

April 12, 1960

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2,932,163

MEANS FOR ACTUATING A VARIABLE NOZZLE

Filed May 12, 1958

4 Sheets-Sheet 1

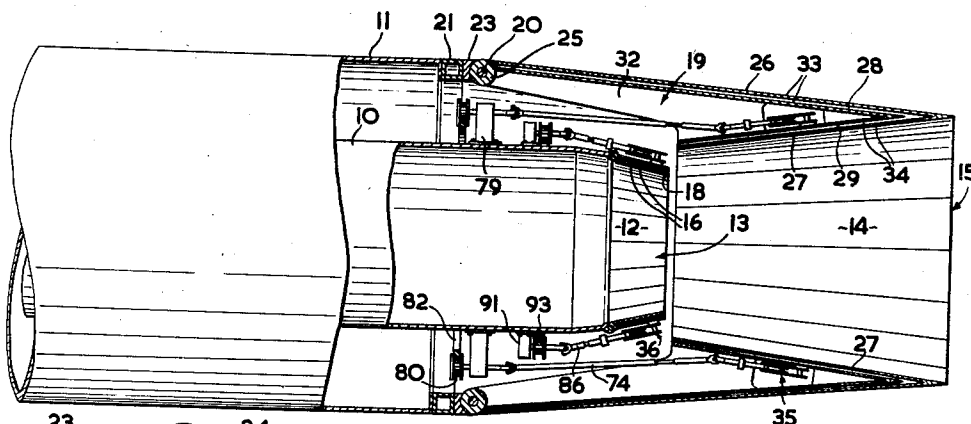


FIG. 1

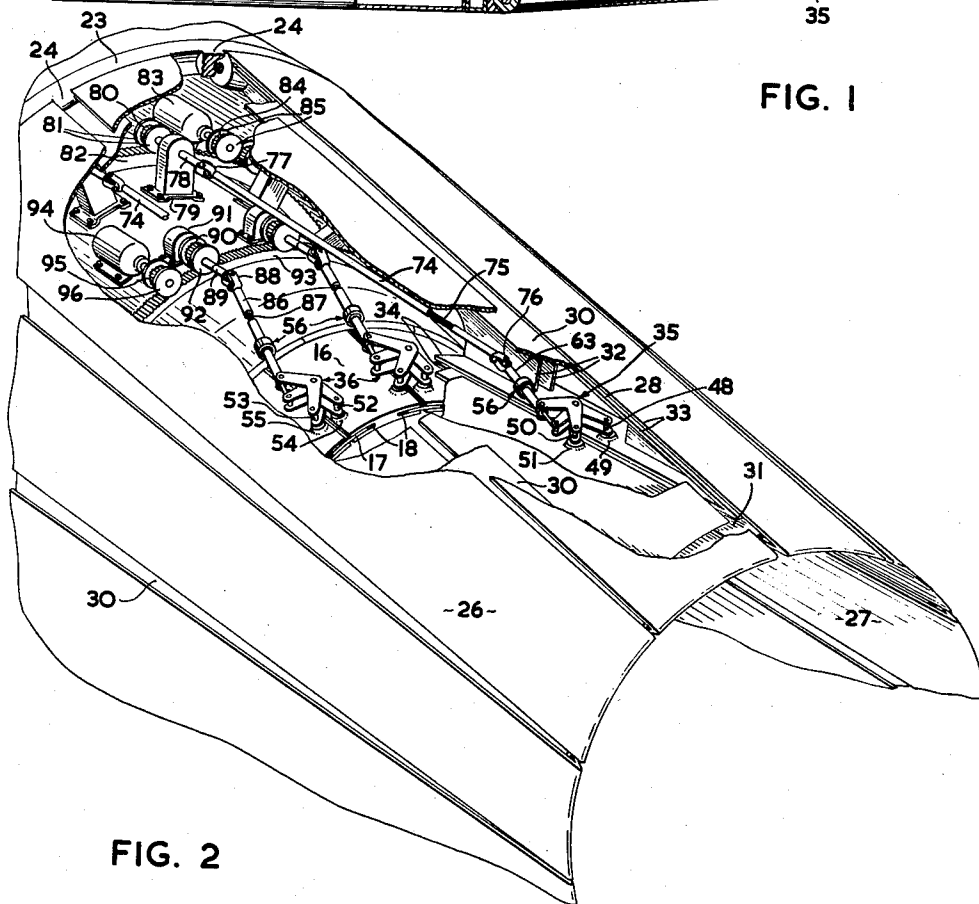


FIG. 2

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4 Sheets-Sheet 2

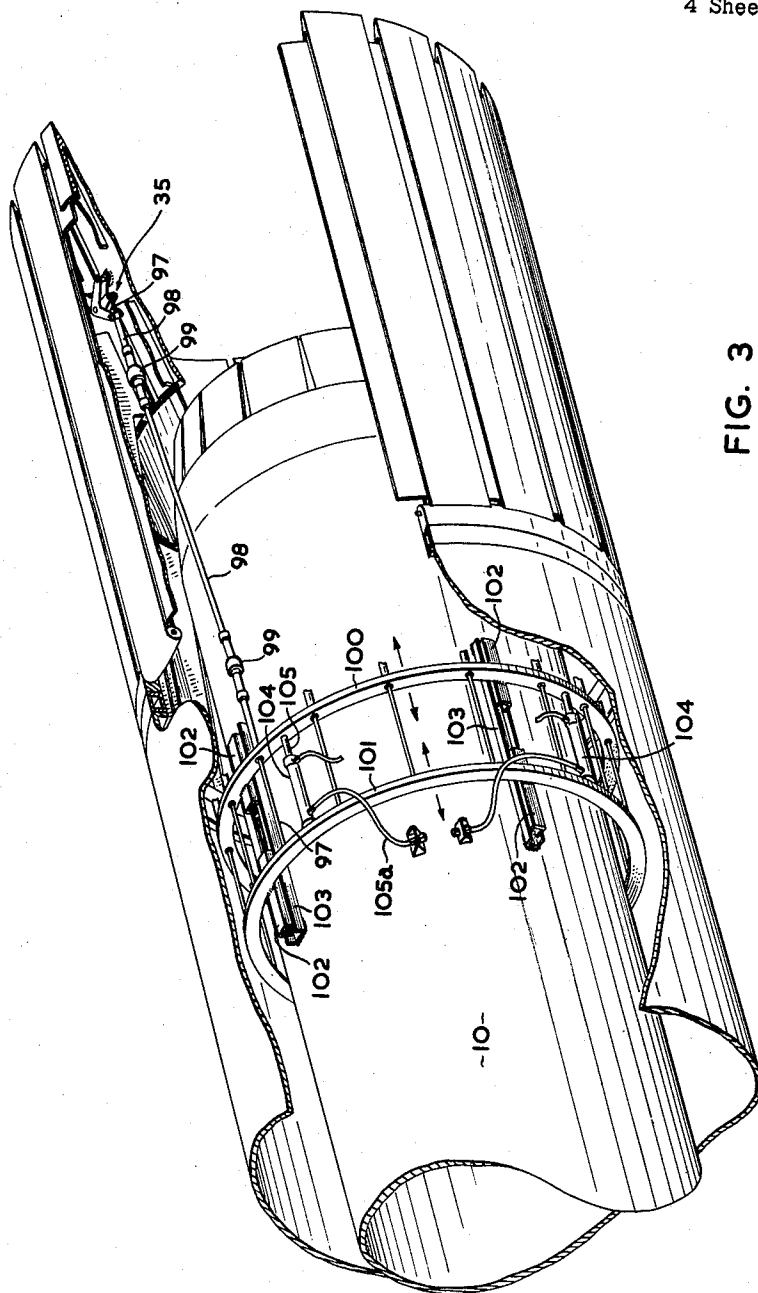


FIG. 3

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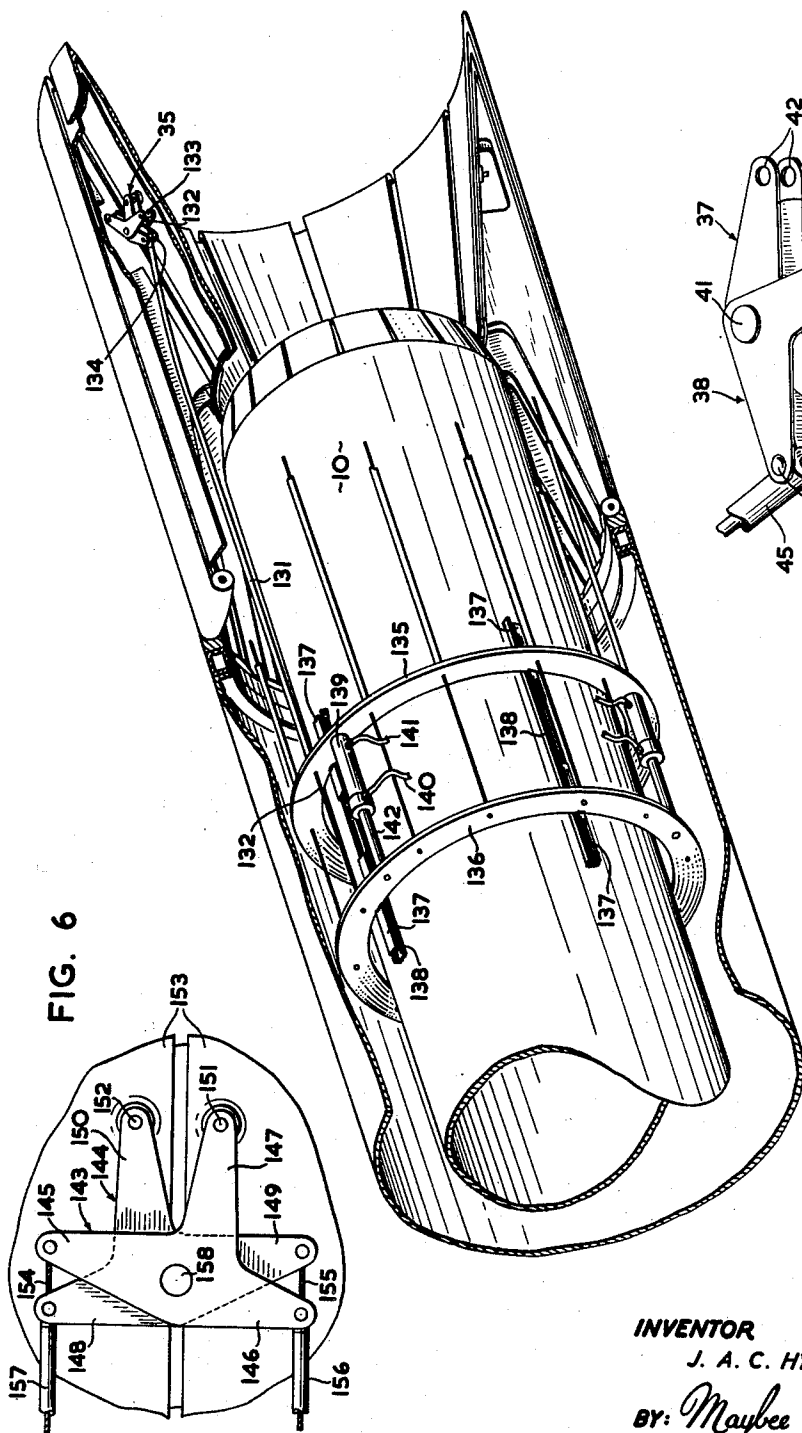


FIG. 4

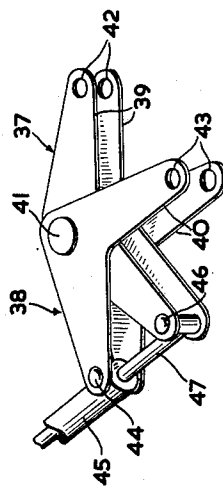


FIG. 5

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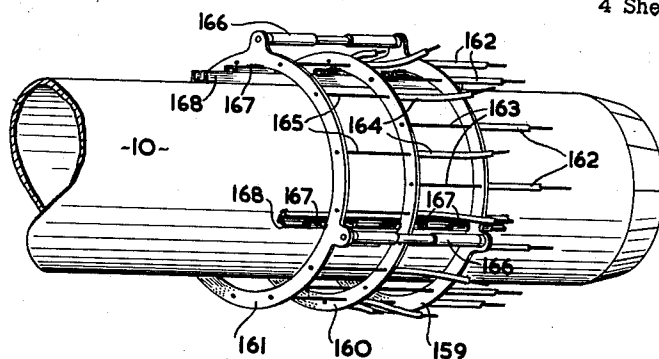


FIG. 7

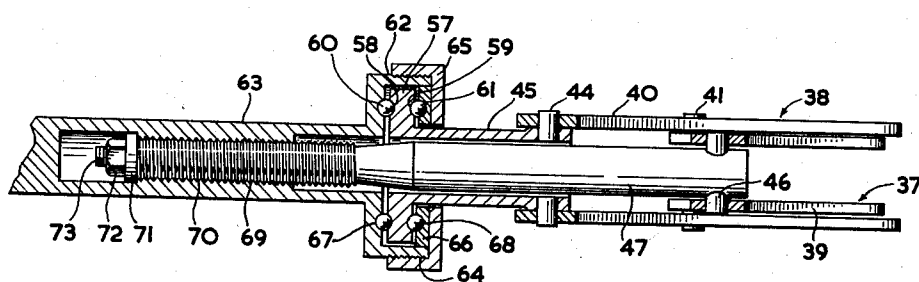


FIG. 8

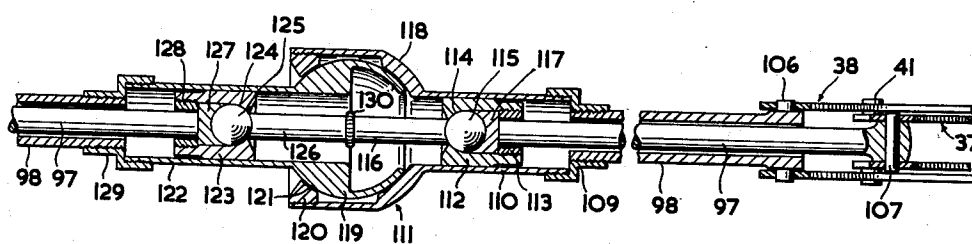


FIG. 9

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MEANS FOR ACTUATING A VARIABLE NOZZLE

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Application May 12, 1958, Serial No. 734,655

10 Claims. (Cl. 60—35.6)

This invention relates to means for actuating a variable nozzle and more particularly to means for actuating a variable nozzle of the type used on reaction propulsion units of aircraft.

Such nozzles generally consist of an annular series of longitudinally extending flaps hingedly mounted at their one ends to supporting structure to define a duct of generally circular cross-section which terminates at the other ends of the flaps in a discharge orifice of variable area. The flaps are moved about their pivots to vary the area of the discharge orifice and, since the flaps are hinged to curved standing structure, the clearance between the longitudinal edges of the flaps will vary so that sealing means are provided to prevent the escape of propulsive gases between the longitudinal edges of adjacent flaps during operation.

Various actuating means have been proposed, but most of them are complicated and are liable to faulty operation as a result of the relatively large deflections of the nozzle flaps which occur and the differential expansions which take place between the various parts due to the heat of the propulsive gases of the reaction propulsion unit.

An object of the present invention is to provide simple actuating means which is applicable to both convergent and divergent nozzles and is capable of absorbing the deflections and differential expansions of the various parts of the engine and cowlings without faulty operation.

A further object of the invention is the provision of actuating means which have relatively small operative parts attached to the nozzle flaps so that the operative parts may be positioned in restricted spaces which would not accommodate conventional actuating gear.

A further object of the invention is the provision of actuating means which may be attached to the flaps near the ends thereof remote from the hinges so that the actuating force required to move the flaps and the bending moments generated in the flaps are reduced as compared with conventional constructions, and in which the actuating forces do not impose additional loads on the nozzle flap hinges and the jet pipe since the actuating means provides its own reactions for the actuating forces.

The invention will be described by way of example with reference to the accompanying drawings in which like reference numerals are used throughout the several views to indicate like parts and in which:

Figure 1 is a longitudinal section through a convergent-divergent nozzle applied to the rear end of a reaction propulsion unit, both the convergent and divergent nozzles being actuated by means according to the invention.

Figure 2 is an enlarged, scrap perspective view of the convergent-divergent nozzle shown in Figure 1,

Figure 3 is a perspective view, partly broken away, showing a convergent-divergent nozzle with the divergent nozzle having actuating means according to a second embodiment of the invention,

Figure 4 is a perspective view, partly broken away, of a variable convergent-divergent nozzle, the divergent

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nozzle having actuating means according to a third embodiment of the invention,

Figure 5 is a detail perspective view of a pair of cranked arms shown in the first and second embodiments of the invention,

Figure 6 is a detail plan view of a second form of a pair of cranked levers for use in the invention,

Figure 7 is a detail view showing an alternative means of operation applicable to the embodiment of the invention shown in Figure 4,

Figure 8 is an enlarged detail section of the screw means employed in the embodiment of the invention shown in Figures 1 and 2, and

Figure 9 is an enlarged detail section of the form of universal joint used in the embodiment of the invention shown in Figure 3.

Referring now to Figures 1 and 2, the convergent-divergent nozzle is shown mounted at the ends of inner and outer pipes 10 and 11 respectively, the convergent nozzle being mounted on the inner pipe 10 and providing a duct 12 convergent to a discharge orifice 13. The divergent nozzle is mounted on the outer pipe 11 and provides a duct 14 diverging to a discharge orifice 15.

The convergent nozzle comprises a plurality of flaps 16 pivoted at their one ends to the extremity of the inner pipe 10. The flaps extend longitudinally from the end of the inner pipe 10 and define the duct 12. Sealing strips 17 are received between adjacent flaps 16 in grooves 18 in adjacent longitudinal edges of the flaps and serve to prevent leakage of the propulsive gases between the longitudinal edges of the flaps as they pivot.

The divergent nozzle is made up of a plurality of flaps 19 which are hinged at their one ends at 20 to the extremity of the outer pipe 11. A box section ring 21 supports a profiled ring 23 which in turn carries lugs 24 between which the flaps 19 are pivoted. Each flap 19 is provided with a barrel-shaped hinge member 25 which conforms to the external curvature of the profiled ring 23. The flaps of the divergent nozzle provide an extension of the cowlings and their outer surfaces 26 are smooth and unobstructed to provide a continuation of the outer pipe 11. The inner surfaces 27 of the divergent flaps define the duct 14. Grooves 28 are provided along the longitudinal edges of the outer surfaces of the divergent flaps and grooves 29 are provided along the longitudinal edges of the internal surfaces of the flaps. Sealing strips 30 are interposed between each adjacent pair of grooves 28 and sealing strips 31 are interposed between each adjacent pair of grooves 29. The sealing strips 30 between adjacent longitudinal edges of the outer surfaces of the flaps ensure that a relatively smooth aerodynamic outer shape is maintained during variation of the nozzle opening. The sealing strips 31 between adjacent longitudinal edges of the inner surfaces of the flaps ensure that propulsive gases passing through the duct 14 will not escape between adjacent longitudinal edges of the flaps.

Each flap of the divergent nozzle is of generally I-section having a double web 32 separating double flanges 33 and double flanges 34, the space between the double flanges 33 providing the grooves 28 and the space between the double flanges 34 providing the grooves 29. The outer surface of each outer flange 33 provides the outer surface 26 of a divergent flap and the inner surface of each inner flange 34 provides the inner surface 27 of a divergent flap.

Mounted between each pair of adjacent divergent flaps 19 is a pivotally connected pair of cranked levers indicated at 35, and mounted between each adjacent pair of flaps 16 of the convergent nozzle is a pair of pivotally connected cranked levers indicated generally at 36. The pairs of cranked levers 35 and 36 are identical and will

be described in greater detail with reference to Figure 5. Each pair of levers comprises a first cranked lever 37 and a second cranked lever 38. Each lever consists of a pair of parallel members, the lever 37 consisting of the members 39 and the lever 38 consisting of the members 40. The members 39 are received between the members 40 and the levers are pivotally interconnected by a pivot pin 41. Aligned apertures 42 are provided in one end of the lever 37 and similar aligned apertures 43 are provided at one end of the lever 38. The other end of the lever 38 is pivotally secured by lugs 44 to an outer member 45 and the other end of the lever 37 is pivotally secured by lugs 46 to the end of an inner member 47 slidable in the outer member 45.

Returning now to Figure 2, and to the pair of levers 35, a pin 48 upstanding from a boss 49 on one of two adjacent flaps 19 is received within the apertures 42; similarly, a pin 50 upstanding from a boss 51 on the other adjacent flap 19 is received in the apertures 43. Referring to a pair of levers 36, a pin 52 upstanding from one of an adjacent two flaps 16 is received in the apertures 42 of the one lever and a pin 53 is received in the apertures 43 of the other lever, the pin 53 upstanding from the other of the adjacent two flaps 16. The pins 52 and 53 are supported from the flaps 16 by swivel ball joints indicated at 54 and 55 respectively.

It will be noticed that the pins 48 and 50 lie substantially in a plane extending generally transversely of the longitudinal axis of the duct; similarly, the pins 52 and 53 lie substantially in a plane extending generally transversely of the longitudinal axis of the duct.

Both in the case of the flaps 19 and the flaps 16, the cranked levers of the pivotally connected pairs are caused to pivot relatively to one another by axial movement between an inner member 47 and an outer member 45 as indicated in Figure 5. This axial movement is obtained by means of complementary nut and screw mechanisms indicated generally at 56 and illustrated in greater detail in Figure 8.

Referring now to Figure 8, the outer member 45 terminates in a flange 57 which is grooved on both sides at 58 and 59 to receive ball bearings 60 and 61. The flange is embraced with clearance by a housing 62 at one end of an internally threaded tube 63. The housing is externally threaded at 64 and receives a cap 65 which retains a pad 66 in contact with the ball bearings 61. The housing 62 is grooved at 67 to accommodate the ball bearings and the pad 66 is grooved at 68 to receive the ball bearings.

The inner member 47 is provided with a screw thread 69 which mates with a screw thread 70 in the interior of the tube 63. The end of the inner member 47 is provided with a stop washer 71 retained in position by a nut 72 on a reduced threaded portion 73. It will be apparent that if the threaded tube 63 is rotated and the inner member 47 is prevented from rotating, the free ends of the inner and outer members 47 and 45 will approach or recede from one another depending upon the direction of rotation of the tube 63. As the ends of the inner and outer members approach one another, the ends of the levers 37 and 38 which are not attached to the inner and outer members will also move toward one another; while if the ends of the inner and outer members recede from one another so will the remote ends of the levers 37, 38 recede from one another. The tube 63 of each screw means is rotated through rods and universal joints as will now be described.

Referring again to Figure 2, the tube 63 of each of the screw means 56 associated with a pair of cranked levers 35 is rotated through a rod 74. The rod 74 is provided with a splined joint 75 to allow the rod to expand longitudinally to allow for differential expansion of the parts under the extreme heat encountered in the engine. One end of the rod 74 is connected by a universal joint 76 to the tube 63 of the screw means 56 and the other

end of the rod 74 is connected through a universal joint 77 to a shaft 78 supported in a bearing housing 79. The shaft extends through the bearing housing and is provided at its other end with a pinion 80 which is flanked by washers 81 of larger diameter than the pinion. Mating with the pinion is a ring gear 82 which, as shown in Figure 1, surrounds the inner pipe 10. The ring gear is maintained in position by engagement with the plurality of pinions 80 which are arranged around the inner pipe, one to each pair of flaps, and is prevented from moving axially by the washers 81 which flank each pinion 80. The ring gear 82 is driven by a motor 83 through a pinion 84 which is also flanked with washers 85 of greater diameter than the pinion.

The screw members 56 associated with the pairs of levers 36 are driven in a similar manner to that described with reference to pairs of levers 35. Each tube 63 of the screw means is attached to a rod 86 having a splined connection 87 to allow the rod to expand axially. The rod is connected through a universal joint 88 with a shaft 89 which carries a pinion 90 and is supported by bearings in a housing 91. The pinion 90 is flanked by washers 92 of greater diameter than the pinion and which serve axially to locate a ring gear 93 supported in the same manner as the ring gear 82. The ring gear 93 is driven by a motor 94 to a shaft on which is secured a pinion 95 having flanking washers 96.

The operation of the embodiment of the invention shown in Figures 1 and 2 is as follows: considering first the divergent nozzle, rotation of the ring gear 82 by the motor 83 will rotate simultaneously all the shafts 74 which will drive all the screw means 56 associated with the pairs of cranked levers 35 pivotally attached to each adjacent two flaps 19. Upon the screw members being driven, the ends of the inner and outer members which are attached to the ends of the levers of each pair will approach or recede from one another so that the other ends of the levers, which are pivotally attached to an adjacent two flaps, will be caused to move towards one another or to move apart. If the longitudinal edges of the flaps are caused to move together then the nozzle will close, whereas if the longitudinal edges of the flaps are caused to move apart, the nozzle will open.

Considering now the convergent nozzle, if it is desired to alter the setting of this nozzle, the ring gear 93 is driven from the motor 94 by the pinion 95 so that all the pinions 90 are rotated simultaneously. Upon rotation of the pinions 90, the shafts 86 revolve and therefore operate the screw gears 56 associated with the pairs of levers 36. Operation of the screw gears causes the ends of the inner and outer members associated with each pair 36 to approach one another or to recede from one another with consequent movement of the other ends of the cranked levers which are pivotally attached through ball joints to the flaps of the nozzle. If the points at which the levers are attached to the nozzle are caused to move away from one another then the longitudinal edges of the flaps will move away from one another and the nozzle will open. Conversely, if the points at which the levers are attached to the flaps are caused to move together then the longitudinal edges of the flaps will approach each other and the nozzle will close.

Referring now to Figure 3, there is shown a second embodiment of the invention in which only the divergent nozzle is shown as being actuated by means according to the invention. No means is shown for actuating the flaps of the convergent nozzle and any convenient means, or the means shown in Figures 1 and 2, may be used. In the second embodiment of the invention, instead of using screw means, rigid rods are used to actuate the cranked levers. The construction of the divergent flaps is precisely the same as in Figures 1 and 2 and will not therefore be further described. Also, the construction of the pairs of cranked levers 35 is identical to that de-

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scribed with reference to Figure 5 and will not therefore be further described.

One end of one of the cranked levers of each pair is pivotally secured to an inner rod 97 and the corresponding end of the other lever is pivotally secured to an outer hollow rod 98. Each pair of concentric rods 97, 98, which forms a set, extends longitudinally upstream through two universal joints, indicated generally at 99, to a pair of unison rings 100, 101. The outer rod 98 of each set is secured to the unison ring 100, while the inner rod 97 passes through the unison ring 100 and is secured to the unison ring 101. The unison rings are aligned by means of channel-shaped shoes 102 carried by each unison ring, the shoes sliding in channel-shaped tracks 103 secured to the inner pipe 10. Hydraulic or pneumatic actuators 104 are interposed between the unison rings, the cylinder of each actuator being attached to the unison ring 101 and the piston rod 105 being attached to the unison ring 100. Each actuator is supplied with operating fluid through pipes 105a.

It will be apparent that, as the unison rings are moved relatively to one another, the inner rod 97 of each set will move within its hollow outer rod 98 and will pivot the levers of the pairs of levers 35 relatively to one another. In order to accommodate the deflections which occur as the nozzle opens and closes the universal joints 99 are constructed in a manner shown in Figure 9.

Referring now to Figure 9, the end of the outer rod 98 is pivotally mounted by lugs 106 between the members 40 of the lever 38 and the end of the inner rod 97 is pivotally mounted by a pivot pin 107 in a boss 108 which is received between the members 39 of the lever 37; the levers 37, 38 are pivotally interconnected by a pivot pin 41. The other end of the outer rod 98 is screw-threaded and is received within a collar 109 which is internally screw-threaded and receives the threaded end of a tubular extension 110 of a socket member indicated generally at 111. Slidable within the tubular extension 110 is a block 112 into which is screwed a collar 113 into which, in turn, is screwed the other end of the inner rod 97. A part spherical seating 114 is formed in the block 112 and on the seating is received the spherical end 115 of a short rod 116. The spherical end 115 is kept in contact with the seating 114 by a pad 117. Received in a part spherical seating 118 in the socket member 111 is a hollow ball member 119 which is retained in position in the socket member by a ring 120 having a part spherical seat 121 to mate with the ball member 119. The ball member 119 has a tubular extension 122 in which is received a slidable block 123. The block has a part spherical seating 124 formed in the interior thereof and on this part spherical seating is received the spherical end 125 of a short rod 126. The spherical end 125 is kept in position on the spherical seating 124 by a pad 127 which in turn is kept in position in the block 123 by a screw-threaded collar 128. Received in the bore of the collar 128 is an extension of the inner rod 97 and secured to the tubular extension 122 by the screw-threaded collar 129 is an extension of the external rod 98. The short rods 116, 126 are threadably interconnected at 130 for assembly purposes.

The purpose of the universal joints shown in Figure 9 is to enable the inner and outer rods to accommodate themselves to the deflection of the nozzle flaps as the nozzle opens and closes. Since it is also essential that the relative axial positions of the inner and outer members do not change except as controlled by unison rings 100, 101, it is necessary to use the type of joint shown which allows the inner and outer members to absorb the imposed deflections without changing their relative axial positions. It will be apparent that the deflection of the outer rods 98 is accommodated by the ball and socket joint constituted by the ball 119 and socket member 111, and that the deflection of the inner rod 97 is accommodated by movement of the spherical ends 115, 125

of the composite rod 116, 126 in the part spherical seatings in the blocks 112, 123.

The operation of the embodiment shown in Figure 3 is similar to the operation of the embodiment described with reference to Figures 1 and 2. If the unison rings 100, 101 are spread apart by the actuators 104, the ends of the inner and outer rods remote from the unison rings approach one another so that the longitudinal edges of the flaps are brought towards one another by the pivoting of the cranked levers, the nozzle closes. If, on the other hand, the unison rings 100, 101 are moved towards one another by the actuators, the ends of the inner and outer rods remote from the unison rings will move away from one another and the longitudinal edges of the flaps will be moved apart by the pivoting of the levers connected to the flaps so that the nozzle will open.

The unison rings 100, 101 are free to slide axially in their guides 103 and will therefore slide without changing their distance apart to take up and axial expansion of the nozzle and will also move, if required, as the nozzle deflects. The relative positions of the cranked levers of each pair are determined solely by the distance between the unison rings 100 and 101 and are not affected by the axial position of the unison rings relatively to the inner pipe if the distance between the rings remains constant.

Referring now to Figure 4, there is shown a third embodiment of the invention which is very similar to the embodiment shown in Figure 3 except that instead of rigid inner and outer rods being used flexible cables are used. The arrangement of the flaps of the divergent nozzle are the same as the arrangement shown and described with reference to Figures 1 and 2 and will not be further described. Similarly, the pairs of cranked levers 35 are identical and, referring to Figure 4, are each operated by a flexible cable consisting of an outer cable 131 and an inner cable 132. The inner cable is attached at one end to a pin 133 which is received between the ends of the members 40 of the lever 38, and one end of the outer cable abuts against the pin 134 received between the members 39 of the lever 37. The flexible cables are operated by a pair of unison rings 135, 136 which are mounted on the inner pipe 10 by shoes 137, which run in channel-shaped guides 138. Interposed between the unison rings 135, 136 are hydraulic or pneumatic actuators 139 which are supplied with hydraulic or pneumatic operating fluid through pipes 140, 141. The cylinder of each actuator is connected to the unison ring 135 and the piston rod 142 of each actuator is connected to the unison ring 136. The outer cables 131 abut against the unison ring 135 while the inner cables 132 pass through apertures in the unison ring 135 and are secured to the unison ring 136.

It will be apparent that if the unison rings 135, 136 are moved relatively to one another then the inner and outer cables of each flexible cable will move relatively to one another and will thus pivot the cranked levers of the pairs of levers 35 relatively to one another. If the unison rings 135, 136 are moved away from one another, then the ends of the cranked levers attached to the flexible cable will move together and so will the other ends of the cranked lever attached to the flaps. The nozzle will therefore close since the longitudinal edges of adjacent flaps will be moved towards one another. If, however, the unison rings 135, 136, move towards one another, then the ends of the cables connected to the cranked levers will move away from one another so that the ends of the cranked levers attached to the flaps will also move away from one another and the nozzle will open. The opening of the nozzle will be assisted by the fluid pressure in the duct 14 constituted by the divergent nozzle.

Referring now to Figure 6, there is shown an alternative type of cranked lever which may be used in place of those described in relation to Figure 5. The arrangement

shown in Figure 6 is shown as being used for flexible cables but it may also be used with either of the other types of actuation described with reference to Figures 1 and 2 and with reference to Figure 3. The cranked levers shown in Figure 6 each comprise three arms, two arms generally in line and the third arm at right angles thereto. One of the levers is indicated generally at 143 and the other lever is indicated generally at 144. The lever 143 consists of an arm 145 more or less in line with a second arm 146. A third arm 147 projects from the arms 145, 146 so that the arms make more or less a T-shaped configuration. The lever 144 comprises an arm 148, a second arm 149 generally in line with the arm 144 and a third arm 150 generally at right angles to the arms 148, 149. The arms 147, 150 are pivotally attached by pins 151, 152 to adjacent flaps 153 of a nozzle and the arms 145, 149 are attached to inner cables 154, 155 whereas the arms 146, 148 are attached to outer cables 156, 157. The levers 143, 146 are pivotally interconnected by a pivot pin 158.

It will be apparent that if the inner and outer cables of each flexible cable are moved relatively to one another so that the arms 146, 149 approach one another and the arms 145, 148 approach one another, the pivot pins 151, 152 will also approach one another and the longitudinal edges of the flaps 153 will be moved towards one another so that the nozzle will close. Conversely, if the inner and outer members of the cables are moved in the opposite direction, the longitudinal edges of the flaps 153 will be moved away from one another and the nozzles will open, assisted by fluid pressure within the nozzle.

The advantage of the type of cranked arm shown in Figure 6 over the type shown in Figure 5 is that torsional stresses on the levers are eliminated. On the other hand two cables are needed to pivot each pair of levers.

Referring now to Figure 7 there is shown a unison ring assembly applicable to the embodiment of the invention described with reference to Fig. 4. In Figure 7 are shown three unison rings 159, 160, and 161. The outer cables 162 of some of the composite flexible cables terminate at the unison ring 159 and the inner cables associated with the outer cables 162 pass through the unison ring 159 and are secured to the unison ring 160; these inner cables are indicated at 163. The outer cables 164 of the other composite flexible cables indicated terminate at the unison ring 160 and the inner cables 165 associated with said outer members 164, pass through the unison ring 160 and are secured to the unison ring 161. Hydraulic or pneumatic actuators indicated at 166 extend between the unison rings 159 and 161 and may be operated to move the unison rings together or move them apart. Each of the unison rings is provided with a shoe 167 which runs in a channel-shaped guide 168 in the inner pipe. The method of operation of the embodiment shown in Figure 7 is the same as in the embodiment shown in Figure 4. The advantage of the construction shown in Figure 7 is that it enables lighter actuators having a longer stroke to be used in place of the actuators used in the embodiment shown in Figure 4.

It will be seen that the invention provides means for actuating a variable nozzle in which the radial, axial or angular deflections of the nozzle flaps relatively to the fixed pipes is absorbed by universally jointed rods or cables.

A further advantage is that the cranked arms which are mounted on the nozzle flaps may be placed in restricted spaces where it would be impracticable to place conventional types of operating gear such as screw jacks and unison rings. A yet further advantage of the invention is that the cranked levers may be placed on the rear or downstream ends of the flaps whereby the beam stresses and bending moments in the flaps are reduced. Moreover, since the cranked levers are towards the downstream end of the flaps the actuating force required to close the nozzle is lower than that which would be re-

quired further upstream which would be where conventional actuating means would be situated if it were used.

It will be understood that the form of the invention herewith shown and described is a preferred example and various modifications can be carried out without departing from the spirit of the invention or the scope of the appended claims.

What I claim as my invention is:

1. Means for actuating a variable nozzle having an annular series of longitudinally extending flaps hingedly mounted at their one ends to supporting structure to define a duct of generally circular cross-section terminating at the other ends of the flaps in a discharge orifice of variable area, said means comprising a plurality of pairs of levers spaced apart around the exterior of the duct, each pair consisting of a first lever and a second lever pivotally interconnected only to each other, each pair being associated with an adjacent two flaps distinct from the flaps associated with other pairs, pivotal mountings interposed between the first levers and flaps of the series, further pivotal mountings interposed between the second levers and other flaps of the series, said pivotal mountings constituting the sole means supporting said levers on said flaps, the pivotal mounting of the first lever of each pair being on one of the flaps associated with the pair and the pivotal mounting of the second lever of the pair being on the other of the flaps associated with the pair, the pivotal mountings of the levers of each pair lying in a plane extending generally transversely of the longitudinal axis of the duct, and operating means to pivot the first and second levers of all the pairs relatively to one another in synchronism to vary the circumferential spacing of the pivotal mountings to pivot the flaps and hence to vary the area of the discharge orifice.

2. Means for actuating a variable nozzle having an annular series of longitudinally extending flaps hingedly mounted at their one ends to supporting structure to define a duct of generally circular cross-section terminating at the other ends of the flaps in a discharge orifice of variable area, said means comprising a plurality of pairs of cranked levers spaced apart around the exterior of the duct, each pair consisting of a first lever and a second lever pivotally interconnected intermediate their ends only to each other, each pair being associated with an adjacent two flaps distinct from the flaps associated with other pairs, pivotal mountings interposed between the one ends of the first levers and flaps of the series, further pivotal mountings interposed between the one ends of the second levers and other flaps of the series, said pivotal mountings constituting the sole means supporting said levers on said flaps, the pivotal mounting of the first lever of each pair being on one of the flaps associated with the pair and the pivotal mounting of the second lever of the pair being on the other of the flaps associated with the pair, the pivotal mountings of the levers of each pair lying in a plane extending generally transversely of the longitudinal axis of the duct, and means connected to the other ends of the levers to pivot the first and second levers of all the pairs relatively to one another in synchronism to vary the circumferential spacing of the pivotal mountings to pivot the flaps and hence to vary the area of the discharge orifice.

3. Means for actuating a variable nozzle having an annular series of longitudinally extending flaps hingedly mounted at their one ends to supporting structure to define a duct of generally circular cross-section terminating at the other ends of the flaps in a discharge orifice of variable area, said means comprising a plurality of pairs of levers spaced apart around the exterior of the duct, each pair consisting of a first lever and a second lever pivotally interconnected only to each other, each pair being associated with an adjacent two flaps distinct from the flaps associated with other pairs, each lever having three arms radiating from the pivotal interconnection, two of the arms being in line and the third arm being at

right angles to the first two arms, pivotal mountings interposed between the third arms of the first levers and flaps of the series, further pivotal mountings interposed between the third arms of the second levers and other flaps of the series, said pivotal mountings constituting the sole means supporting said levers and said flaps, the pivotal mounting of the first lever of each pair being on one of the flaps associated with the pair and the pivotal mounting of the second lever of the pair being on the other of the flaps associated with the pair, the pivotal mountings of the levers of each pair lying in a plane extending generally transversely of the longitudinal axis of the duct, and operating means connected to the first and second arms of the levers of each pair to pivot the first and second levers of all the pairs relatively to one another in synchronism to vary the circumferential spacing of the pivotal mountings to pivot the segments and hence to vary the area of discharge orifice.

4. Means for actuating a variable nozzle having an annular series of nozzle flaps hingedly mounted at their one ends to supporting structure to define a duct of generally circular cross-section terminating at the other ends of the flaps in a discharge orifice of variable area, said means comprising a plurality of pairs of levers spaced apart around the exterior of the duct, each pair consisting of a first lever and a second lever pivotally interconnected only to each other, each pair being associated with an adjacent two flaps distinct from the flaps associated with other pairs, pivotal mountings interposed between the first levers and flaps of the series, further pivotal mountings interposed between the second levers and other flaps of the series, said pivotal mountings constituting the sole means supporting said levers on said flaps, the pivotal mounting of the first lever of each pair being on one of the flaps associated with the pair and the pivotal mounting of the second lever of the pair being on the other of the flaps associated with the pair, the pivotal mountings of the levers of each pair lying in a plane extending generally transversely of the longitudinal axis of the duct, a plurality of longitudinally extending hollow outer members, inner members extending through the outer members and being movable relatively thereto; an inner member and its associated outer member constituting a set, a first unison member to which one ends of the inner members are secured, a second unison member to which one ends of the outer members are secured, and means to move the unison members relatively to one another, the other ends of the inner and outer members being secured to the levers, the inner member of each set being secured to the first lever of a pair and the outer member of the set being secured to the second lever of the pair, movement of the first and second unison members relatively to one another varying the area of the discharge orifice by pivoting the first and second levers of the pairs relatively to one another thus pivoting the flaps.

5. Means for actuating a variable nozzle having an annular series of longitudinally extending flaps pivotally mounted at their one ends to supporting structure to define a duct of generally circular cross-section terminating at the other ends of the flaps in a discharge orifice of variable area, said means comprising a plurality of pairs of levers spaced apart around the exterior of the duct, each pair consisting of a first lever and a second lever pivotally interconnected only to each other, each pair being associated with an adjacent two flaps distinct from the flaps associated with other pairs, pivotal mountings interposed between the first levers and flaps of the series, further pivotal mountings interposed between the second levers and other flaps of the series, said pivotal mounting constituting the sole means supporting said levers on said flaps, the pivotal mounting of the first lever of each pair being on one of the flaps associated with the pair and the pivotal mounting of the second lever of the pair being on the other of the flaps associated with the pair, the pivotal mountings of the levers of each pair lying in a

plane extending generally transversely of the longitudinal axis of the duct, a plurality of flexible longitudinally extending hollow outer members, flexible inner members extending through the outer members and being movable relatively thereto, an inner member and its associated outer member constituting a set, a first unison member to which the inner members are secured at their one ends, a second unison member to which the outer members are secured at their one ends, and means to move the unison members relatively to one another, the other ends of the inner and outer members being secured to the levers, the inner member of each set being secured to the first lever of a pair and the outer member of the set being secured to the second lever of the pair, movement of the first and second unison members relatively to one another varying the area of the discharge orifice by pivoting the first and second levers of the pairs relatively to one another thus pivoting the flaps.

6. Means for actuating a variable nozzle having an annular series of longitudinally extending flaps hingedly mounted at their one ends to supporting structure to define a duct of generally circular cross-section terminating at the other ends of the flaps in a discharge orifice of variable area, said means comprising a plurality of pairs of levers spaced apart around the exterior of the duct, each pair consisting of a first lever and a second lever pivotally interconnected only to each other, each pair being associated with an adjacent two flaps distinct from the flaps associated with the other pairs, pivotal mountings interposed between the first levers and flaps of the series, further pivotal mountings interposed between the second levers and other flaps of the series, said pivotal mountings constituting the sole means supporting said levers on said flaps, the pivotal mounting of the first lever of each pair being on one of the flaps associated with the pair and the pivotal mounting of the second lever of the pair being on the other of the flaps associated with the pair, the pivotal mountings of the levers of each pair lying in a plane extending generally transversely of the longitudinal axis of the duct, a plurality of longitudinally extending hollow outer members, inner members extending through the outer members and being movable relatively thereto, an inner member and its associated outer member constituting a set, screw means associated with each set for moving the inner and outer members relatively to one another, the inner member of each set being secured to the first lever of a pair and the outer member of the set being secured to the second lever of the pair, and means to operate all said screw means in unison to vary the area of the discharge orifice by moving the inner members of all the sets relatively to the outer members thus pivoting the first and second levers of the pairs relatively to one another and pivoting the flaps.

7. Means for actuating a variable nozzle having an annular series of longitudinally extending flaps hingedly mounted at their one ends to supporting structure to define a duct of generally circular cross-section terminating at the other ends of the flaps in a discharge orifice of variable area, said means comprising a plurality of pairs of levers spaced apart around the exterior of the duct, each pair consisting of a first lever and a second lever pivotally interconnected, each pair being associated with an adjacent two flaps distinct from the flaps associated with other pairs, pivotal mountings interposed between the first levers and flaps of the series, further pivotal mountings interposed between the second levers and other flaps of the series, the pivotal mounting of the first lever of each pair being on one of the flaps associated with the pair and the pivotal mounting of the second lever of the pair being on the other of the flaps associated with the pair, the pivotal mountings of the levers of each pair lying in a plane extending generally transversely of the longitudinal axis of the duct, a plurality of flexible longitudinally extending hollow outer

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members, flexible inner members extending through the outer members and being movable relatively thereto, an inner member and its associated outer member constituting a set, a first unison member to which some of the inner members are secured at their one ends, a second unison member to which the outer members associated with said inner members are secured at their one ends and to which the inner members, other than those secured to the first unison member, are also secured at their one ends, a third unison member to which the outer members associated with the inner members secured to the second unison member are secured at their one ends, means to move the unison members relatively to one another, the other ends of the inner and outer members being secured to the levers, the inner member of each set being secured to the first lever of a pair and the outer member of the set being secured to the second lever of the pair, movement of the unison members relatively to one another varying the area of the discharge orifice by pivoting the first and second levers of the pairs relatively to one another thus pivoting the flaps.

8. Means for actuating a variable nozzle having an annular series of longitudinally extending flaps hingedly mounted at their one ends to supporting structure to define a duct of generally circular cross-section converging to terminate at the other ends of the flaps in a discharge orifice of variable area, said means comprising a plurality of pairs of levers spaced apart around the exterior of the duct, each pair consisting of a first lever and a second lever pivotally interconnected only to each other, each pair being associated with an adjacent two flaps distinct from the flaps associated with the other pairs, pivotal mountings interposed between the first levers and flaps of the series, further pivotal mountings interposed between the second levers and other flaps of the series, said pivotal mountings constituting the sole means supporting said levers on said flaps, the pivotal mounting of the first lever of each pair being on one of the flaps associated with the pair and the pivotal mounting of the second lever of the pair being on the other of the flaps associated with the pair, the pivotal mountings of the levers of each pair lying in a plane extending generally transversely of the longitudinal axis of the duct, a plurality of longitudinally extending outer members, inner members extending through the outer members and being movable relatively thereto, an inner member and an associated outer member constituting a set, complementary screw and nut means associated with each set for moving the inner and outer members relatively to one another, the screw means being secured to the inner member and the nut means being secured to the outer member, a shaft extending from each of said nut means to a pinion, a ring gear in engagement with all said pinions and means to rotate said ring gear to operate all said screw and nut means in unison thereby to vary the area of the discharge orifice by moving the inner members of all the sets relatively to the outer members thus pivoting the first and second levers of the pairs relatively to one another and pivoting the flaps.

9. Means for actuating a variable nozzle having an annular series of longitudinally extending flaps hingedly mounted at their one ends to supporting structure to define a duct of generally circular cross-section diverging to terminate at the other ends of the flaps in a discharge orifice of variable area, said means comprising a plurality of pairs of levers spaced apart around the exterior of the duct, each pair consisting of a first lever and a second lever pivotally interconnected only to each other, each pair being associated with an adjacent two flaps distinct from the flaps associated with the other pairs, pivotal mountings interposed between the first levers and the flaps of the series, further pivotal mountings interposed between the second levers and other flaps of the series, said pivotal mountings constituting the sole means supporting said levers on said flaps, the pivotal mounting of

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the first lever of each pair being on one of the flaps associated with the pair and the pivotal mounting of the second lever of the pair being on the other of the flaps associated with the pair, the pivotal mountings of the levers of each pair lying in a plane extending generally transversely of the longitudinal axis of the duct, a plurality of longitudinally extending hollow members, inner members extending through the outer members and being movable relatively thereto, an inner member and its associated outer member constituting a set, complementary nut and screw means associated with the members of each set, the inner members of the set being secured to the screw and the outer member of the set being secured to the nut, a shaft extending longitudinally from each nut, a pinion on the end of each shaft remote from said nut, a ring gear engaging all said pinions, and means to drive the ring gear to operate all said screw means in unison whereby the area of the discharge orifice is varied by moving the inner members of all the sets relatively to the outer members thus pivoting the first and second levers of the pairs relatively to one another and pivoting the flaps.

10. Means for actuating a variable nozzle having an annular series of nozzle flaps hingedly mounted at their one ends to supporting structure to define a duct diverging to terminate at the other ends of the flaps in a discharge orifice of variable area, said means comprising a plurality of pairs of levers spaced apart around the exterior of the duct, each pair consisting of a first lever and a second lever pivotally interconnected, each pair being associated with an adjacent two flaps distinct from the flaps associated with the other pairs, pivotal mountings interposed between the first levers and flaps of the series, further pivotal mountings interposed between the second levers and other flaps of the series, said pivotal mountings constituting the sole means supporting said levers on said flaps, the pivotal mounting of the first lever of each pair being on one of the flaps associated with the pair and the pivotal mounting of the second lever of the pair being on the other of the flaps associated with the pair, the pivotal mounting of the levers of each pair lying in a plane extending generally transversely of the longitudinal axis of the duct, a plurality of rigid longitudinally extending hollow outer members, rigid inner members extending through the outer members and being movable longitudinally relatively thereto, universal joints, adapted to transmit both tension and compression, in the inner and outer members and connecting the adjacent ends thereof, a first unison member to which one end of each of the inner members is secured through a universal joint, a second unison member to which one end of each outer member is secured through a universal joint, the other ends of the inner and outer members being secured to the levers through universal joints, the inner member of each set being secured to the first lever of a pair and the outer member of the set being secured to the second lever of the pair, and means to move the unison members relative to one another, movement of the first and second unison members relatively to one another varying the area of the discharge orifice by pivoting the first and second levers of the pairs relatively to one another thus pivoting the flaps.

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