the cup, whereupon contact with a slight upward projection of the valve stem depresses it and opens the valve applying the full vacuum to the cup practically instantaneously due to the minimum of entrapped air; and third, an arrangement of parts facilitating a quick release of the work. The effects of these improvements are (1) to entirely eliminate leakage derived from uncovered cups since the latter are selectively and automatically operable by contact with the work which may be of any size, and (2) to limit the work of the vacuum pump to overcoming the unavoidable leakage around the elastic lips of those cups which are in actual operation. The needless work of first evacuating a considerable amount of air entrapped in the body of the cups is reduced to a negligible factor and there is no other source of leakage except an unavoidable minimum which in some case, occurs around the cup lips. The third feature of providing for quick release of the work adds greatly to efficient use of the device. This last function is obtained by the insertion of a three-way valve in the main trunk line to the air pump for simultaneous release of the vacuum in the various cups which are active and a cooperating adjustment of the relation of the relative height of the rubber lip of the vacuum cup and the height of the air valve stem above the surface of the main body of the cup which is common with the surface of the table, if several cups are used in a common table. The length of the air valve stem may be adjusted so that it will project above the surface of the main body of each cup at least high enough to keep the air valve open and maintain atmospheric pressure in the cup until the lip of the cup has come free from the contacted surface of the work. This arrangement prevents retention of any residual vacuum within the body of the cup when the three-way valve is opened to disconnect the pump and let outside air into the system. As soon as release takes place, the spring closes the air valve permitting a new vacuum to be established in the system upon closing of the three-way valve. This system eliminates much lost time in changing work from one sheet to the next.

In the accompanying drawing:

Figure 1 is a plan view of a flat surfaced work table having embedded therein a series of vacuum cups made according to the present invention and showing the main and branch lines to the

cups and the three-way valve located in the main line;

Figure 2 is an enlarged section substantially on line 2—2 of Figure 1, the section passing through the middle of one of the vacuum cups to show details of the construction;

Figure 3 shows a section of a table having a curved surface with vacuum cups embedded therein and constructed so as to conform to the curvature of the table, so that curved sheet material may be firmly held during a polishing operation, and

Figure 4 shows in perspective view a special vacuum-cup-form for holding formed panels for radio cabinets; vacuum cups are shown mounted in two flat planes arranged at a 90° angle, the two planes being connected by a curved corner having the same curvature as the formed panels.

Referring to Figure 1, the vacuum cups are indicated as a whole at 10, and are each positioned in a recess 11 formed in the surface of a work supporting table, as illustrated in detail in Figure 2. Each cup assembly includes a filler plug 12 occupying the major portion of the body of the cup, which plug has a preferably integral stem 13 extending through an opening 14 in the bottom of the recess 11. The plug and stem are provided with a coextensive central opening 15, and the wall of the opening in the plug portion is internally threaded as at 16 to adjustably receive an externally threaded valve member 17 while the stem 13 is externally threaded as at 18 to receive a clamping nut 19. A washer 20 is disposed in the recess 11 and has an opening 21 through which the stem 13 of the plug passes. This washer is provided with a recess 22 of a contour substantially conforming to the contour of the lower surface of the plug 12 for receiving the plug. Interposed between the adjacent substantially conical opposed walls 23 of the plug and washer is a molded rubber lip ring 24. The parts are positioned as shown, and the nut 19 is then threaded on the stem 13 so as to clamp the assembly together.

The lip-ring 24 is molded to a ring form so as to provide a thin elastic projecting edge adapted to seal off leakage when there is reduced pressure within the cup. In practice we prefer to modify the construction of the lip ring according to the particular character of work which is to be done. If the surface to be held is comparatively rough so that there is difficulty in obtaining a tight seal against leakage, we prefer to shape the lip ring so that there is a considerable projection of the rubber lip beyond the edge of filler plug 12, and we also shape the rubber ring so that the projecting portion is relatively thin and flexible. This provides a more effective seal for rough surfaces such as plywood. If, on the other hand, the main use of the system is to be in handling comparatively smooth surfaces such as sheet metal or glass, we then find that the foregoing feature is necessary and a narrow ring having its edge projection likewise above the plane of the plug and of the surface of the table, but of thicker and less flexible rubber, provides a satisfactory seal and is somewhat more convenient and durable.

An important feature of the invention is the design of the cup with reference to the filler plug 12. It is essential that the plug 12 occupy as large a proportion as possible of the body of the cup as this construction reduces objectionable entrapped air to the minimum. This also provides a support to prevent the outside air pres-

sure from deflecting thin sheet material in a downward direction into the cup. The surface of the filler plug should form an extension of the plane of the table in which it is embedded, i. e., both surfaces are in the same horizontal plane. Except for the lip ring which, of course, should be made of an elastic flexible material such as rubber and the air valve to be described subsequently which is best made of metal with rubber valve seats, the remaining parts of the cup such as washer 20 and filler plug 12 may be made of any convenient material such as metal or molded plastics.

Referring to Figure 2, in the central perforation or opening 15 of filler plug 12 is inserted spring-operated air valve 26 having the valve stem 26 in the form of a blunt pin projecting slightly upward from the surface of filler plug 12. It is to be noted that the position of the cup in the recess 11 in the table is so adjusted that the surface of the filler plug 12 is in the same plane as the surface of the table. It is also to be noted that the edge of lip-ring 24 projects slightly above this plane, a convenient amount for some classes of work being about $\frac{1}{4}$ " and the free end of valve stem 26 also preferably projects a little higher than the plane of the lip-ring. The air valve 26 may conveniently be the ordinary form of rubber seated air valve used in automobile tires as shown in Figure 2. We have found that in such valves the spring 27 which keeps the valve closed except when the valve stem 26 is depressed, is strong enough, owing to the very small area of the valve, to overcome the suction of a full atmospheric vacuum of approximately 14 lbs. per square inch, so that in practice this cheap and common form of air valve inserted in our vacuum cup in the manner shown is effective to prevent leakage except when the valve stem 26 is depressed. In a multiple cup system made according to the present invention and referring to Figure 1, each vacuum cup is provided with a connection for the attachment of a small copper or other branch pipe 28 to a main trunk line 29 leading to the vacuum pump, not shown. The piping used is of small diameter to eliminate as far as possible the inefficiency of exhausting entrapped air when applying a vacuum.

Referring to Figure 1, the upper face of each vacuum cup has a groove 30 machined diametrically in the surface of filler plug 12 so as to communicate with the opening 15 and enable the vacuum system to reach and exhaust the small amount of air which may be entrapped between the filler plug, the lip ring, and the contacting surface. Additional annular grooves may be used if desired to further facilitate the removal of entrapped air. The groove or grooves are also desirably of small section to minimize entrapped air and may be for example only about $\frac{1}{4}$ of an inch wide and deep. Preferably, a single diametric groove 30 is employed.

In Figure 1, there is shown a number of cups inserted flush with the surface of a flat work table and in Figure 3 there is shown a similar but curved work table having vacuum cups similar to that shown in Figure 1 inserted in its surface, but with the feature that the cups are made to conform to the curvature of the surface. A table of this character is useful in repetition manufacture where the sanding or polishing of sheet material of uniform curvature is required. In Figure 4, there is shown another form of the invention for holding specially formed panels having flat surfaces in two planes connected by a curved surface

31. Special panels of this sort are frequently made in the manufacture of radio cabinets and have hitherto been difficult to hold satisfactorily during processing.

Referring now to Figure 1, where is illustrated in dotted lines the lower side of the table the pipe connections 28 connecting the individual vacuum cups to a main trunk line 29 leading to a vacuum pump or source of vacuum not shown, through three-way valve 32. The three-way valve is arranged in the usual manner with three ports so that in one position, the vacuum pump communicates with the cups, while in another position, the line to the vacuum pump is shut off and an opening to the atmosphere is connected to the line leading to the individual vacuum cups. It is seen that the operation of this three-way valve assists materially in providing a quick release for sheet material held down on the surface of a work table by the action of the individual cups. This objective is accomplished by the arrangement shown in Figure 2 where the upper projection of the valve stem 26 above the plane of the table is arranged to be somewhat greater than the normal upward projection of the lip ring. When operating the system with very flat smooth sheet material such as plate glass, it is preferable to adjust the individual valve stems 26 in the cups so that they are not permitted to rise far enough to close off their valves before the seal formed by the lip rings and the vacuum within the cups has been broken. With such extremely smooth material, leakage past the lip rings is almost entirely absent. Hence, the valve stems must be made long enough to prevent closing of the valves until the sheet is out of contact with the lip rings. With rougher material, such as plywood, there is always a considerable leakage past the lip rings, and, consequently, the valve stems may be adjusted with a shorter projection so as to close the air valves earlier because in practice we have found that the leakage past the lip rings is sufficient to prevent the formation of any vacuum even though the sheet is lifted with the valves closed a little before contact between the sheet and the lip rings is broken. If an attempt is made to quickly lift up a perfectly flat smooth sheet from the table before all the vacuum has been eliminated and while any of the valve stems are in the closed position, the elastic edges of the lip-rings will stretch upward so that the sealed off volume and consequent vacuum within the cups is at once increased to a high value and removal of the sheet from the table is resisted by a powerful force. If, however, the valve stems project upward slightly higher than the lip-rings, the air valves are held open and there is no residual vacuum to resist removal of the sheet because of the connection with outside air through the three-way valve. With rougher material the leakage prevents this condition being reached. In operating the system, when a plate of glass or the like is placed on the table and contacts with the projecting valve stem 26, the valve will start to open, but since gravity and the vacuum are both tending to snap the sheet of glass into sealing contact with the lip-ring 24, any leakage caused by the slight opening of the valve is practicably negligible and will not affect the efficient operation of the system.

It will be seen particularly by reference to Figures 3 and 4 that the present invention is by no means restricted to operation on flat surfaces. Provided the contour of the surface of the cup

is substantially the same as the contour of the surface to be held, the invention may be applied to holding curved and even irregular surfaces. It is also not restricted to circular cups. For some purposes rectangular cups are desirable since they may be spaced closer together so as to increase the vacuum applying surface in a table of a given area.

It will now be evident that the invention furnishes a very inexpensive and effective solution to the difficulties mentioned in the foregoing description. The invention is of considerable assistance in polishing plate glass. A vacuum table carefully built with an exceedingly true smooth bed containing a considerable number of vacuum cups made after the present invention and accurately located in the table so that the surface of filler plugs 12 is very exactly in the same plane as the surface of the table, provides a convenient and satisfactory true surfaced support for most of the work of surfacing and polishing. At most, it is now only necessary to use the method of embedding the glass in plaster of Paris for the initial truing up of one side, and as soon as a reasonably true surface has been established on that side, the glass can be transferred to the vacuum bed table and the other side trued up and polished on the table. When that is completed, the sheet can be turned over on the table and the first side brought to a polish. In many cases the glass is true enough to work it on the vacuum table from the start.

A table of this character will also obviously hold either magnetic or non-magnetic sheet metal for grinding and polishing and in the case of magnetic metals, the former difficulty with magnetic tables in removing the polishing dust is eliminated. Another advantage is that our system avoids any great inrush of air through the air valves of the individual cups such as would tend to draw dust into the system and pump. It will also be seen that a table constructed after the present invention is well adapted for sanding plywood and the former difficulties with leakage through uncovered openings when working with small panels on a large table do not occur. Since the cups may be spaced in the surface of the table as frequently as conditions require, the main difficulty of handling warped panels is also eliminated because the strong holding power of the high vacuum in the individual cups first brought into action, is ample to resist and tendency for one portion of a panel to spring upward when another portion is pressed down against the table. As fast as any portion of the panel is brought in contact with the table, it is immediately securely gripped and if there is a warped portion, all that is necessary is to press that portion down until the entire panel is contacted with the table when it is held securely in a flat position.

In glass polishing the advantages of our method of quick release are important. The surface of glass is so smooth that leakage at the lips of the cups is practically nil so that a small residual vacuum in a multiplicity of cups would interfere seriously with removal of the glass upon completion of the work, but by our combined feature of providing the three-way valve and designing the projecting portion of the air valve stems to always project somewhat higher than the lips of the cups, we make it impossible for any vacuum to remain and interfere with a quick removal of the sheet from the table as soon as the three-way valve has been opened.

An important feature of vacuum tables and vacuum systems made according to the present invention which arises from our provision for eliminating entrapped air from the system and of eliminating all leakage except around the edges of the lip rings, is the surprisingly small air pump required to handle a system having a large number of cups. In actual practice, working relatively smooth materials where the lip-seal of the individual cups is most effective, it has been found in many cases that no mechanical pump is needed at all and that an ordinary water tap aspirator connected through a vacuum bottle to the cups, is adequate to handle a large table provided with numerous cups. As this very simple form of air pump only costs three or four dollars and a good sized vacuum pump usually costs several hundred dollars, the great economy effected by our new type of vacuum cup and vacuum cup system is apparent. This great gain is obtained both by our method of eliminating entrapped air and of avoiding leakage by providing means for keeping the source of vacuum shut off from all cups not in actual operation.

Other modes of applying the principles of the invention may be employed, changes being made as regards the details described, provided the features stated in any of the following claims, or the equivalent of such, be employed.

We claim:

1. A vacuum cup system for holding surfaces of articles by suction, comprising a work table having a surface substantially conforming to the contour of the surface to be held, one or more vacuum cups embedded therein with their working faces parallel to the surface, each cup being provided with an elastic marginal lip-ring slightly projecting above the surface of the table and adapted to seal off a vacuum produced between a contacting surface and said cup, a contact operated spring-closed air valve having an upward projecting valve stem, said valve being capable of preventing loss of vacuum in the system but permitting suction when the cup is applied to a surface and the valve stem depressed, and means for producing a vacuum connected with said cup through said air valve.

2. A vacuum cup system as set forth in claim 1 with the added feature that the amount of upward projection of the valve stem above the plane of the surface of the work table is greater than the upward projection of the lip-ring of said cup above said plane, whereby to prevent closing of the valve until the surface of the article is out of contact with the lip-ring.

3. A vacuum cup system for holding surfaces of articles by suction, comprising a work table having a surface substantially conforming to the contour of the surfaces to be held, one or more vacuum cups embedded therein, each cup being provided with an elastic marginal lip-ring supported by and projecting slightly above a central filler plug having its exposed surface in the form of an extension of the plane of the surface of the table, a contact operated spring-closed air valve having an upwardly projecting valve stem mounted in said filler plug, said valve being capable of preventing loss of vacuum in the system but permitting suction when the cup is applied to a surface and the valve stem depressed, and means for producing a vacuum connected with said cup through said air valve.

4. A vacuum cup system as set forth in claim 3 with the added feature that the amount of upward projection of the valve stem above the plane

of the surface of the work table is greater than the upward projection of the lip-ring of said cup above said plane, whereby to prevent closing of the valve until the surface of the article is out of contact with the lip-ring.

5 5. In a vacuum cup system for holding surfaces of articles against one or more marginally sealed cups by suction from an external source, the improvement which comprises substantially reducing the volume of air to be evacuated by nearly filling each cup with a filler plug adapted to support the surface which is being held and associating with said plug a contact operated spring-closed air valve connecting to the source of vacuum and having an upward projecting valve stem, said valve being capable of preventing loss of vacuum in the system but permitting suction when the cup is applied to a surface and the valve stem depressed.

10 20 6. A vacuum cup for holding surfaces of articles by suction, comprising an elastic marginal lip-ring and a contact operated spring-closed air valve having an upwardly projecting valve stem and a connection for a source of vacuum, said valve being capable of preventing leakage of air from the cup to the source of vacuum, but permitting suction when the cup is applied to a surface and the valve stem depressed.

25 30 7. A vacuum cup for holding surfaces of articles by suction, comprising an elastic marginal lip-ring supported by and projecting slightly

above a central filler plug having its exposed surface substantially conforming to the contour of the surface to be held, and a contact operated spring-closed air valve mounted in said filler plug having an upwardly projecting valve stem and a connection for a source of vacuum, said valve being capable of preventing leakage of air from the cup to the source of vacuum but permitting suction when the cup is applied to a surface and the valve stem depressed.

10 8. A vacuum cup as set forth in claim 7 with the added feature that the amount of upward projection of the valve stem above the surface of the filler plug exceeds the normal upward projection of the lip-ring above said surface, whereby to prevent closing of the valve until the surface of the article is out of contact with the lip-ring.

15 9. In a vacuum cup for holding surfaces of articles by suction, the combination which comprises a marginal seal capable of retaining a vacuum formed between said cup and a contacting surface and means for permitting vacuum to be applied to said cup from an external source when said cup is in contact with a surface to be held, said means being also effective to prevent leakage of air into the source of vacuum when said cup is out of contact with the surface.

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