ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

THE CERN PNEUMATIC TRANSPORT SYSTEM

by

H. Horisberger

GENEVE
Propriété littéraire et scientifique réservée pour tous les pays du monde. Ce document ne peut être reproduit ou traduit en tout ou en partie sans l'autorisation écrite du Directeur général du CERN titulaire du droit d'auteur. Dans les cas appropriés, et s'il s'agit d'utiliser le document à des fins non commerciales, cette autorisation sera volontiers accordée. Le CERN ne revendique pas la propriété des inventions brevetables et dessins ou modèles susceptibles de dépôt qui pourraient être décrits dans le présent document ; ceux-ci peuvent être librement utilisés par les instituts de recherche, les industriels et autres intéressés. Cependant, le CERN se réserve le droit de s'opposer à toute revendication qu'un usager pourrait faire de la proximité scientifique ou industrielle de toute invention et tout dessin ou modèle décrits dans le présent document.

© Copyright CERN, Genève, 1960

Literary and scientific copyrights reserved in all countries of the world. This report or any part of it, may not be reprinted or translated without written permission of the copyright holder, the Director-General of CERN. However, permission will be freely granted for appropriate non-commercial use. If any patentable invention or registrable design is described in the report, CERN makes no claim to property rights in it but offers it for the free use of research institutions, manufacturers and others. CERN, however, may oppose any attempt by a user to claim any proprietary or patent rights in such inventions or designs as may be described in the present document.
THE CERN: PNEUMATIC TRANSPORT SYSTEM

by

H. Horisberger

GENEVE

CERN 60-9
Proton Synchrotron Division
24th March, 1960

PS/1368
THE CERN PNEUMATIC TRANSPORT SYSTEM

by

H. Horisberger

I. Introduction

CERN has developed a transport system for heavy loads using compressed air cushions. It should, however, not be confused with the systems used on the British Hoovercraft or the American Curtiss Wright air suspension car, which take advantage of the dynamic flow of a large quantity of air, in order to lift a relatively small weight up to 30 cm above the floor and to move it at high speeds over a rather rough surface.

The CERN system has been devised in order to move heavy equipment at low speeds on a rather smooth surface, making use of the static air pressure retained by a seal, which lifts the equipment one or two millimeters above the floor. In this way, it is possible to reduce the friction coefficient for sliding of a piece of equipment on its floor by a factor of 20 or more. This is especially interesting for the alignment of physical apparatus to fixed flight paths of particle beams but will certainly find other applications in other fields.

On a test set up similar to the one shown in fig. 2, where a load of 30 tons was moved on 4 disks of 500 mm diameter, the friction coefficient on a smooth concrete floor was measured as being about 1 %, whereas the coefficient for a smooth steel plate on that same floor and for the same specific pressure amounts to about 30 %.
The air cushion system may consist of one or several platforms, depending on the size and weight of the apparatus to be moved. Fig. 1 shows a group of 2 quadrupole magnets supported by one single platform. The total weight of the group is 5 tons, the diameter of the seal 960 mm. Here the weight must be very well centered on the platform. Fig. 2 shows a bending magnet on 4 platforms of 500 mm diameter and of a total weight of 20 tons. Fig. 3 shows a schematic section of the CERN 1 m propane chamber at present under construction which will be equipped with 4 platforms of 960 mm diameter and which will have a total weight of about 100 tons. Here, each platform will have its own pressure regulating system which is necessary due to the asymmetric loading of the 4 feet.

II. Construction of platform

Fig. 4 shows a cross-section through such a platform. It consists of a steel disk A, a fabric reinforced rubber membrane B, a number of leaf spring segments C, the annular seal D and the two retaining rings E. An exchangeable bakelite ring F with radial grooves for the air passage makes contact with the floor during sliding with insufficient pressure or when the apparatus is at rest.

The platforms built in CERN are of circular shape for reasons of easy construction. The seal "D" is made from an extruded synthetic rubber profile and vulcanised to a circular ring. The leaf springs C inserted between the seal and the membrane are made in such a way that they stiffen the seal in the radial direction but leave a good flexibility in the azimuthal direction. In this way, each portion of the circumference of the seal can follow the irregularities of the floor by pivoting like a lever around its fixing point.
The working pressure on the inside of the seal is governed by the weight to be transported and the size of the platform and should for reasons of good operation of the seal not exceed 4 kg/cm². A backing pressure behind the membrane assures the contact of the seal on the floor. For good floor conditions, for instance on machined floor plates, the contact pressure can be very low, a few grams per cm length. On a smooth concrete surface, as it exists in the experimental halls at CERN, this pressure must be increased to about 100 g/cm. Experience has shown, however, that it is advantageous to reduce the pressure on the seal to a very minimum and let some air escape under the seal for air lubrication which then reduces the wear on the seal.

On a test plate the backing pressure behind the seal was measured as a function of the lifting pressure for moving on a machined surface and practically no leakage under the seal. The results, as given in Fig. 5, indicate that the backing pressure is practically linear with the lifting pressure for the given proportions, which were the same as those shown in Fig. 4. Since the backing pressure is only a few tenths of an atmosphere smaller than the lifting pressure, they could be both the same, when moving on a smooth floor. This, of course, would permit a simplification of the control circuit.

In order to maintain a constant pressure under the platform and therefore avoid "pumping" or vibrating of the system, it is necessary to incorporate an air reservoir, close to the platforms or, if possible for reasons of space, directly into the platform.

If several platforms are used to support a piece of equipment, the pressures of each platform must be regulated individually, since the total weight of the apparatus will most certainly not be distributed uniformly on them.
As said before, it is necessary that the floor is rather smooth. However, good results have been obtained with the platforms moving directly on the concrete floor of the CERN experimental Halls. Cracks in the floor can easily be sealed off with scotch tape. Whenever the finish of the floor is not good enough, it must be covered with thin steel sheets. The joints between the sheets are sealed with scotch tape.

The air consumption is in general quite small. The CERN platforms are supplied from the general compressed air distribution system. For independant systems, a small compressor of say 1 HP with a reservoir to compensate for momentary leaks is entirely sufficient.

III. Some advantages of the air cushion system

a) The pneumatic platforms are of simple construction and therefore cheap compared to any other system of transport such as carriages on rails or a system of ball units on steel plates.

b) It uses very little space, especially in height

c) The coefficient of friction is low, in the order of 1 %, result: Small moving force.

d) Freedom of movements in all directions and with precision.

e) The platforms can at the same time be used as permanent supports of the apparatus. If 4 platforms are used, it will be necessary to insert a spring element between each platform and the apparatus in order to obtain a somewhat even distribution of the weight over all four.

f) The platforms can be standardized and used for different pieces of equipment.

H. Horisberger

Acknowledgments: The underlying idea was conceived by Mr. Augsburger, chief of the workshop of the PS division. The development work and the test on models were carried out in collaboration with his workshop and particularly Mr. Stierlin.
$p_2$  \( \text{kg/cm}^2 \)

$p_1$  lifting pressure

$p_2$  pressure behind membrane

![Graph showing $p_2$ as a function of $p_1$.]

**Fig. 5**