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Coanda

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[54] SYSTEM FOR PNEUMATICALLY ADVANCING A CONTAINER WITHIN A DUCT

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[30] Foreign Application Priority Data

June 6, 1969 France 69.18838

[52] U.S. Cl. 243/6, 302/24, 239/318

[51] Int. Cl. B65g 51/04

[58] Field of Search. 243/6; 302/2, 24, 25; 104/138, 104/155; 239/318

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Assistant Examiner—James L. Rowland
Attorney, Agent, or Firm—Cushman, Darby & Cushman

[57] ABSTRACT

A system for advancing a container along a duct comprises suction nozzles between successive duct sections, which nozzles are provided with circumferential slots through which air is introduced under pressure. The slots are contoured to lead the incoming air toward a tube section which projects into the divergent part of the nozzle and defines a gas outlet between it and said divergent part.

14 Claims, 4 Drawing Figures

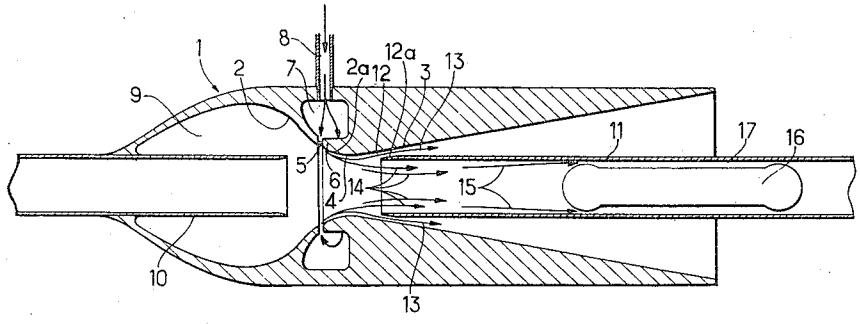

FIG. 1

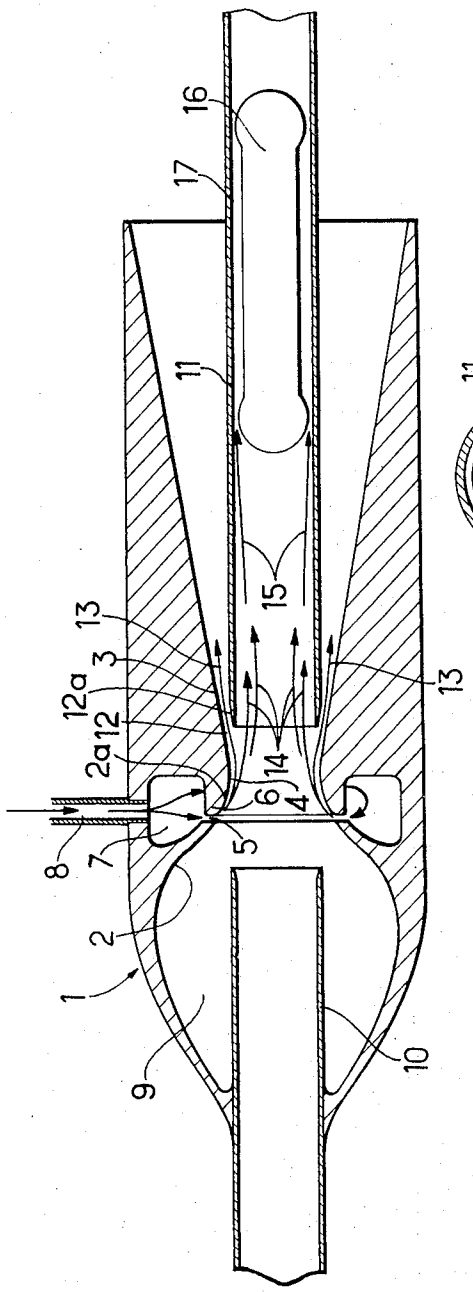

FIG. 2

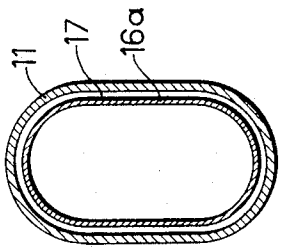

FIG. 3

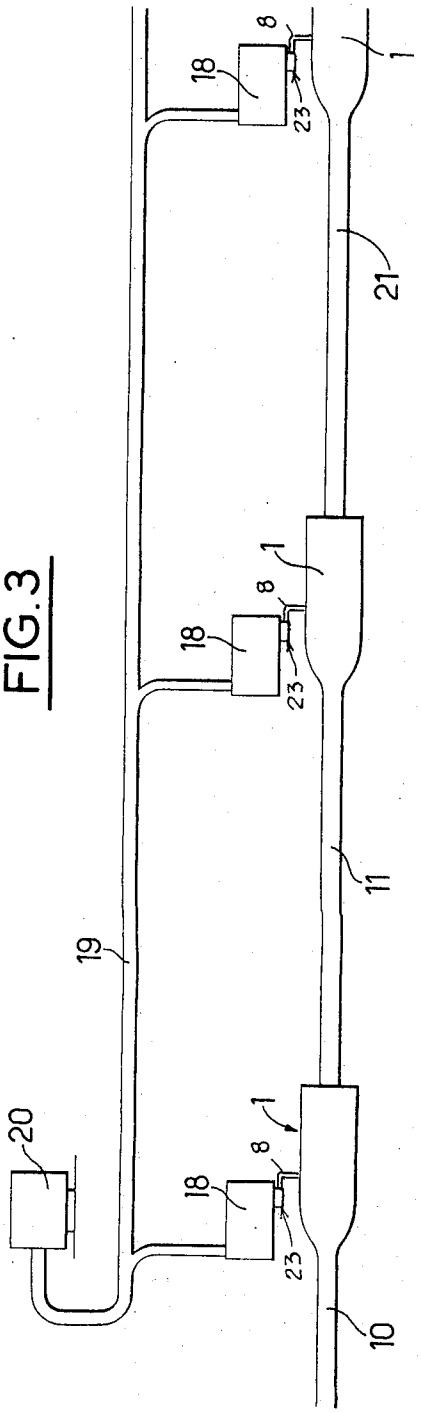
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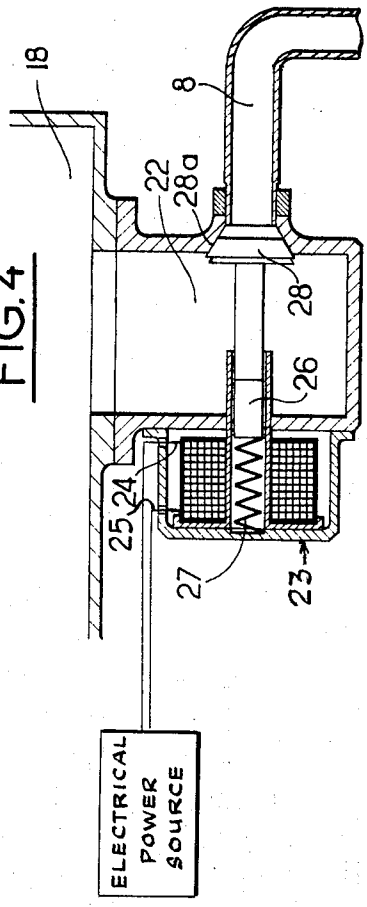
FIG. 4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ELECTRICAL POWER SOURCE

SYSTEM FOR PNEUMATICALLY ADVANCING A CONTAINER WITHIN A DUCT

This is a continuation, of application Ser. No. 32,958 filed Apr. 29, 1970.

SUMMARY OF THE INVENTION

This application relates to a method and apparatus for pneumatic transportation inside a tubular duct. The process is characterized by the successive use of special suction and pressure nozzles of the convergent-divergent type. These nozzles are attached to the free end of sections of the said duct which are positioned upstream of the nozzles. A subatmospheric pressure is produced in the ducts upstream of the nozzles which tends to draw a vehicle forward while holding it suitably spaced from the wall of the upstream section of the duct and then leading it into the downstream section while keeping it suitably spaced.

These nozzles are controlled by a sheet of fluid ejected at high speed through a thin annular slot a little upstream of the throat of the nozzle.

The principal characteristic of the present invention resides in the fact that the downstream lip of the mouth of the slot is continued as an incurved surface forming the convergent upstream part of the throat of the nozzle.

This convergent portion, which creates a dissymmetry on opposite sides of the mouth, is the locus of a strong low pressure area producing a demand for air corresponding to a rate of flow considerably higher than that entering through the said slot.

The fluid injected through the slot, which is usually air, forms a layer around the vehicle, which layer moves rapidly and draws the vehicle along, while supporting it and preventing it from coming in contact with the walls of the tubular duct.

The fluid sheet arriving through the slots produces a substantial low pressure along the lip on the side of the throat which forces this sheet to curve inwardly toward the throat of the nozzle while creating a strong suction in the convergent part thereof upstream of the slot.

The rapidly moving fluid layer propagates itself up to the throat of the nozzle and forms at its periphery a tubular fluid wall which moves at high speed.

A part of this fluid tube continues through a duct section which begins in the throat of the nozzle, and an excess portion leaves through a space between the beveled end of that duct section and the parallel wall formed by the divergent part of the said nozzle.

Applicant's research has demonstrated that the shock waves which may be engendered at the outlet of the slot propagate through this space without interfering with the operation of the device.

The arrangement is such as to provide a duct section, and consequently a fluid tube separating the duct section from the vehicle, so that the latter maintains its verticality without coming in contact with the walls of the duct section.

The successive supply of gas under pressure at the different nozzles is so carried out that the vehicle traveling along the duct receives the successive impulses necessary to its progress from the slots preceding and following the section of the duct in which the vehicle is located, and the slots in the nozzles further upstream are no longer supplied with gas after the vehicle has passed through the sections associated therewith.

The control means for opening and closing the supply to the nozzles may consist, for example, of electromagnetically actuated valves controlled by photoelectric cells.

In order for the process to be economical a supply reservoir is provided for each nozzle or group of nozzles. This is opened suddenly and furnishes the quantity of air under pressure necessary to insure the progress of the vehicle to the next nozzle.

During the periods when the reservoirs are not supplying gas to the nozzles, they are refilled over a relatively long period of time since the periods of time during which the nozzles are actually being supplied are quite short. Consequently a motor of relatively low capacity will suffice.

Another advantage of the new process resides in the fact that the various vehicles do not have any motor and serve only as containers designed to hold passengers or freight, and are completely controlled from a point outside the containers, so that the dead weight may be reduced to a substantial extent in proportion to the pay load.

The characteristics of the present invention will be better understood from a reading of the following description of a preferred embodiment of the invention, which is given purely by way of illustration and example, with reference to the accompanying drawings, in which:

FIG. 1 is a longitudinal axial cross-section through one of the nozzles used in carrying out the invention;

FIG. 2 is a transverse cross-section showing the position of the vehicle relative to the wall of the tubular duct;

FIG. 3 is a schematic longitudinal view of a portion of a simple installation; and

FIG. 4 is a schematic cross-section through an electromagnetic valve of a conventional type adapted to be used to control the sudden discharge of a reservoir through one of the slots.

The nozzle 1 shown on FIG. 1 comprises a convergent part 2 connected to a divergent part 3 by a throat 4.

The air used to supply the various nozzles enters the convergent part through an annular slot 5 the downstream lip of which is tangentially connected to the end 2*a* of the convergent part 2 of the nozzle nearest the throat 4. The air supplying the slots 5 passes through an annular chamber 7 connected to a reservoir by the passageway 8. This air turns down toward the throat 4 of the nozzle while creating in the chamber 9 a strong suction which is transmitted to the duct section 10 so as to draw the vehicle and the fluid tube which surrounds the vehicle toward the duct section 11. The excess air, like shock waves, leaves through an annular space 12 in the direction indicated by the arrows 13, whereas the air drawn into the duct section 11, which may come either from the slot 5 or the tube 10 flows forwardly in the direction indicated by the arrows 14 and 15 so as to form a fluid tube 17 around the vehicle 16 which prevents all contact between the vehicle 16 and the duct section 11.

It will be noted that the shape of the bevels 12*a* at the end of the tube 11, which are parallel to the walls of the divergent portion 3, of the nozzles, as well as the shape of the vehicle 16, are such as to permit it to move without friction within a section of the duct having a substantial curvature.

In the section shown in FIG. 2 the tube 11 and the solid jacket 16*a* of the vehicle 16 are shown. This assembly is separated from the duct 11 by a fluid tube 17.

In the schematic representation shown on FIG. 3 the successive nozzles 1 are shown simply by their external contours and connected by pipes 8 to the supply reservoirs 18 containing gas under pressure, which is to be discharged suddenly into the nozzles 1 at the desired moment.

These reservoirs 18 are all connected through a pipe 19 to a compressor or source of compressed air represented schematically at 20.

As has been indicated above, the various nozzles are brought successively into communication with the reservoir 18 connected thereto by control means actuated through conventional electrical circuits, which may include photoelectric cells, so as to provide such communication over a relatively short time corresponding to the passage of said vehicle through the corresponding nozzle. Each reservoir 18 is then refilled over a relatively long period of time corresponding to the passage of the vehicle through the remaining portions of the tubular duct.

FIG. 3 shows the two duct sections 10 and 11 of FIG. 1 and a similar tube downstream of the two tubes and carrying reference numeral 21.

The electromagnetic valve 23 shown on FIG. 4 is of a conventional type.

The chamber of this valve is in communication with a reservoir 18 containing air under pressure. An electrical current is supplied to the windings of this valve through the terminal 24 and the terminal 25.

The flux created by this winding attracts the plunger 26 of the electromagnet thus compressing a spring 27. The displacement of the plunger 26 lifts the valve member 28, which leaves its seat 28*a*.

A rubber sealing ring may be provided between the valve member and its seat.

When the valve member leaves its seat the compressed air at 22 can suddenly enter the annular chamber 7 shown on FIG. 1 by passing through the pipe 8 so as to supply the slot 5 of a nozzle.

It then suffices to provide a distributor capable of closing the supply circuit at the appropriate moment by interrupting the current through the terminals 24, 25 of the successive electromagnetic valves.

It will, of course, be appreciated that this embodiment has been described purely by way of example, and may be modified as to detail without thereby departing from the basic principles of the invention as set forth in the following claims.

What is claimed is:

1. In a pneumatic transportation system for advancing an object within a tubular duct system with a gas pressure differential, and in which the tubular duct system has a series of suction nozzles functioning as relay stations to produce gas pressure differentials along the path of travel of the object, the improvement in each suction nozzle comprising

a chamber in open communication with said tubular duct system for allowing passage of an object from a free end of one tube section of the tubular duct system into the free end of a next tube section of the system, said tube sections having their respective free ends spaced from one another within said chamber, and said chamber having an upstream convergent portion followed by a downstream divergent portion in its interior shape in a zone generally between the free ends of said tube sections,

a gas inlet means for admitting a fluid into said chamber to establish a pressure differential within said tubular duct system, said gas inlet means including a gas inlet slot communicating with the interior of said chamber through the convergent portion thereof, said gas inlet slot being formed around a circumference near the smaller diameter end of said convergent portion so as to intersect the interior wall of the chamber with an upstream slot edge which forms an acute angle with said interior wall and with a downstream slot edge which is curved to merge with a shaped curvature of said convergent portion of the chamber, so that a gas introduced through said gas inlet slot will tend to follow the downstream slot edge, and

a gas outlet means in said suction nozzle providing for a release of excess gas pressure developed in the suction nozzle.

2. The improvement of claim 1 wherein the free end of said one tube section projects into said upstream convergent portion of said chamber.

3. The improvement of claim 1 wherein the free end of said next tube section projects into said downstream divergent portion of said chamber.

4. The improvement of claim 3 wherein said gas outlet means is defined between the free end of said next tube section and said divergent portion of said chamber.

5. The improvement of claim 4 wherein the free end of said next tube section projecting into the divergent portion of said chamber is provided with a bevelled outer surface which is parallel to the inner wall surface of said divergent portion which encircles the end of the tube section.

6. The improvement of claim 1 and including in each gas inlet means an annular chamber which communicates with said gas inlet slot and which receives a supply of gas from a reservoir.

7. The improvement of claim 1 wherein gas supply reservoirs are connected to each gas inlet means of each suction nozzle of the system, and including control means for controlling introduction of gas into successive suction nozzles of the system as an object is advanced through the system.

8. The improvement of claim 7 and including means for suddenly supplying each gas inlet slot of the system with gas from its associated reservoir and for refilling each reservoir over a longer period of time than that over which the gas inlet slots were supplied.

9. The improvement of claim 1 wherein the object to be transported comprises a passenger carrying vehicle.

10. The improvement of claim 9 wherein the cross section of said tubular duct system has major and minor axes of symmetry at right angles to each other.

11. The improvement of claim 9 wherein the free end of said one tube section projects into and is completely enclosed by an upstream end of said convergent portion of the chamber.

12. The improvement of claim 11 wherein the free end of said next tube section is carried within said divergent portion of the chamber so as to define said gas outlet means around the free end of the tube section, said divergent portion being open to the atmosphere at its downstream end.

13. The improvement of claim 12 wherein gas supply reservoirs are connected to each gas inlet means of each suction nozzle of the system, and including control means for controlling introduction of gas into successive suction nozzles of the system as a vehicle is advanced through the system.

14. The improvement of claim 13 and including means for suddenly supplying each gas inlet slot of the system with gas from its associated reservoir and for refilling each reservoir over a longer period of time than that over which the gas inlet slots were supplied.

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