

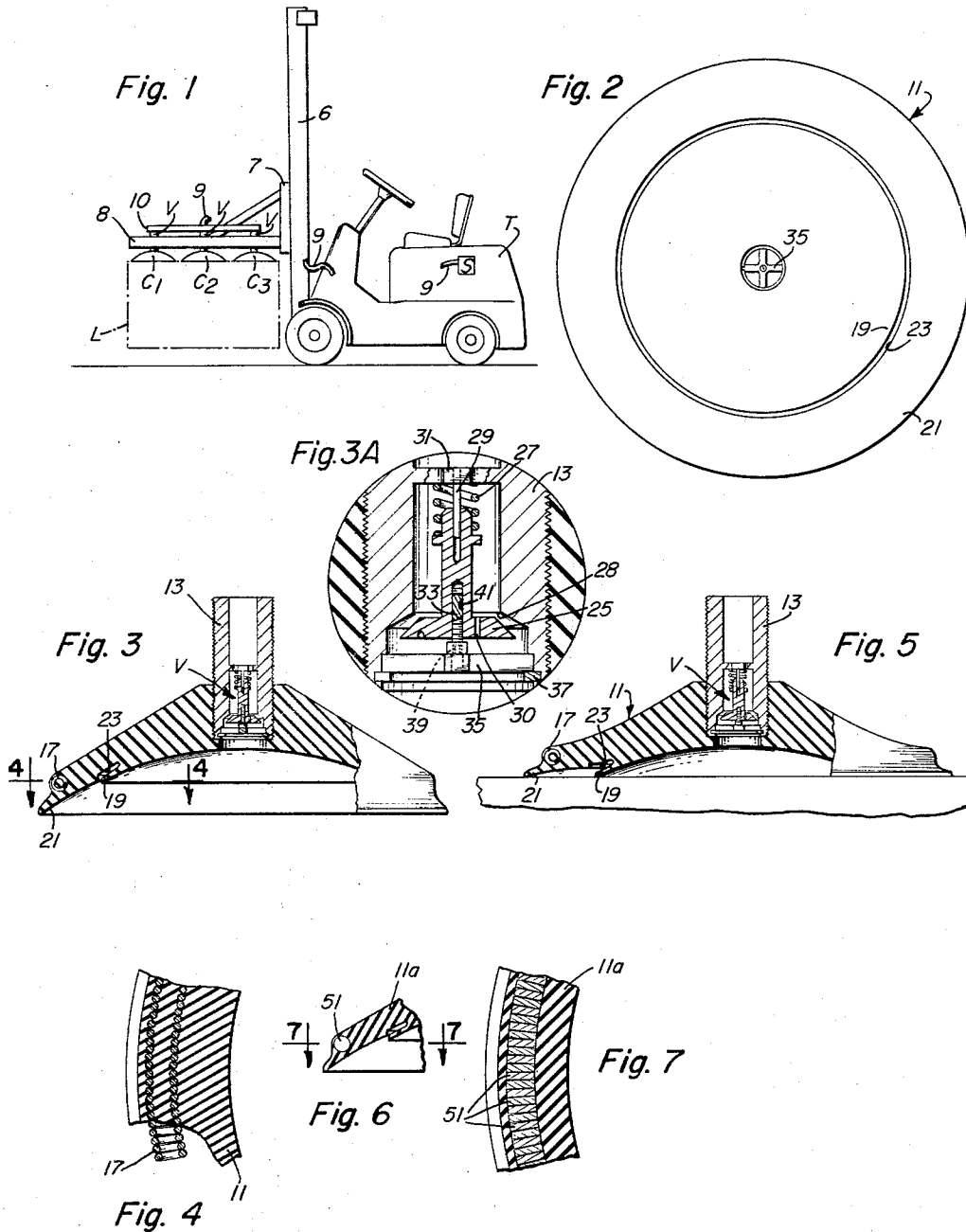
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J. E. OLSON

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SUCTION CUP CONSTRUCTION AND APPARATUS

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SUCTION CUP CONSTRUCTION AND APPARATUS

John E. Olson, Portland, Oreg., assignor to Hyster Company, Portland, Oreg., a corporation of Nevada
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This invention relates to improvements in flexible suction cups and suction cup systems and apparatus.

It is well known that a flexible suction cup tends to distort under load and will contract under substantial axial loading. As the cup contracts its effective area is reduced to proportionately reduce its capacity to support a load.

It is an object of the present invention to provide a flexible cup so constructed that it is prevented from contracting inwardly of a predetermined limit, to thereby maintain its holding power.

It is current practice in suction cup load handling apparatus to provide a cup having a diameter of such magnitude that there is a 100% safety factor in relation to the loads to be handled. Such a cup will not drop a load if there is a sudden increase in loading, as for instance when the apparatus, such as a vehicle, rides over a bump or a depression. Otherwise a cup of such excess size would not be required. Because the loads are frequently porous, a constant pumping of air must be maintained to maintain the desired subatmospheric pressure over the entire area of the cup face in spite of infiltration of air through the load. Thus it is undesirable to have the effective vacuum area any larger than necessary.

Another object of the invention is to provide a cup designed so that normally it has a smaller effective area than heretofore provided, but which is capable, under emergency conditions, of having a larger effective area, thus to make it possible to utilize a smaller capacity vacuum pump.

In multiple suction apparatus of the type shown in my prior copending application entitled, "Suction Apparatus and Method for Picking Up Articles, Especially Paper Rolls," Serial No. 64,639, filed October 24, 1960, which has matured into Patent No. 3,147,872, the arrangement is such that when the cups are connected to the source of vacuum, the pressure drop across the pressure controlled valves of the cups is sufficient to close them. After engaging a load, leakage across the valves will enable the valves of the cups which fully engage the load to reopen to create rapidly a subatmospheric pressure at the faces of such cups. The delay which occurs before the valves reopen, while seemingly brief, accumulates during a day's operation and thus makes the load handling longer by the amount of such cumulative time.

It is another object of the invention to provide a multiple suction cup apparatus so designed that the source of vacuum is not capable of closing the valves of the cups when all the cups are exposed, but is capable of closing such valves when at least one cup is fully covered by the load, whereby the valves of the cups which engage a load will be open upon engaging a load and will remain open, while the remaining valves will close to save work on the pump.

Various other objects of the invention will be apparent from the following description taken in connection with the accompanying drawings wherein:

FIG. 1 is a side view of a lift truck having a suction type load pick up means embodying the concepts of the present invention;

FIG. 2 is a front elevational view of a suction cup of my invention;

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FIG. 3 is a side elevational view of the cup, with parts broken back to a mid-section line;

FIG. 3A is an enlarged fragmentary sectional view of the valve portion V of FIG. 3;

FIG. 4 is an enlarged fragmentary vertical sectional view taken along line 4-4 of FIG. 3;

FIG. 5 is a view similar to FIG. 3 but showing the cup under internal subatmospheric pressure;

FIG. 6 is a fragmentary radial section through the marginal portion of a modified cup; and

FIG. 7 is a vertical section taken along line 7-7 of FIG. 6.

Referring to FIG. 1, a lift truck T has a mast 6 along which a load carriage 7 is elevated in conventional fashion. The carriage has a horizontal support member 8 for supporting a plurality of suction cups C1, C2, and C3. The cups are supplied with vacuum by a hose 9 which is connected at one end to a source of vacuum S on the truck body and is connected at its opposite end to a manifold 10. The latter is connected to the cups C1, C2, and C3 through a valve V for each cup. Thus the cups can support a load L when the cups are supplied with vacuum.

Referring to FIGS. 2-5 each suction or vacuum cup shown comprises a body 11 of elastomer material formed in the shape of a cup, which may be considered as being of generally conical form. The housing 13 (FIG. 3) of a valve V is partially embedded in the body 11 in a co-axial relation to said body.

The body 11 decreases in thickness toward the peripheral margin thereof, and because of this and the larger circumference of the margin as compared to the central body portion, the margin is sufficiently flexible to enable it to conform to irregularities of the load surface which it engages.

A closed coil spring 17 of overall circular form is totally or almost totally embedded in the marginal portion of the cup body in concentric relation to the axis of such body. This coil spring will readily permit the marginal portion of the body to expand (FIG. 5), and to contract from such expanded position back to its undeformed condition (FIG. 3), but will function to prohibit contraction of the marginal portion inwardly of the FIG. 3 position, because of the engagement or abutment of the adjacent coils with one another. It is pointed out that since the coils are embedded in the body, lateral displacement of the coils is prevented. Another way of considering the coil spring is that while by itself as a column, its l./r. is rather poor, when embedded in the body, its l./r. is increased sufficiently to enable it to resist contraction of the body inwardly of the FIG. 3 position.

In operation, as the loading on the cup increases, it will tend to contract from its FIG. 5 position, and will be allowed to contract somewhat. However, since contraction decreases the total area under subatmospheric pressure, it is apparent that the cup would soon drop the load if unlimited contraction were permitted. However, the coil spring 17 limits such contractive movement and thus enables the cup to withstand greater loading than heretofore possible.

The cup in FIGS. 2-5 has another novel feature in the form of an outwardly projecting auxiliary lip 19 which is disposed inwardly of and concentric with the outer lip 21 of the cup. The inner lip also projects forwardly of the immediately adjacent front surface portions of the cup for ready contact with a load. However, the lip 19 is disposed rearwardly of the lip 21 when the cup is free as in FIG. 3. A recess 23 is formed back of the lip 19 so that when the cup is passed against a load, the cup will tend to have a pronounced flexing at the location of the recess to thus tend to project the auxiliary lip for-

wardly as shown in FIG. 3 for ready contact with the load.

The area of the cup inwardly of the inner or auxiliary lip 19 is sufficient to support a load under normal operating conditions. If there is a sudden increase in loading, such as might occur when the lift truck T runs over a bump or a depression, the inner lip 19 may be torn away from the load. However, the outer lip 21 will still be in engagement with the load and thus the effective area of the cup will be increased substantially. Since the subatmospheric pressure will now be effective over a larger area, a greater holding force will be produced to enable the cup to continue to support the load despite the increased loading. After the emergency is over, the inner lip will resume full contact with the load. Because of normal air leakage at the outer lip (or through the load) the area between the inner and outer lips will soon drop to substantially atmospheric because this outer area is not in communication with the pump.

One advantage of inner lip cup construction is that with porous loads, such as those which are wrapped or enclosed in paper products, the amount of air drawn from the load will be proportional to the effective area of the cup. When effective area is determined by the inner lip, it is apparent that the amount of leakage air is less than when the effective area is determined by the outer lip. Thus the work done by the vacuum pump in maintaining a desired subatmospheric pressure is less with a cup having an inner lip because during the major portion of operating time, the effective area of the cup is determined by the inner lip 19.

Each valve V includes the valve body 13 within which is a movable valve member 25 (FIG. 3) urged by a light coil spring 27 away from a valve seat 28. The valve member is slidably mounted on a pin 29 for movement toward and away from the seat, and the valve member is formed with a small leakage passage 30 therethrough. The pin 29 is supported by a spider 31 on the body 13.

Adjustment of the "at-rest" position of the valve member 25 is attained by means of a screw 33, which is threaded into the valve member. The head of the screw abuts against a spider-like retainer 35 which is held in place by a split ring 37.

The head of the screw 33 has a non-circular socket or recess 39 to receive a mating wrench to enable adjustment of the screw relative to the valve member and hence adjustment of the clearance between the valve member and the seat 28.

The screw 33 is of the lock type, having a nylon insert 41 so as to releasably hold the screw in any position of adjustment. The screw can, for instance, comprise a standard Allen-head cap screw with nylon locking insert.

In operation, if the rush of air through the valve is sufficient to move the valve member 25 to its closed position, the valve may still reopen if subsequently the associated cup fully engages a load. This is so because air drawn through the leakage passage 30 will decrease the differential pressure across the valve and allow the spring to move the valve member to its open position.

FIGS. 6 and 7 show a modified form of the invention in which the articulated contraction limiting member is in the form of a number of disks 51. These disks are arranged in overall circular or ring fashion with the axes of the disks coaxial with the ring axis and with adjacent disks in contiguous relationship. The disks are embedded in the body 11a of the cup like the coil spring 17. The disks limit contracting movement of the cup in a manner similar to that of the coil spring 17. For ease of manufacture discs may each have a hole in the center so they may be strung on a central cord like beads.

It is pointed out that while a cup may have both an auxiliary lip and a contraction limiting means, it could have only one.

Referring to FIG. 1, the vacuum source is selected to have a capacity such that the source cannot draw sufficient air through the valves V to close them. However, the capacity of the pump is such that if one of the cups is fully covered, such as by engaging a load, sufficient air is drawn through the remaining valves to close them. Thus, only the cups whose valves fully engage the load are open, and the valve of the cup that did fully engage the load was open at the time such cup engaged the load.

The selection of a vacuum source of a desired capacity, mentioned above, is only approximate, and the desired action of the valves is thereafter attained by selecting valve springs which supply the desired resistance, and by adjusting the screws 33 of the valves to get the delicate adjustment desired.

Having described the invention in what is considered to be the preferred embodiment thereof, it is desired that it be understood that the invention is not to be limited other than by the provisions of the following claims.

I claim:

1. A suction cup comprising:

a cup member formed of elastomer material and being generally of conical form,
a closed coil spring of overall annular form embedded in the marginal portion of said cup member to limit contraction of said marginal portion but permit expansion thereof and also flexing thereof in an axial direction.

2. A suction cup comprising:

an elastomer body member of cup form which expands upon contact with a load and tends to contract when supporting a load,
means for limiting contraction of said body member toward the axis of said body member;
said means being a closed coil spring embedded in said body member adjacent the periphery thereof.

3. A suction cup comprising:

an elastomer body member having a peripheral lip for sealingly engaging a load,
a second lip formed on said body inwardly of said peripheral lip for engaging said load and normally forming a seal therewith,
said peripheral lip forming a seal with a load whenever the seal of said second lip is broken so that the cup has a large effective area until said second lip again resumes its sealed relation to the load,
said second lip being spaced axially inwardly of said peripheral lip in the undeformed condition of said body member,
said body member abruptly changing in thickness at said second lip so that said second lip is projected forwardly upon flexing of said body member,
an articulated means carried by the peripheral margin of said body member outwardly of said second lip, the nature of said articulated means being such that it permits outward expansion of said peripheral margin upon engagement with a load but prevents inward contractive movement of said peripheral margin substantially beyond the undeformed position of said marginal portion.

4. In combination:

a plurality of suction heads,
a common source of vacuum for said heads,
and normally open valve means for controlling the communication of said source with said heads,
said valve means being pressure responsive to individually close off communication between said heads and source when subjected to a predetermined differential pressure,
said source having an insufficient capacity to create said differential pressure when all the heads are exposed to the ambient air but being so capable when a predetermined number of said heads are covered, and said valve means being operable under the lat-

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ter circumstances to close only in relation to the heads which are exposed,
 each suction head having an elastomer body and articulated means of overall annular form carried by said body member, said articulated means being expandable beyond its original circumference and being fixed against contraction inwardly beyond said original circumference so as to prevent contraction of said elastomer body member inwardly toward the axis of said body member, for preventing contraction of said elastomer body,
 and an auxiliary lip inwardly of said marginal lip portion for normally engaging a load and forming a seal therewith.

5. A suction cup comprising:
 an elastomer body member of cup form which expands upon contact with a load and tends to contract when supporting a load,
 means for limiting contraction of said body member toward the axis of said body member and for permitting expansion of said body member away from said axis,

said means being of overall annular form and embedded in said body member adjacent the periphery thereof, and being expandable outwardly beyond its original diameter but fixed against contraction substantially inwardly of said original diameter.

6. A suction cup comprising:
 a cup member having an elastomer marginal portion,

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and means carried by said marginal portion for preventing contraction of said marginal portion but permitting it to flex and expand,

said means being of overall annular form and comprising a series of portions of relatively incompressible material as compared to said elastomer marginal portion,

said portions being separable from one another to increase the circumference of said annular means, and being contractible to positions in abutment with one another to define the inner limit of contraction of said annular means.

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GERALD M. FORLENZA, *Primary Examiner.*

ERNEST A. FALLER, SAMUEL F. COLEMAN,
Examiners.