Dec. 24, 1935. W. S. DIEHL 2,025,577

VENTURI TUBE

Filed July 18, 1933 4 Sheets-Sheet 1

Fig. 1.

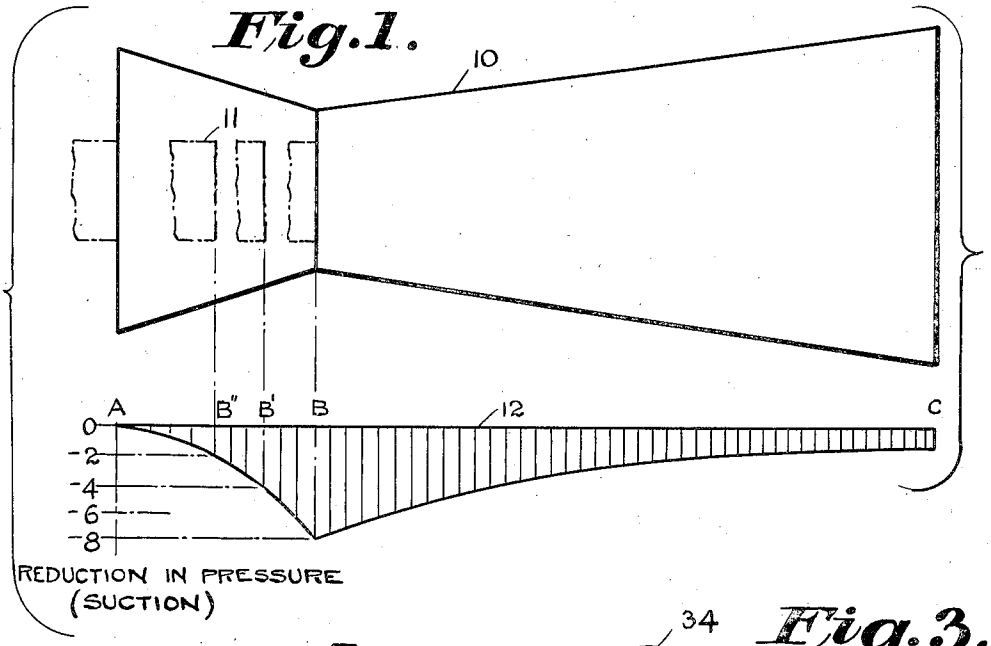
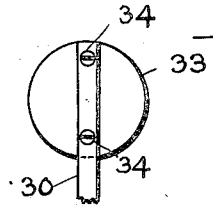



Fig. 3.



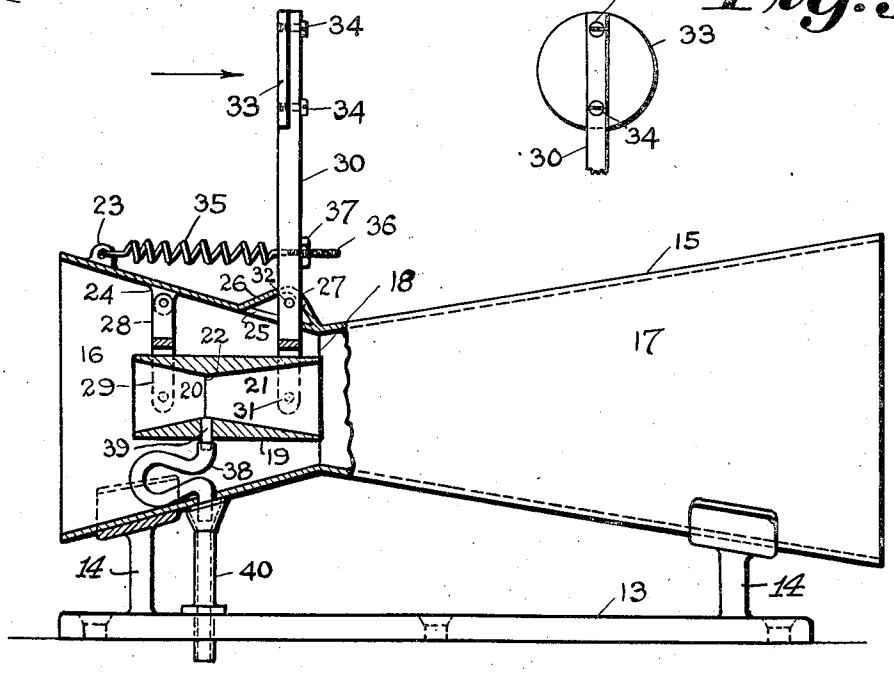




Fig. 2.

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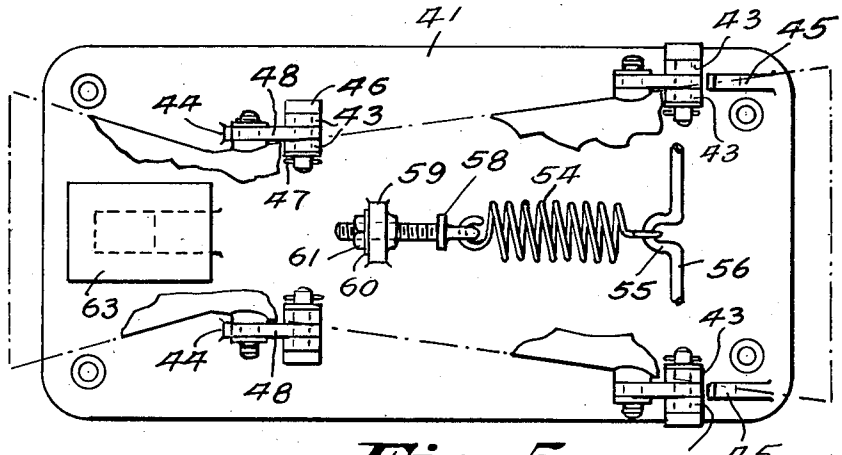


Fig. 5.

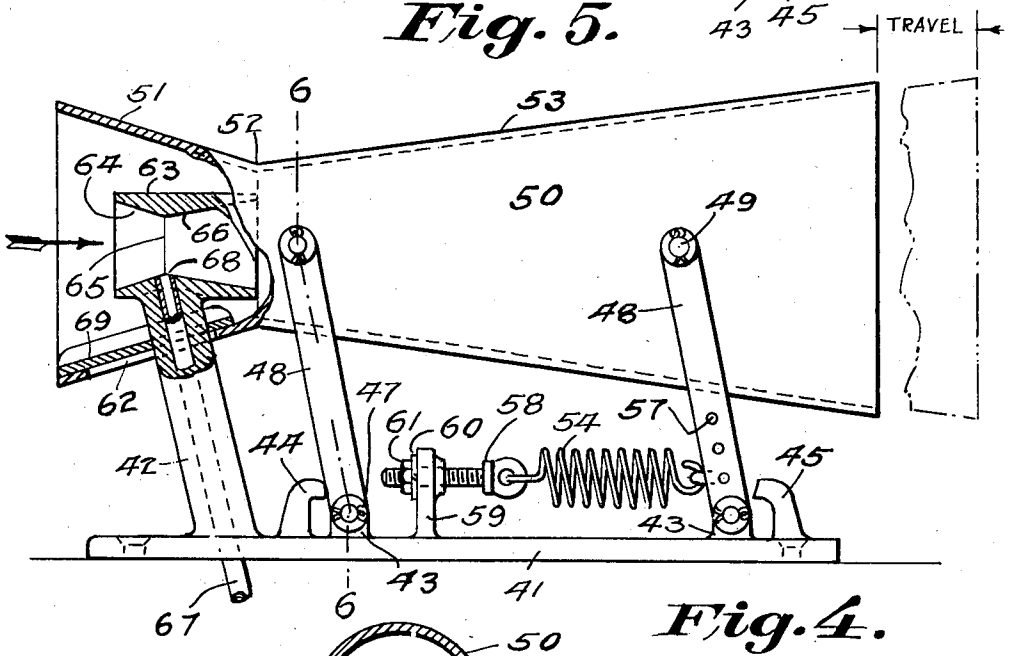


Fig. 4.

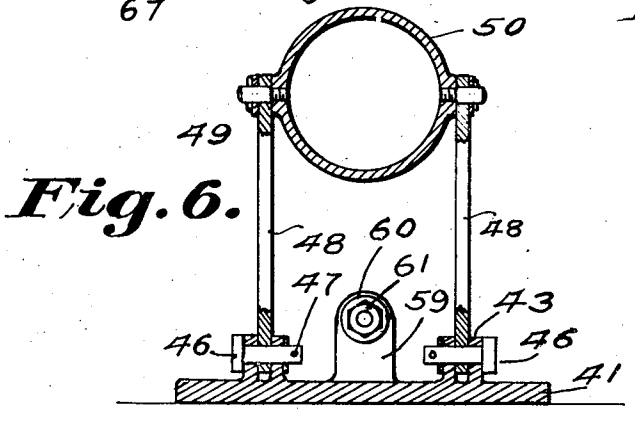


Fig. 6.

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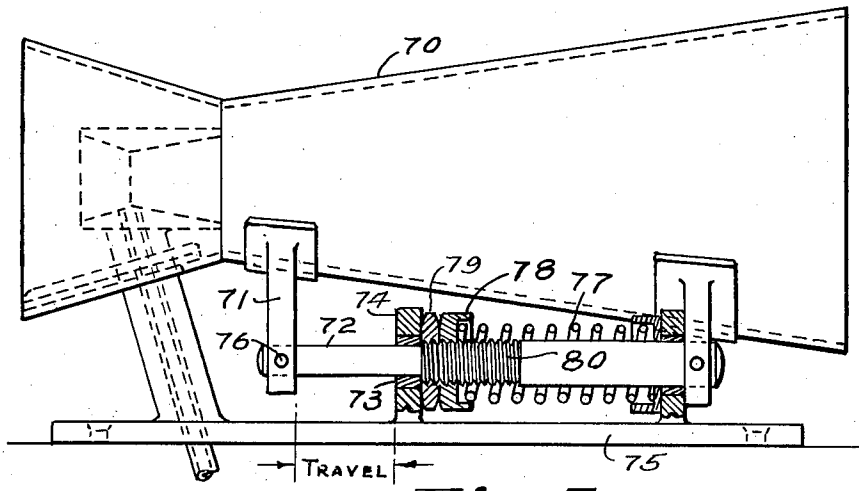


Fig. 7.

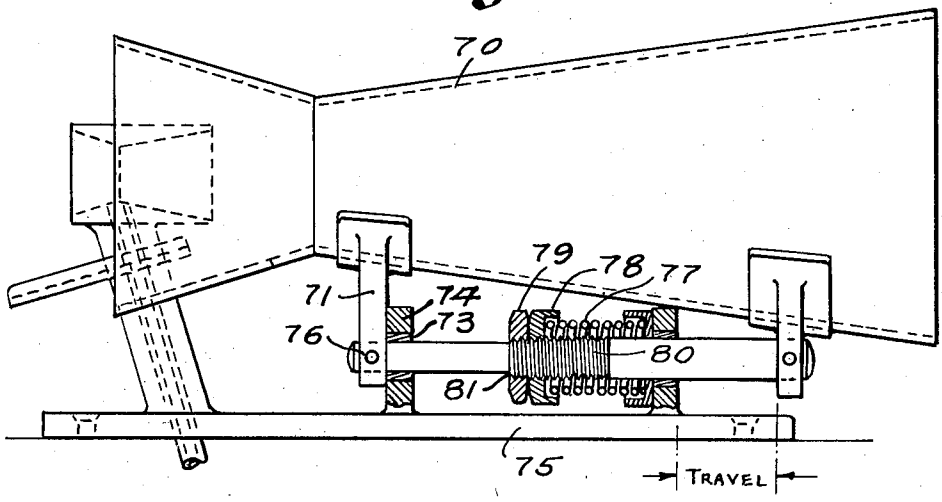


Fig 8.

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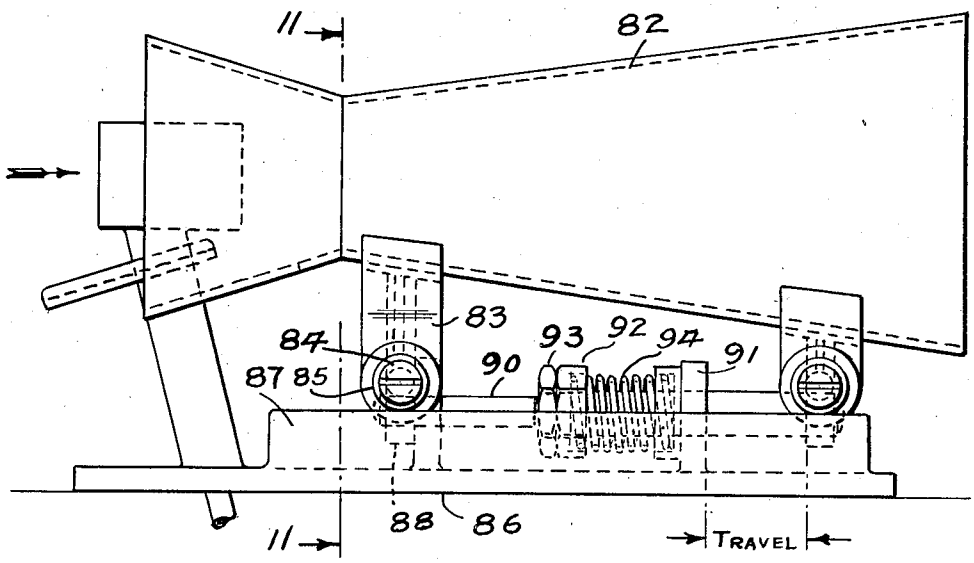


Fig. 10.

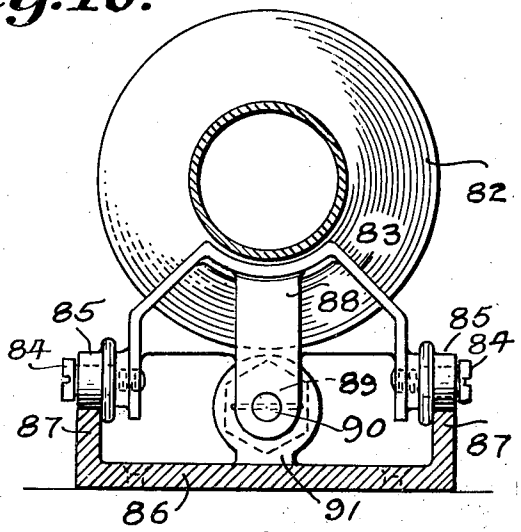


Fig. 11.

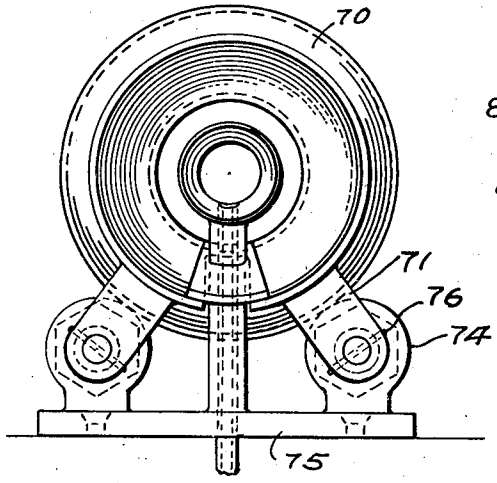


Fig. 9.

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# UNITED STATES PATENT OFFICE

2,025,577

## VENTURI TUBE

Walter S. Diehl, United States Navy

Application July 18, 1933, Serial No. 681,038

13 Claims. (Cl. 230—111)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

My invention relates broadly to Venturi tubes, and more particularly to controlled Venturi tubes for use with aircraft instruments.

The Venturi tube is most commonly used in aircraft for producing the suction required for operating gyroscopic instruments such as the directional gyros, the artificial horizon, the turn indicator, etc. It is necessary that the speed of the rotor of each of the said instruments remain essentially constant in order to obtain the best performance and to obtain this condition, the operating suction must remain constant. The suction obtained from the conventional type of Venturi tube varies with the air speed of the airplane to such an extent that the instruments are not efficient and, in some instances, the instruments are rendered inoperative. It is therefore the primary object of my invention to automatically regulate the amount of suction developed by a venturi so as to obtain the best performance of the instruments operated by suction.

It is another object of my invention to provide in a venturi, means for controlling the suction to a practically constant value above any desired limiting speed.

With the above and other objects in view, this invention consists in the construction, combination and arrangement of parts as will be described more fully hereinafter.

Reference is to be had to the accompanying drawings forming a part of this specification, in which like reference characters indicating corresponding parts throughout the several views, and in which:

Fig. 1 is a diagrammatic view showing the operation of my improved device against a scale;

Fig. 2 is a side elevation of my improved device shown partly in section;

Fig. 3 is a detail of Fig. 2;

Fig. 4 is a side elevation of a modification of my improved device, shown partly in section;

Fig. 5 is a plan view of Fig. 4 with the outer Venturi shell removed;

Fig. 6 is a view on lines 6—6 of Fig. 4;

Fig. 7 is a side elevation of a modified form of my improved device;

Fig. 8 is the same as Fig. 7 with the outer shell moved aft;

Fig. 9 is an end view of Fig. 7;

Fig. 10 is a side elevation of another modification of my improved device;

Fig. 11 is a view on lines 11—11 of Fig. 10.

In order to illustrate the principle involved and the relative positions of my improved device over the conventional type venturi, I have diagrammatically shown in Fig. 1 the outline 10 of an outer Venturi tube with an inner tube or venturi 11 shown in various dotted positions with reference to a scale 12 which designates reductions in pressure or suction. The usual location of the inner venturi 11 is with the exit at or near the throat B and, at this point, the negative pressure has its maximum value. Thus, for example, at some given speed, the negative pressure at point B due to the outer tube is —8" of mercury. Now, retaining the same speed, if the inner venturi is moved forward so that its exit is at B', the negative pressure due to the outer tube is reduced to —4" instead of —8" of mercury. In the same manner, moving the inner tube 11 forward to B" would reduce the pressure due to the outer tube to about —2" of mercury and a similar reduction would take place until the zero point designated as A or the forward end of the venturi 10 is reached. At the point A the suction developed will be that of the inner tube alone.

Referring more particularly to Fig. 2 of the drawings, 13 is a base to which is mounted by standards 14 a double throat type Venturi tube consisting of an outer shell 15 having the converging section 16, diverging section 17 and throat 18, and a concentric small tube 19 having the converging section 20, diverging section 21 and throat 22.

The converging section 16 is provided with an outer lug 23, an inner lug 24 and a slot 25 over which is mounted an exterior housing 26 that has lever aperture 27. To movably mount the small tube 19 within the converging section 16 of shell 15, I pivotally secure to lug 24 one end of a supporting member 28 which has its other end forked and each arm 29 of the fork pivotally secured to the forward section 20 of tube 19. A lever 30 having its lower end forked and each arm 31 of the fork pivotally secured to section 21 passes through slot 25 and aperture 27 and is pivotally secured by pin 32 to the housing 26.

A vane 33 is attached by screws 34 to the upper end of lever 30. The movement of lever 30 is limited in forward direction when it abuts against the shell of tube 15 and the motion of the lever in the aft direction is restrained by a suitable spring 35 that has one end fastened to lug 23 and the other end that is threaded as at 36 passing through an aperture in lever 30 and adjustably secured by nut 37 screwed onto threads 36.

A flexible hose or tube 38 passes through shell 15 and is connected to a tube nipple 39 that establishes a passage from the throat 22 of small tube 19. The end of the tube 38 on the outside of

shell 15 is in turn hooked up or connected with a conveying tube 40 that connects the instrument to be operated with the venturi.

Thus my invention consists in mounting the inner tube 19 so that it may move forward relative to the outer shell 15 when the air speed exceeds a fixed, definite value regulated by the resisting force of the spring 35. In the practical operation of my improved device, the Venturi tube is suitably mounted on an aircraft by securing the base 13 to a wing or other part of the plane so that the air stream not only passes through the venturi but also strikes vane 33. When the air pressure against vane 33 is sufficient to overcome the resistance of spring 35, the force of the air striking the vane will move lever 30 aft around its pivot point or pin 32 which, in turn, causes tube 19, being pivotally mounted and attached to the lever, to move forward a proportionate amount. In this manner, the relative positions of the inner and outer Venturi tubes are shifted so that the pressure reduction at the throat 22 is controlled and maintained substantially constant.

Figs. 4 to 6 show a modification of my improved device wherein the inner tube is stationary and the outer tube is movably mounted so that it may move aft relative to the inner tube when the air speed exceeds a fixed, definite value regulated by the resisting force. In this construction, I provide a base 41 which has a bracket 42, integral lugs 43, forward stop members 44 and rear stop members 45. Pivotally secured to lugs 43 by means of pins 46 and cotter keys 47 are supporting arms 48 whose upper ends have an aperture for pivotally engaging lugs 49 on outer Venturi tube or shell 50 which consists of a converging section 51, throat portion 52 and diverging section 53.

To hold the shell 50 so that forward arms 48 bear against stops 44 and to restrain movement of the shell in the aft direction, I provide a suitable spring 54 that has one end secured to an offset portion 55 of a cross bar 56 that has its ends positioned in one of a series of apertures 57 in each of the rear arms 48. The other end of the spring 54 is secured to an eye bolt 58 that is threaded into a lug 59 extending up from base 41. The eye bolt 58 is adjustably secured to the lug by lock washer 60 and nut 61.

The bracket 42 extends through a slot 62 in the converging section 51 of tube 50 and mounted on this bracket inside tube 50 is a small or inner tube 63 that also has a converging section 64, throat portion 65 and diverging section 66. A tube or conduit 67 having an opening 68 in throat portion 65 passes through the bracket 42 and base 41 and can be suitably connected with the instrument to be operated by the venturi. In order to obtain high efficiency at low speeds, the slot 62 is covered by a shield 69 that is secured to the bracket 42, thus keeping the opening or slot 62 closed until the air pressure or resistance is sufficient to move the shell 50.

Thus, the invention in the modified form of my improved device resides in mounting the outside tube or shell 50 so that it may move aft relative to the inner tube 63 when the air speed exceeds a fixed definite value regulated by the resisting force of spring 54 which can be adjusted by means of eye bolt 58 and nut 61. In the practical operation of the modified form of my improved device, the venturi is mounted on the airplane so that the air stream passes through the venturi. In the normal position or when the outer shell 50 is completely restrained by spring 54, the rear edge of inner tube 63 is approximately in the throat portion 52 of shell 50. When the air pressure of the air stream passing through the venturi is sufficient to overcome the resistance of spring 54, the force of the air striking the walls of the converging section 51 will tend to move the shell 50 aft through the pivoted arms 48. In this manner the relative position of the outer shell and the inner tube are shifted so that the pressure reduction at the throat 65 is controlled and maintained substantially constant.

Figs. 7 to 11 disclose modified forms of movably mounting the outer shell of the venturi to the base. In Figs. 7 to 9, the shell 70 has four lugs 71, two on each side, and each pair of lugs supports a rod or shaft 72 which in turn movably passes through bearings 73 that are mounted in lugs 74 projecting from base 75. The rods 72 are secured to the lugs 71 by pins 76. The motion of shell 70 is restrained by springs 77 positioned around rods 72 between lugs 74 by means of cups 78 and an adjustable nut 79 screwed onto a threaded portion 80 of the rod 72. A shoulder 81 on the rod 72 acts as a stop when the shell is in the normal or rest position. The practical operation of this form is the same as set out for the modification shown in Figs. 4 to 6; that is, the outer shell is mounted so that it may move aft relative to the inner tube when the air speed exceeds a fixed definite value regulated by the resisting forces of springs 77 mounted on rods 72. The amount of resistance can be suitably adjusted by the nuts 79.

In Figs. 10 and 11, I show a shell 82 having two pairs of side lugs 83 to which are secured by bolts 84 the flanged rollers 85. The base 86 has sides or flanged portions 87 on which the rollers 85 are adapted to move, thus movably mounting the shell 82. In order to restrain the movement of the shell, I provide on the underside and preferably in the center, a pair of downwardly extending lugs 88 to which is secured by pins 89 a rod 90 that in turn movably passes through lugs 91 projecting up from the base 86. Positioned on rod 90 between the lugs 91 by means of cups 92 and an adjustable nut 93 is a spring 94 that restrains the motion of shell 82. In like manner, the practical operation of this modification is similar to the description of Figs. 3 to 9. The outer shell is mounted so that it may move aft guided by means of rollers 85 rotating on flanges 87 when the air speed exceeds a fixed definite value regulated by the resisting forces of the spring 94 adjustably mounted around the rod 90.

It will be understood that the above description and accompanying drawings comprehend only the general and preferred embodiment of my invention, and that various changes may be made therein within the scope of the appended claims, without sacrificing any of the advantages of this invention.

The herein described invention may be manufactured and used by or for the Government of the United States of America for governmental purposes, without the payment of any royalties thereon.

What I claim is:

1. In an aircraft suction venturi adapted to be mounted on an airplane in exposed relation to the surrounding air, a base member, an outer tube member, an inner tube member, means movably mounting said inner member coaxially in said outer member, and means for automatically moving said inner member forward with respect to the outer tube member when external air speed

against said last mentioned means exceeds a definite value.

2. In a venturi adapted for use with an aircraft and adapted to be mounted thereon for rapid movement relatively to a surrounding fluid, a base, an outer tube member secured to the base, a second tube member movably secured in said outer tube member, and means responsive to the relative velocity of the fluid surrounding the outer tube constructed and connected to move said second tube member with respect to the outer tube when the air speed of the aircraft exceeds a definite value.

3. In a suction venturi for use with an aircraft and adapted adapted to be mounted thereon in exposed relation to the surrounding air, a base, an outer tube member secured to the base, a second tube member movably and coaxially secured to said first tube member, a suction delivery tube secured to said second tube member, and means responsive to the relative velocity of the air surrounding the outer tube adapted to move said second tube member with respect to the first member when a definite value of the air speed of the aircraft is changed.

4. In an aircraft venturi adapted to be mounted on an airplane in exposed relation to the surrounding air, a base, an outer Venturi tube member secured to the base, an inner Venturi tube member movably and coaxially secured inside said outer member, means responsive to the relative velocity of the fluid surrounding the outer tube member adapted to move said inner tube member with respect to the outer tube member to maintain a substantially constant pressure in the throat of the inner tube and adjustable restraining means regulating the movement of said means adapted to move the inner tube member.

5. In a suction venturi for aircraft, a base, an outer Venturi tube secured to said base, an inner Venturi tube, means movably mounting said inner tube in the outer tube, said mounting means having a pivoted shaft extending through the outer tube, a vane secured to the extruding end of said shaft for moving the inner tube when air pressure is placed on the vane, and adjustable restraining means adapted to regulate the movement of said shaft and thereby regulate the movement of said inner tube with respect to said outer tube within definite values of air pressure against said vane.

6. In a venturi for an aircraft adapted to be mounted thereon in exposed relation to the air, a base, an inner and outer Venturi tube, means rigidly attaching said inner tube to the base member, means movably mounting said outer tube to the base member, means adapted to automatically regulate the movement of said movably mounting means when there is relative movement of the venturi with respect to the surrounding air whereby air resistance moves said outer tube with respect to said inner tube when the air speed of the aircraft exceeds a definite value thus maintaining a substantially constant suction in said inner venturi, and a suction delivery tube connected with said inner Venturi tube.

7. In a suction producing device for an aircraft and adapted to be mounted thereon in exposed relation to the surrounding air, a base, a small venturi having a delivery tube secured to said base, a larger venturi positioned around said small venturi, means slidably mounting said larger venturi to the base, restraining means for resisting sliding motion of the larger tube until the flow of the surrounding air exceeds a definite value at which point the larger venturi moves with respect to the smaller venturi, and adjusting means for regulating the initial resistance.

8. In a suction venturi for an aircraft and adapted to be mounted thereon in exposed relation to the surrounding air, a base, an outer Venturi tube having a diverging section, a converging section and throat portion, pivoted arms movably securing the outer tube to the base, a slot in said converging section, a bracket secured to the base and extending through the said slot, an inner venturi mounted on said bracket within the outer Venturi tube, adjustable means adapted to restrain the movement of said pivoted arms whereby said outer venturi moves with respect to said inner venturi when the air speed of the aircraft exceeds a definite amount, and a suction delivery conduit connected with said inner venturi.

9. In a suction venturi for use in an aircraft and adapted to be mounted thereon in exposed relation to the surrounding air, a base, an outer Venturi tube having a converging section, a diverging section and throat portion, pivoted arms movably securing the outer tube to the base, a slot in said converging section, a bracket secured to the base and extending through the slot, an inner Venturi tube mounted on said bracket within the outer Venturi tube, a suction tube connected to said inner Venturi tube, means adapted to restrain the movement of two or more of said arms whereby said outer venturi moves with respect to said inner tube by an amount depending on the excess of air speed of the aircraft over a definite value set by said restraining means, and means adapted to adjust said restraining means to change the definite value of resistance set thereby.

10. In a suction venturi for an aircraft and adapted to be mounted thereon in exposed relation to the surrounding air, a base, an outer Venturi tube having a diverging section, a converging section and throat portion, pivoted arms movably securing the outer tube to the base, a slot in said converging section, a bracket secured to the base and extending through said slot, an inner venturi mounted on said bracket within the outer Venturi tube, adjustable means adapted to restrain the movement of said pivoted arms whereby said outer venturi moves with respect to said inner Venturi when the air speed of the aircraft exceeds a definite amount, a suction delivery conduit connected with said inner venturi, and means secured to said bracket adapted to cover the slot in the outer venturi.

11. In a venturi for use with an aircraft and adapted to be mounted thereon in exposed relation to the surrounding air, a base, an outer Venturi tube having a converging section, a diverging section and a throat portion, a slot in said converging section, a bracket secured to the base and extending through said slot, an inner Venturi tube mounted on said bracket within the outer Venturi tube, a suction tube connected to said inner Venturi tube, and means for slidably mounting said outer venturi to the base whereby the outer tube moves with respect to the inner tube when the air speed exceeds a definite value, said latter means comprising lugs extending from the outer tube, a shaft supported by said lugs, base lugs having bearings for movably mounting said shaft and means for restraining the movement of said shaft within predetermined values of air speed of the aircraft.

12. In a venturi for use with an aircraft and adapted to be mounted thereon in exposed rela-

tion to the surrounding air, a base having flanged side members, an outer Venturi tube having a converging section, a throat portion, and diverging section, a slot in said converging section, a bracket secured to the base and extending through said slot, an inner Venturi tube mounted on said bracket within the outer Venturi tube, a suction tube connected to the inner Venturi tube, means for movably mounting said outer tube under the influence of air resistance, said means consisting of lugs secured to the underside of the tube and rollers adapted to rotate on said flanged sides of the base, secured to said lugs; and adjustable restraining means adapted to control the movement of said outer tube within predetermined values of air speed of the aircraft.

13. In a venturi, an outer Venturi tube, an inner Venturi tube, a suction tube connected to said inner Venturi tube, means mounting said tubes for relative movement with respect to each other and a surrounding fluid, and means adapted to be automatically actuated by the fluid resistance surrounding the outer tube, thereby regulating the relative movement of said tubes with respect to each other to maintain a substantially constant suction in the inner venturi at all fluid velocities of the surrounding fluid.

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