United States Patent [19]

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[11] **3,739,987**

[45] **June 19, 1973**

[54] **ARRANGEMENT OF JACKS FOR CONTROLLING FLAPS AND ITS APPLICATION TO THE CONTROL OF A JET PIPE**

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[22] Filed: **Jan. 7, 1972**

[21] Appl. No.: **216,195**

[30] **Foreign Application Priority Data**

Jan. 8, 1971 France 7100528

[52] **U.S. Cl.** **239/265.39,** 92/61, 92/118

[51] **Int. Cl.** **B64c 15/06**

[58] **Field of Search** 239/265.11, 265.19, 239/265.37, 265.39, 265.41; 60/230; 92/61, 118, 120; 74/519

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Assistant Examiner—A. Kashnikow
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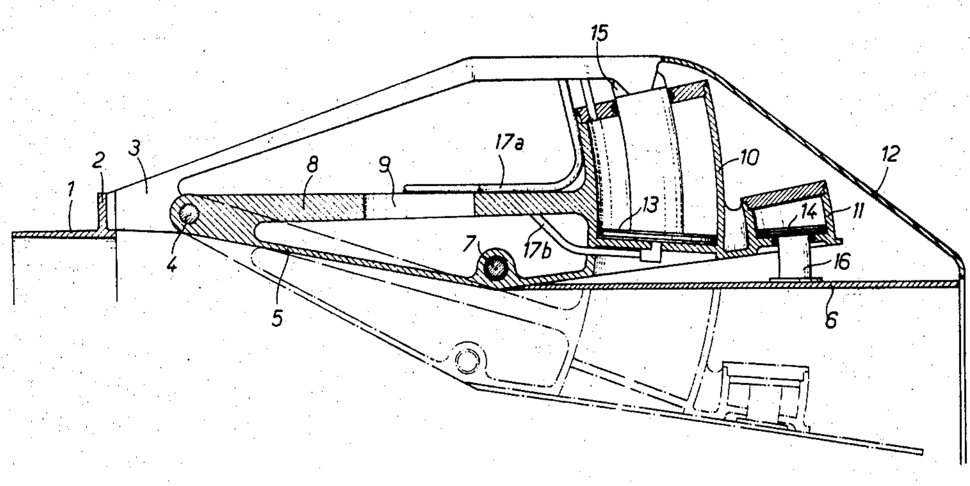
[57] **ABSTRACT**

A control device for controlling two hinged elements arranged one behind the other by means of a tandem assembly of fluid operated jacks, in which control device each of the jacks has a cylinder in the form of a torus with an axis in the arc of a circle centered on a point located outside of the said cylinder, and a piston mounted in the cylinder. The piston has an external torus-shaped surface for co-operation with the wall of the cylinder whereby relative travel between the cylinder and the torus-shaped piston follows a curved line centered on the said external point.

11 Claims, 7 Drawing Figures



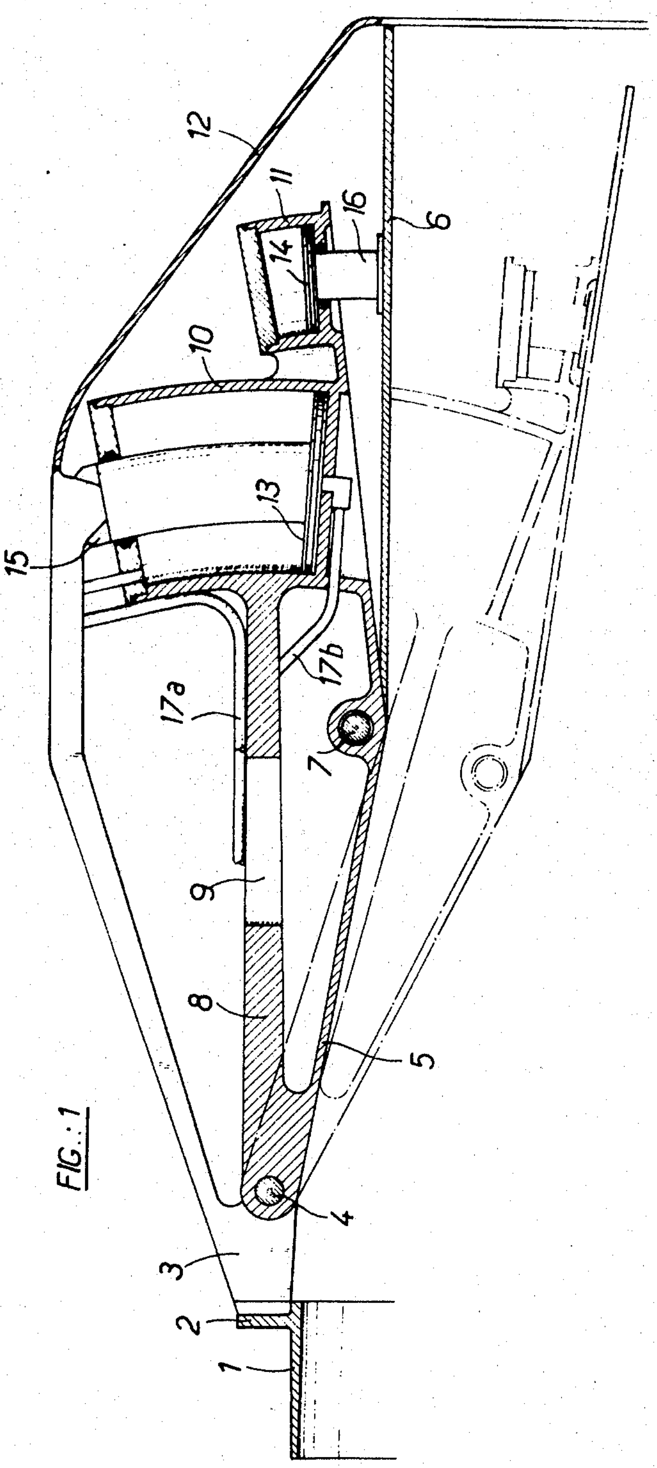


FIG. 1

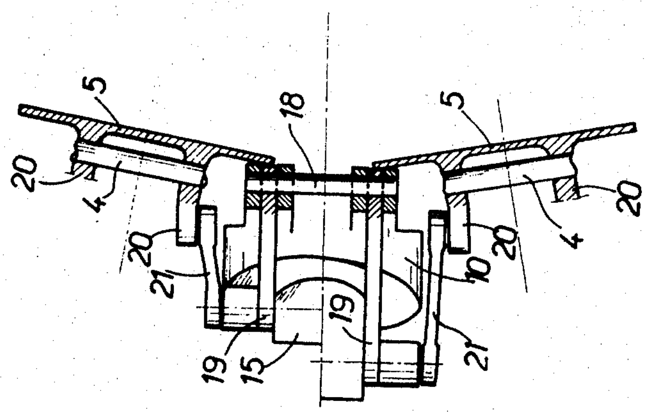

5
18
5
20
4
20
21
10
20
4
20
19
15
19
21

FIG.:7

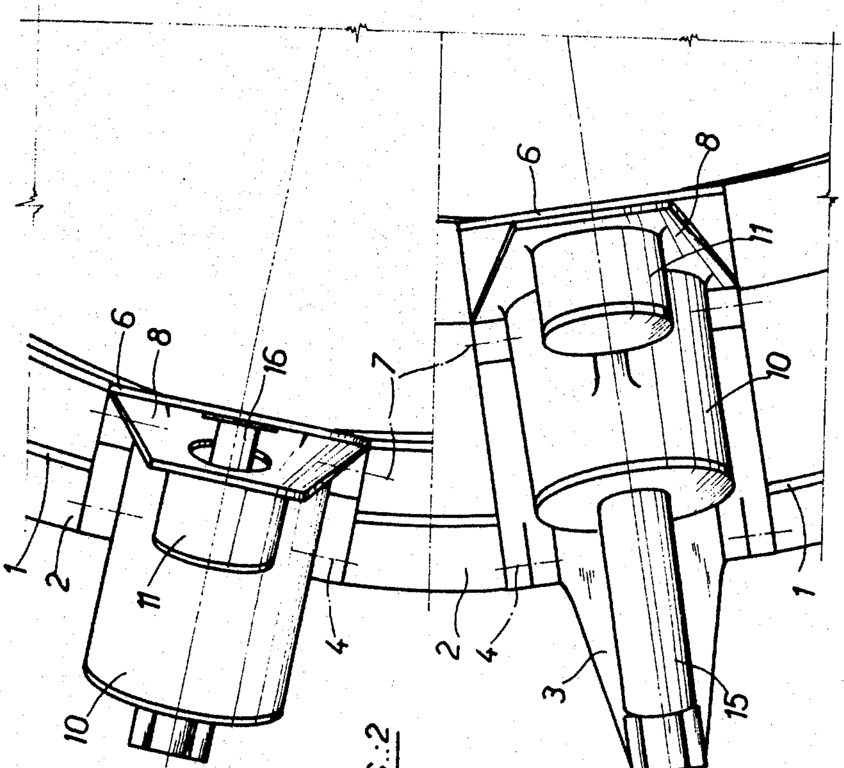

6
8
11
6
8
16
7
10
1
2
11
4
2
4
1
3
15
10

FIG.:2

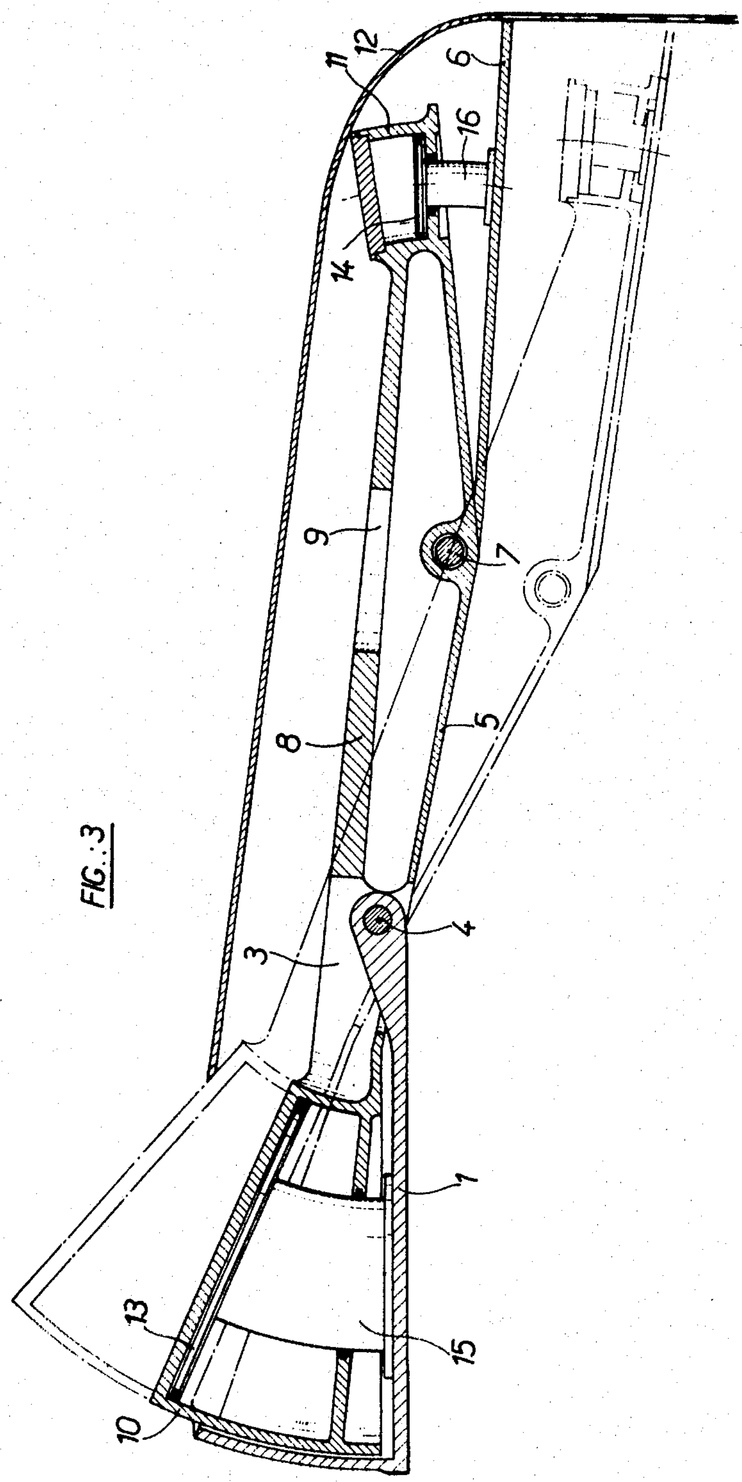


FIG. 3

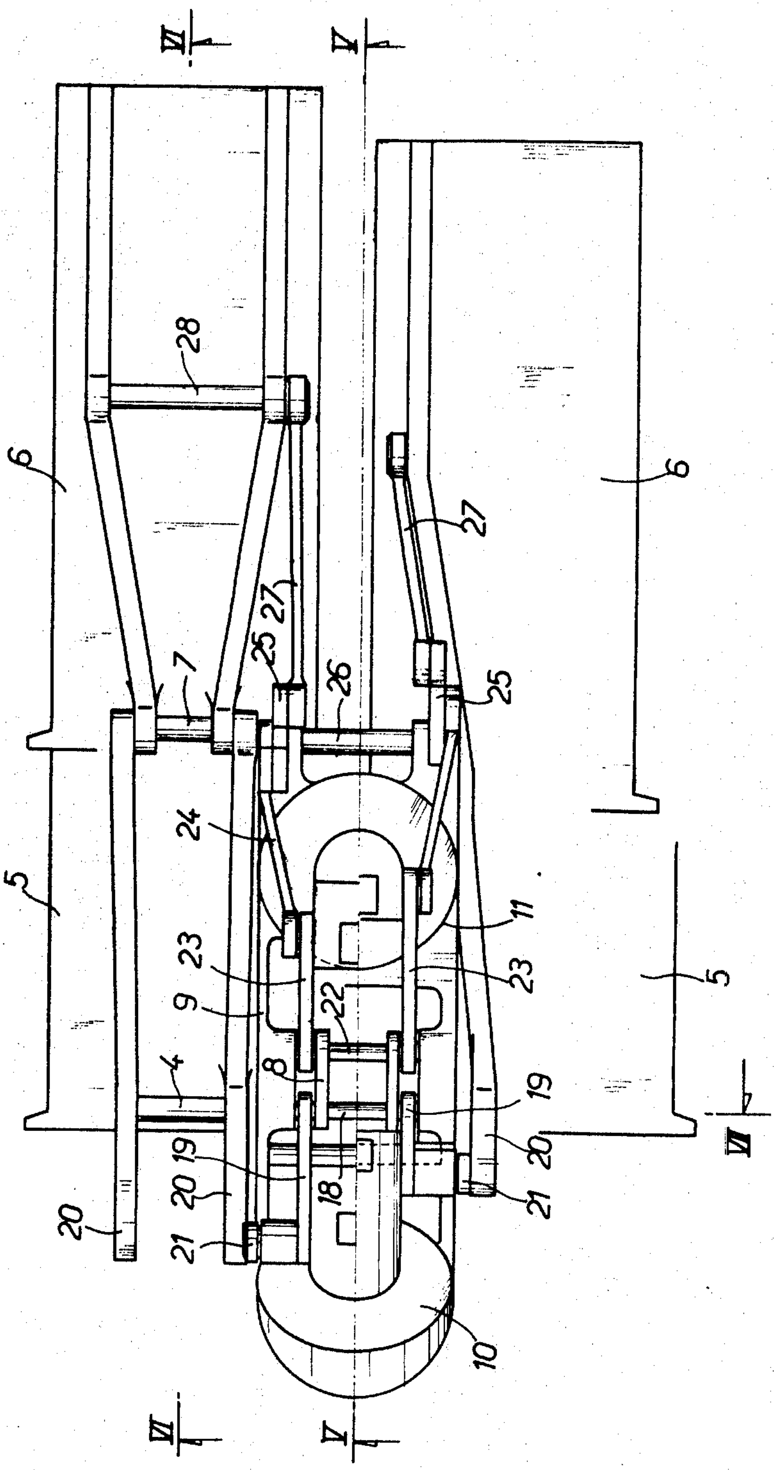

VI
V
28
6
27
27
25
7
26
25
6
24
11
5
23
23
9
22
4
8
19
5
VII
VII
19
20
20
19
18
20
21
21
20
10
VI
V

FIG.: 4

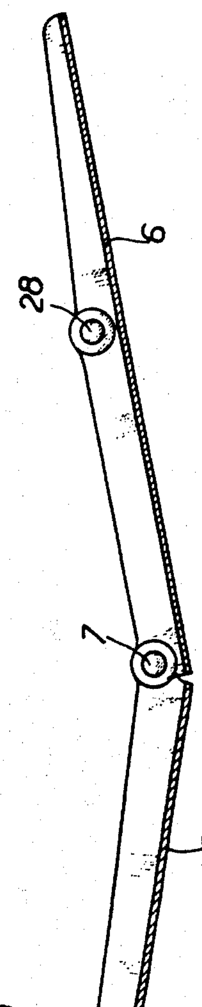


FIG.6

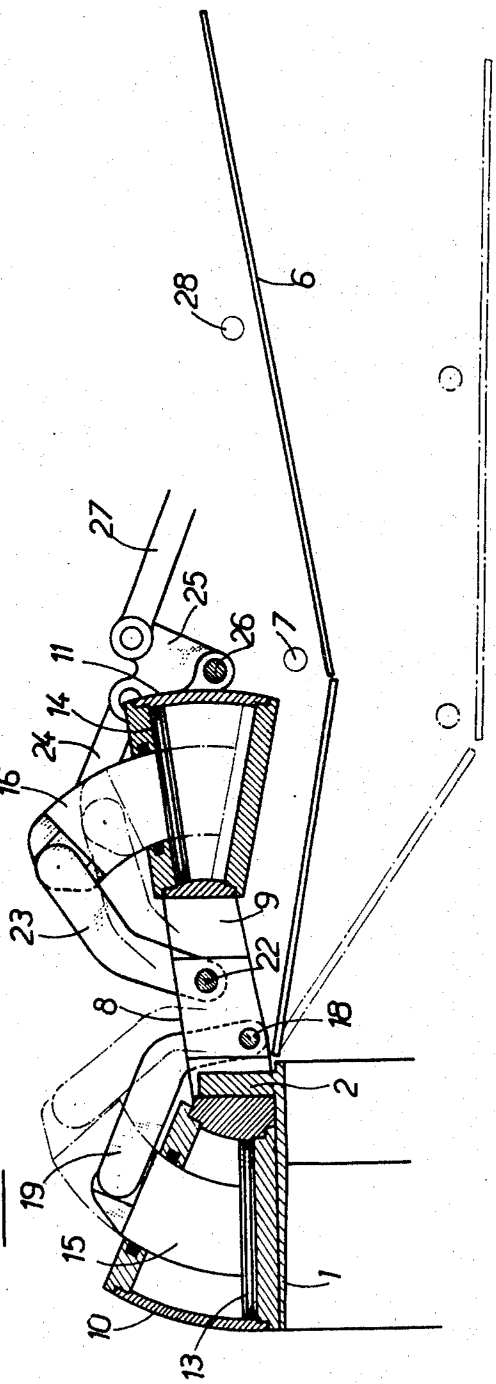


FIG.5

ARRANGEMENT OF JACKS FOR CONTROLLING FLAPS AND ITS APPLICATION TO THE CONTROL OF A JET PIPE

BACKGROUND OF THE INVENTION

This invention relates to a device for controlling flaps by means of jacks of toroidal shape with curved path of movement, and more particularly with movement along the arc of a circle.

Such jacks or servo mechanisms with circular movements are needed every time where parts or elements are to be actuated or controlled, the movement of which takes place along a limited angular vector about a hinge. These situations are met with frequently in the control of machine elements, and more particularly in the controls of aircraft and ships and in the operation of various elements, such as air brakes, the controls for opening and closing doors etc.

The conventional solution, which consists in acting on a control lever by means of a jack or servo mechanism with conventional rectilinear movement, has the drawback of requiring at least two additional hinges over and above the main hinge of the controlled element. It presents difficult problems of bulk and necessitates frequently the use of intermediate connecting rods for the transmission of forces.

Servo motors with circular movements have, therefore, in many fields substantial advantages over conventional devices with rectilinear movements, but their generalization requires the possibility of providing an industrial construction suitable to give them a very precise geometrical shape combined with a surface which is compatible with the absolutely necessary degree of tightness.

The applicant has provided for this purpose machine tools which make possible a practical, simple, and convenient solution of machining problems, both for forming a precise bore with a toroidal wall, and for shaping a piston with an external toroidal surface.

SUMMARY OF THE INVENTION

The object of the present invention is to provide the tandem assembly of two torus-type jacks for controlling two hinged elements in sequence, wherein the curved path of one or the other of these torus-shaped jacks or of both may be centered on the hinge axis of the corresponding element.

According to the invention, there is provided a control device for controlling two hinged elements arranged one behind the other by means of a tandem assembly of fluid operated jacks, wherein each jack has a cylinder in the form of a torus with an axis in the arc of a circle centered on a point located outside of the said cylinder, a piston being mounted in the cylinder having an external torus-shaped surface for cooperation with the wall of the said cylinder, whereby relative travel between the cylinder and the torus-shaped piston follows a curved line centered on said external point.

In one embodiment of the invention, the bodies of the two jacks with toroidal bores are constructed together and are integrated in a rigid structure pivoting about one of the hinges, and incorporating the corresponding hinged element. The piston rod of the torus-shaped jack centered on this hinge rests on a fixed part, whilst the piston rod of the other torus-shaped jack acts on the second hinged element.

The two jacks in tandem may be arranged either near each other on the same side of the hinge of the said rigid structure, or they may be spaced apart on opposite sides of this hinge.

The present invention may be applied particularly advantageously to the control of a flow path of convergent-divergent profile, and more particularly to the control of an outlet jet pipe or of the collecting conduit of a jet propulsion unit, wherein such a jet pipe or the like is generally formed by a circular juxtaposition with partial covering of the upstream flaps, followed by a similar juxtaposition of the downstream flaps hinged to the former.

In an embodiment of the present invention, one of the two torus-shaped jacks mounted in tandem controls simultaneously two consecutive flaps belonging to the said upstream juxtaposition, and located on either side of the body of the jack, whilst the other jack controls simultaneously two consecutive flaps forming part of the downstream juxtaposition, and also located on either side of the body of this other jack. To this effect, every jack acts on the two consecutive flaps it controls through the intervention of a double linkage leading to the respective flaps.

The bodies of the two toroidal bores of the two jacks are preferably integrated in the fixed structure of the said jet pipe or the like, and the piston rods are connected to the flaps by the said double linkage.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be further described, by way of example, with reference to the accompanying drawings in which:

FIG. 1 is a partial longitudinal cross-section of an adjustable jet pipe equipped with a control device according to a first embodiment of the invention;

FIG. 2 is a partial end elevation of the embodiment shown in FIG. 1 with the cover removed for clarity;

FIG. 3 is a cross-section similar to FIG. 1, but showing a second embodiment of a control device according to the invention;

FIG. 4 is a partial plan view of a third, preferred, embodiment of the control device according to the invention; and

FIGS. 5, 6 and 7 are respectively, cross-sections along the lines V—V, VI—VI, and VII—VII in FIG. 4.

DESCRIPTION OF PREFERRED EMBODIMENTS

FIGS. 1 and 2 show the fixed end portion of a jet pipe **1** having a flange **2** to which is fixed a bracket **3** carrying a hinge pin **4** near the fixing point to the jet pipe **1**. The adjustable end part of the jet pipe comprises two flaps. On the one hand, an upstream flap **5** hinged at **4** to the fixed bracket **3**, and on the other hand a downstream flap **6** hinged at **7** to the upstream flap **5**. It can be seen that the latter defines an adjustable convergent portion between the hinges **4** and **7** located respectively with constant cross-section near the inlet zone of the convergent portion and with variable cross-section at its geometrical neck. Similarly, the downstream flap **6** forms a potentially divergent extension of the convergent section, and is also adjustable, extending from the geometrical variable neck to an equally variable outlet section of the jet pipe. This forms, therefore, a jet pipe with variable geometry of a type suitable for modern high-speed jet propelled aircraft, and more particularly for supersonic transport aircraft.

In the embodiment shown in FIGS. **1** and **2**, the upstream flap **5** forms part of a strong box structure **8** having lightening holes **9** and two jack bodies in pairs or in tandem **10** and **11**. The assembly of the box structure **8** with its flap **5** and the jack bodies **10** and **11** can pivot together on the hinge **4** mounted on the bracket **3**, which may be extended by a rear cover **12** formed to reduce the drag of the base of the reaction engine.

The bodies of the jacks **10** and **11** have bores in the shape of circular sectors of torii with their axes centered respectively on the hinge axes **4** and **7**. Pistons **13** and **14** are located in the bores of the bodies of the jacks **10** and **11** and are also in the form of circular sectors of torii and are integral with curved rods **15** and **16**, fixed respectively to the bracket **3** and the downstream flap **6**. The jacks **10** and **11** are double-acting and the conduits for the hydraulic fluid for the jack **10** are shown diagrammatically at **17***a* and **17***b*. The pistons **13** and **14** are preferably mounted floatingly on the rods **15** and **16** and, together with said rods are equipped with sealing joints permitting a certain play.

The arrangement described above operates as follows.

The control of the primary jack **10**, whose rod **15** is connected to the bracket **3**, has the effect of causing the body of the jack to slide relative to the piston **13**, and consequently to pivot the box structure **8** and, therefore, the upstream flap **5** which is integral therewith, about the hinge **4**, thereby modifying the convergence and the cross-section of the neck of the jet pipe. Similarly, the control of the secondary jack **11** has the effect of causing the piston **14** to slide and thereby to modify the angular setting of the downstream flap **6**, which is acted upon by the rod **16**, relative to the box structure **8** and, therefore to the upstream flap **5**. In this manner, the divergence of the latter (which may also be zero or even negative, in which case the configuration is convergent from end to end), as well as the outlet cross-section of the jet pipe, can be modified.

Since the jacks have a toroidal shape and in addition a circular axis centered on the respective hinge, the transmission is reduced to its simplest term: any transmission by connecting rods or the like is avoided, as well as any articulated kinematic chain other than the pivot of each flap, with the exception of systems which may be mounted at the points of application of the jacks for taking up any possible changes due to thermal expansion.

FIG. **1** and the right-hand side in FIG. **2** show in solid lines an intermediate configuration of the jet pipe in which the upstream flap **5** is at its smallest convergence, the cross-section of the neck is, therefore, at its maximum, and the downstream flap **6** is at its highest maximum fixing. In this manner, it is possible to obtain a configuration of the jet pipe of maximum opening by controlling the secondary jack **11**, so as to move its piston **14** to its upper base, in which case the downstream flap will be at maximum divergence and the outlet cross-section of the jet pipe will have the highest value. A second intermediate position of the jet pipe is shown in FIG. **1** and on the left side of FIG. **2** in dash-dot lines: here the piston **13** is at the upper end of the primary piston **10**, fixing thereby the upstream flap **5** at its maximum convergence and reducing correspondingly the cross-section of the neck at the point of the hinge **7**, whilst the piston **14** at the upper end of the secondary jack **11** reduces the fixing of the downstream flap **6** which has, therefore, only a small convergence. This may be accentuated by moving the piston **14** to the inner end of the secondary jack **11**, thereby imparting to the jet pipe a configuration of extreme closure with minimum outlet cross-section.

Obviously, if the two intermediate configurations shown are considered insufficient, it is possible to provide the jacks with mechanical locking systems and devices for blocking them in other predetermined intermediate positions.

In the embodiment of FIG. **3**, where the same reference numerals have been used for designating elements corresponding to those described above, the primary jack **10** is on the side of the primary hinge **4** remote from the secondary jack **11**, whilst the general kinematic arrangement remains the same. The embodiment shown in FIG. **3** can be controlled in like manner to that described with reference to FIGS. **1** and **2**.

It will be evident that the embodiments just described are merely examples, and that they can be modified, particularly by using equivalent techniques, without thereby departing from the principle of the invention. Thus, it is possible to integrate the body of the primary jack **10** with the fixed bracket **3**, in which case the piston **13** and its rod **15** are incorporated in the fixed structure. The same may also be applied to the relation between the secondary jack **11** and its piston rod **16** on one hand, and the downstream flap **6** and the fixed structure on the other hand.

The invention provides a viable light and efficient solution to problems encountered in steam pipelines, in the pipelines of high-speed aerodynamic blowers, ejection pipes of jet engines, such as rockets and turboreactors, and to problems for collecting air for high-speed aerobic engines, such as ram jets.

The invention is also applicable to the control of two-dimensional flows and to the control of flows having a revolutional symmetry. In the latter case, the flaps to be controlled can have the shape of cone segments, so as to form by circular repetition and partial overlaps continuous truncated cones.

These arrangements have the form of a crown of segments in circular juxtaposition and partial superimposition, and are encountered in the technology of jet pipes, particularly for supersonic aircraft. In this field, the control jacks are attached only to certain, so-called "guide" flaps which are separated by flaps without jacks, or "guided" flaps which act as intermediate connecting flaps, wherein the synchronization between the guide flaps is effected by the intermediate connecting flaps, wherein the forces transmitted by these intermediate flaps may be regarded only as small and only adapted to compensate the differential outputs which are possible between the various jacks equipping the whole crown.

However, in practice the necessity of a synchronization or, more exactly, of a mechanical linkage between each jack would appear to be imperative if the following are to be avoided:

a jamming between flaps during operation which would make the operational forces considerably higher;

the substantial and very rapid wear of contacting surfaces caused by jamming;

a deformation of the circumference produced by the fouling of the clearance between two flaps.

The embodiment shown in FIGS. **4** to **7** meets these conditions and ensures additionally that, in the case of a total failure of one jack the defective control is immediately taken up by the adjacent jacks. It will be noted that, in this embodiment, the same reference numerals have been used to indicate equivalent elements. In this case however, the bodies of the jacks **10** and **11** are not integral with the flaps **5** and **6**, are spaced from the outer surface of said flaps, which surface has a temperature of the order of 700° C, and are fully exposed to the flow of cooling air which has a temperature of the order of 350° C.

As can be seen best in FIGS. **4** and **7**, the structure **8**, in which the bodies of the jacks **10** and **11** are incorporated, is arranged on both sides of and symmetrically to two upstream flaps **5—5**, and this arrangement is repeated around the whole crown of upstream flaps. Contrary to the preceding embodiments the structure **8** is here integral with the fixed end portion of the jet pipe **1**, and the body of the jack **10** is located upstream of the end flange **2**.

On the other hand, the body of the jack **11** is close to the end flange **2** so that the assembly of the fixed structure is compact and overhang is reduced.

It will be noted that in this embodiment, the rod **15** of the piston **13** moves in its toroidal bore in the jack **10** by turning around a hinge axis **18**. The mechanical connection between this piston rod **15** and the axis **18** is ensured by a pair of double angled arms **19—19** integral with the end of the rod **15**. Thus, the axis **18** does not coincide with the hinge axes **4** of the upstream flaps **5—5** located on either side. Each of the latter is extended by two angled arms **20—20** connected to the end of the piston rod **15** by connecting rods **21—21** equipped with swivel joints at the ends.

Each jack **10** acts simultaneously on two upstream flaps **5—5** located on either side thereof, and this double control is repeated over the whole circumference of the jet pipe. Thus, the application of each jack **10** carries along directly the movement of two flaps **5—5** to which it is connected, and that of all the flaps **5** forming the upstream crown by means of the collaboration of successive linkages.

The same applies with regard to the control of the downstream flaps **6** by each toroidal jack **11** whose piston rod **16** moves about an axis **22** near the axis **18.** As in the upstream part, a double angled arm **23—23**, integral with the rod **16**, is hinged about the axis **22**. However, in the case of the downstream part, the mechanical connection between the jack **11** and the flaps **6—6** controlled thereby comprises a double connecting rod **24—24** connecting the end of the piston rod **16** to a double reversing lever **25—25** pivoting about a pivot **26** and a double connecting rod **27—27** connected between the reversing lever **25—25** and a hinge **28** on each of two downstream flaps **6—6** controlled by the jack **11**, swivel joints being provided at the end of each connecting rod **27**.

Thus, also for the downstream part, the actuation of a single jack **11** operates directly the two flaps **6—6** to which it is connected, and successively the assembly of the downstream flaps by the collaboration of successive linkages.

The control device according to the invention is capable of modification without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A control device for controlling two hinged elements arranged one behind the other by means of a tandem assembly of fluid-operated jacks, in which control device each of said jacks comprises a cylinder having a wall in the form of a torus with an axis in the arc of a circle centered on a point located outside of the said cylinder and a piston mounted in said cylinder, said piston having an external torus-shaped surface for cooperation with the wall of said cylinder whereby relative travel between said cylinder and said piston follows a curved line centered on said external point.

2. A control device as claimed in claim **1**, in which one of said hinged elements has a hinge axis and in which said external point coincides with said hinge axis.

3. A control device as claimed in claim **2**, including a fixed structure and in which one of said hinged elements having a hinge axis is incorporated in said fixed structure, said fixed structure being pivotable about said hinge axis.

4. A control device as claimed in claim **3**, in which a piston rod is connected to each piston, the piston rod of a first piston being connected to a fixed part and the piston rod of a second piston acting on the other of said hinged elements.

5. A control device as claimed in claim **2**, in which two said jacks are arranged near each other and on the same side of said hinge axis.

6. A control device as claimed in claim **2**, in which two said jacks are spaced apart on opposite sides of said hinge axis.

7. A control device as claimed in claim **1**, in which said hinged elements comprise successive control flaps in the geometry of a conduit formed by circular juxtaposition with partial overlap of upstream flaps followed by a similar juxtaposition of hinged downstream flaps following said upstream flaps.

8. A control device as claimed in claim **7**, in which one of said jacks controls simultaneously two adjacent flaps of said upstream juxtaposition and a second jack controls simultaneously two adjacent flaps of said downstream juxtaposition, said flaps being located on either side of the respective jack.

9. A control device as claimed in claim **8**, including a double linkage connecting each of said jacks to the flaps associated therewith.

10. A control device as claimed in claim **9**, including a fixed structure of said conduit, the cylinders of said jacks being integral with said fixed structure and piston rods connected to the pistons of said jacks being connected to the associated flaps by said double linkages.

11. The application of the control device claimed in claim **7** to the control of a flow configuration having a convergent-divergent profile more particularly to the jet pipe or collector channel of a jet engine particularly for a supersonic aircraft.

* * * * *