United States Patent [19]

Donnelly et al.

[11] **3,766,844**

[45] **Oct. 23, 1973**

[54] **PROTECTIVE SYSTEM FOR CONTAMINATED ATMOSPHERE**

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[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

[22] Filed: **Dec. 21, 1971**

[21] Appl. No.: **210,344**

[52] **U.S. Cl.** .... **98/33 R,** 98/1.5, 49/68, 52/66, 135/1

[51] **Int. Cl.** **F24f 13/00**

[58] **Field of Search** .... 98/1.5, 33 R, 39, 98/40, 41, DIG. 7; 128/204; 135/1, 4; 52/66, 71; 49/68

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Primary Examiner—Meyer Perlin
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[57] **ABSTRACT**

A system and method to provide protective shelter in contaminated atmosphere areas utilizing a protective shelter, a portable protective entrance, gas-particulate filter unit and associated components, pressure sensing network and associated components and controls, sliding-plate airflow valves, and a power distribution unit.

13 Claims, 62 Drawing Figures

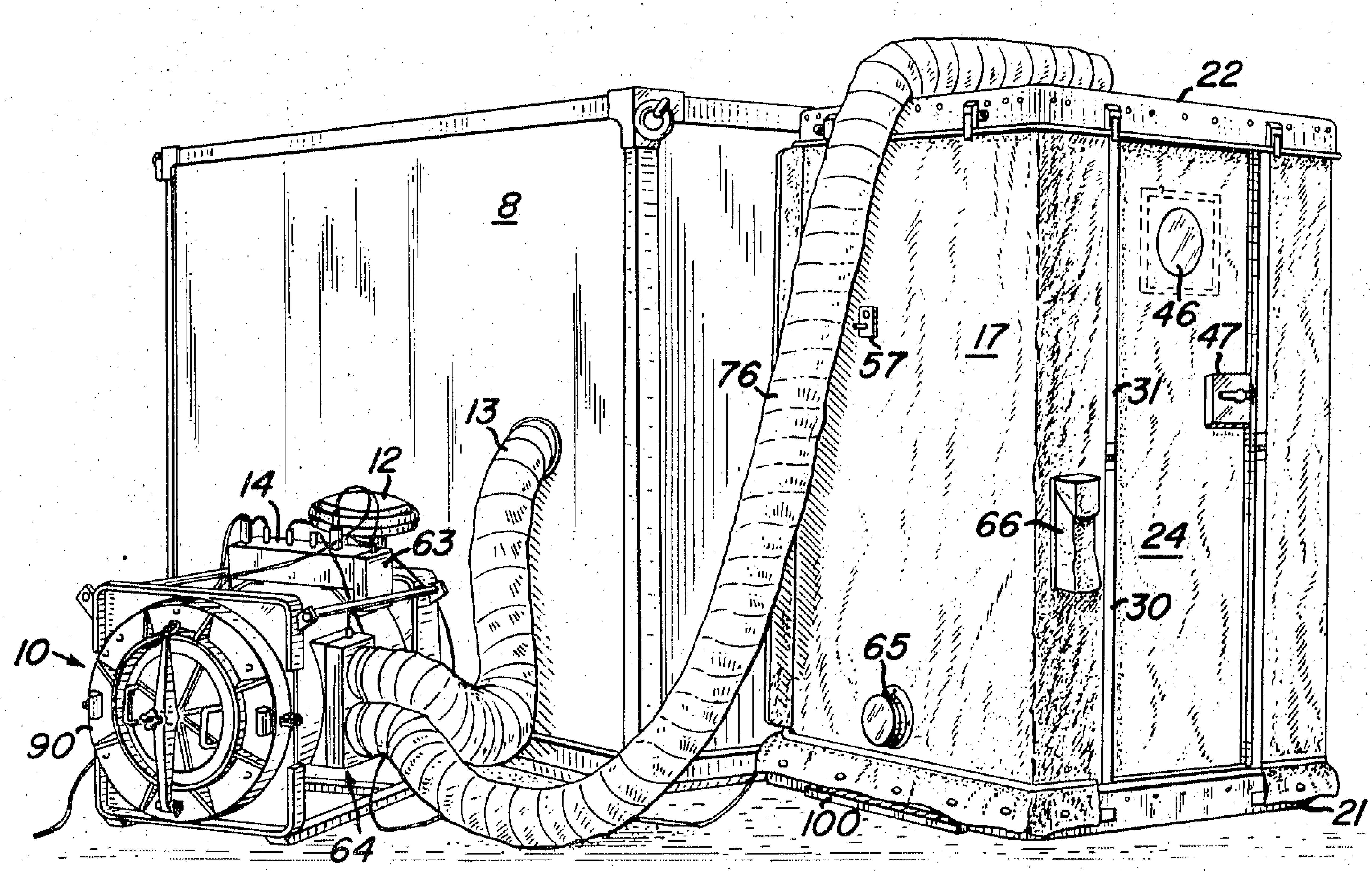


Fig. 1

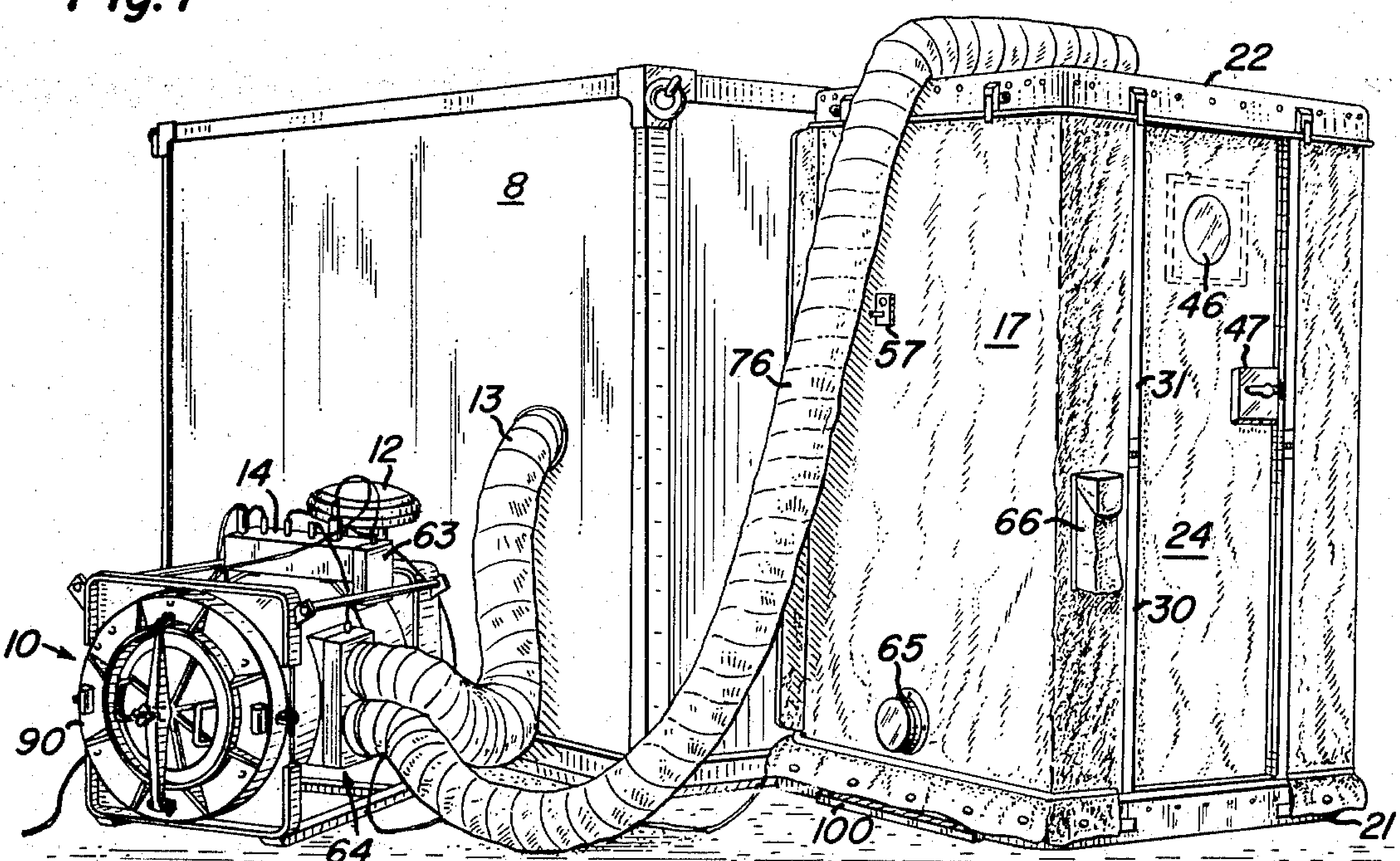


Fig. 2

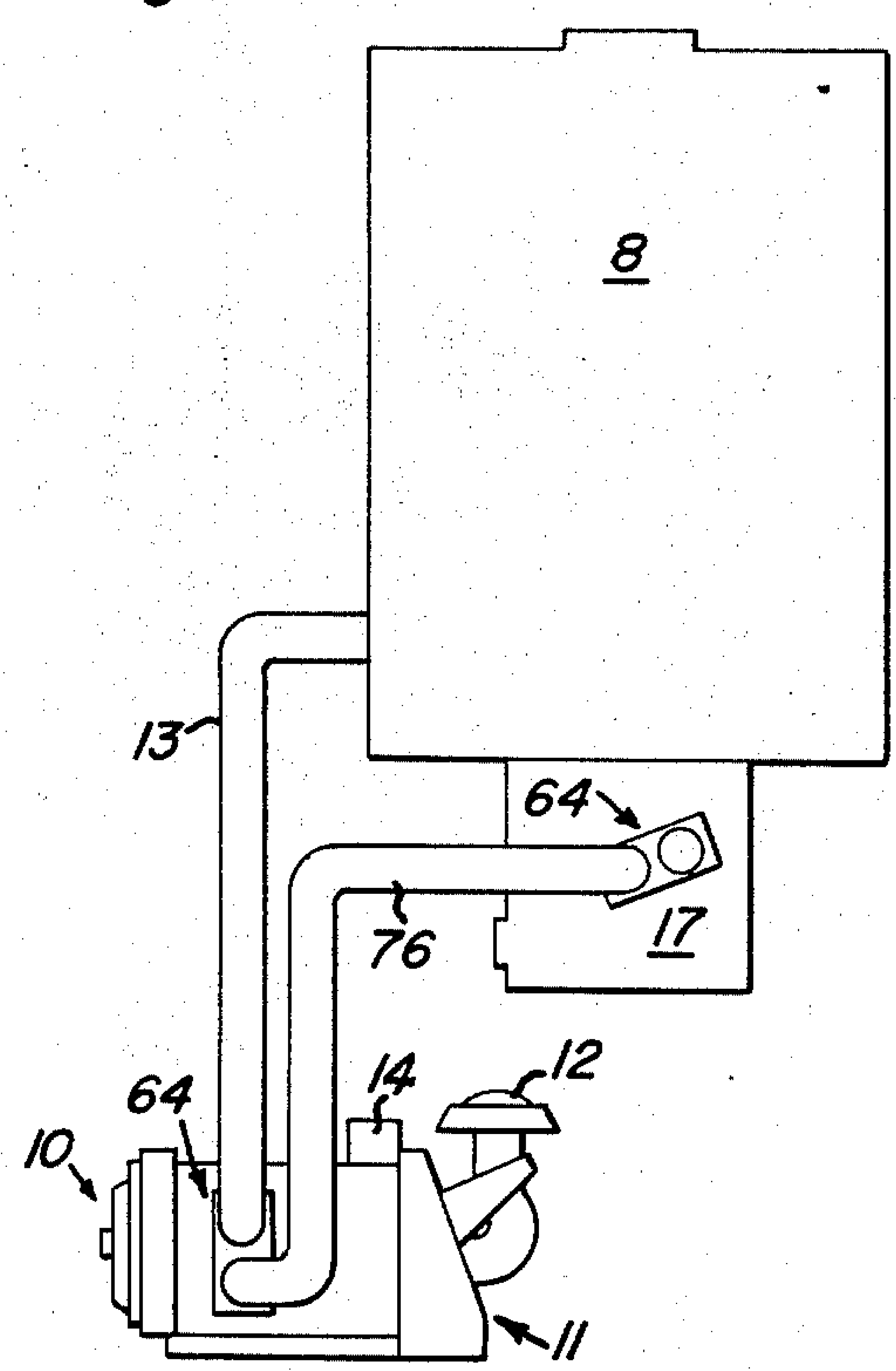
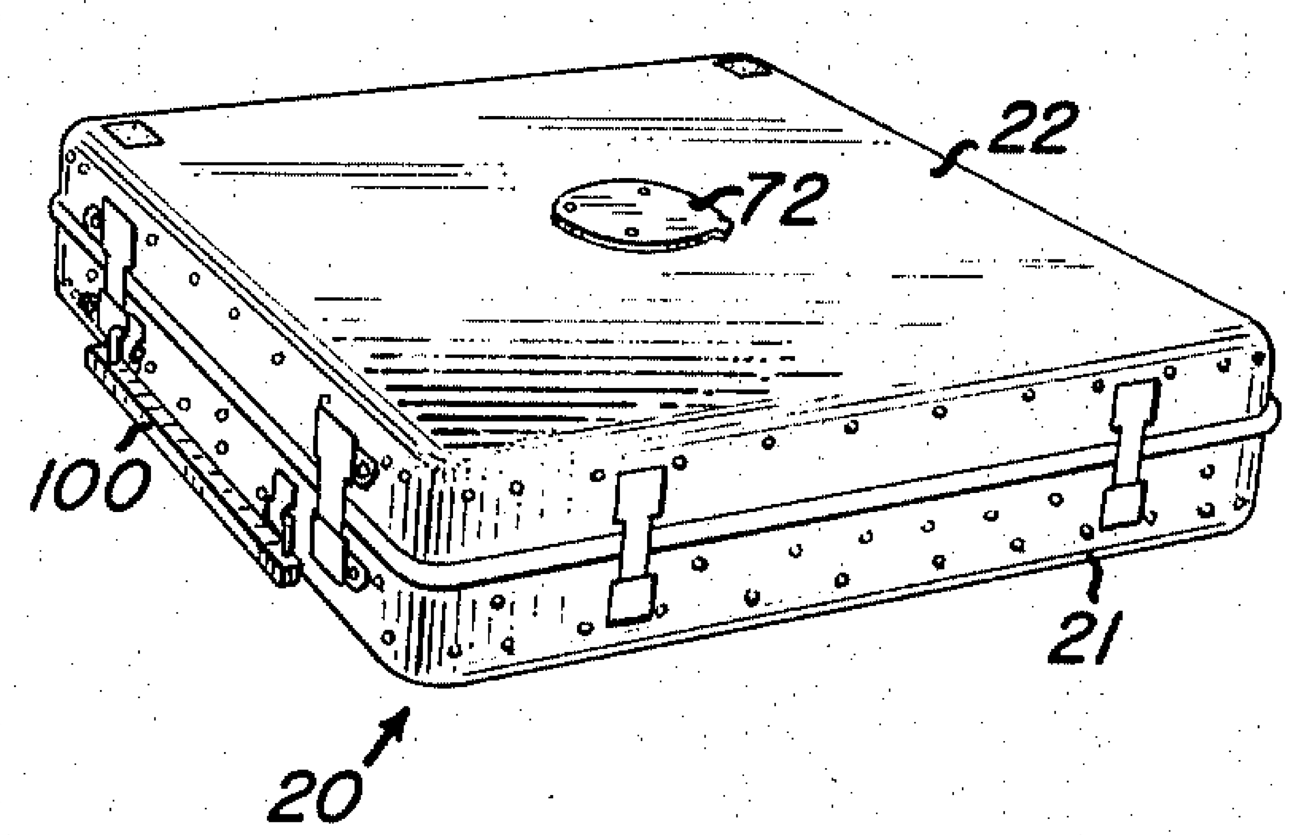


Fig. 3



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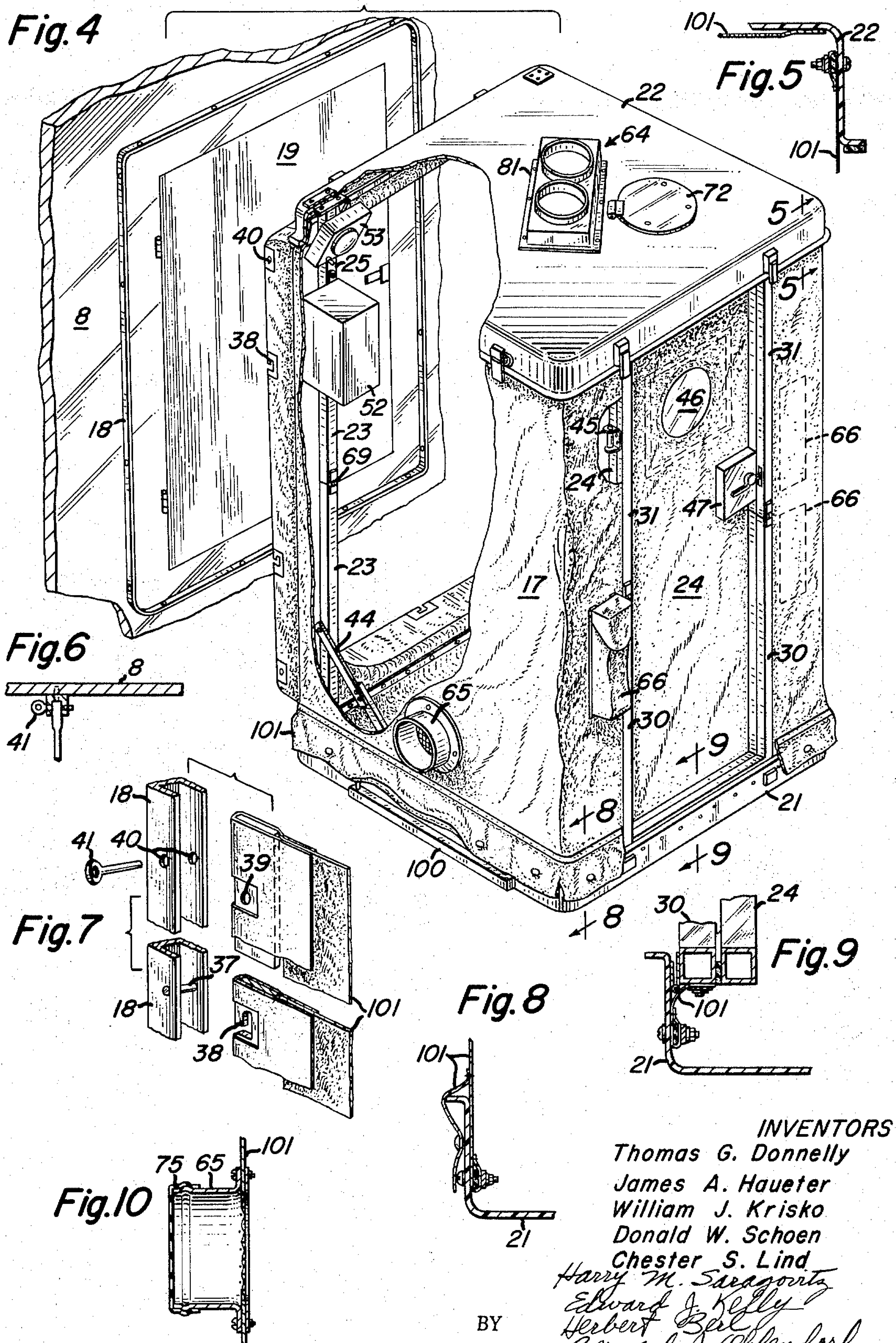

Fig.4

Fig.5

Fig.6

Fig.7

Fig.8

Fig.9

Fig.10

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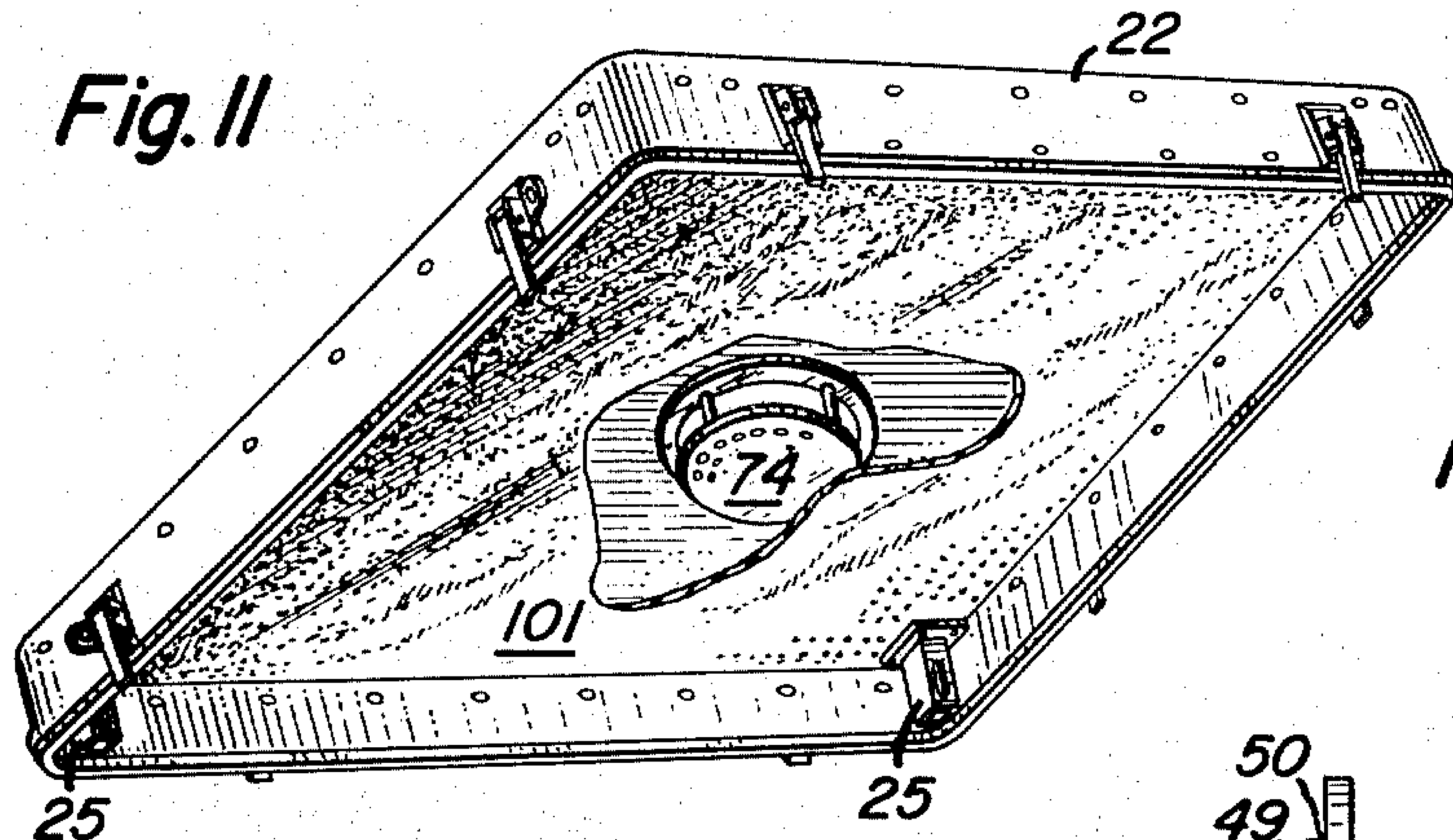
Fig. 11



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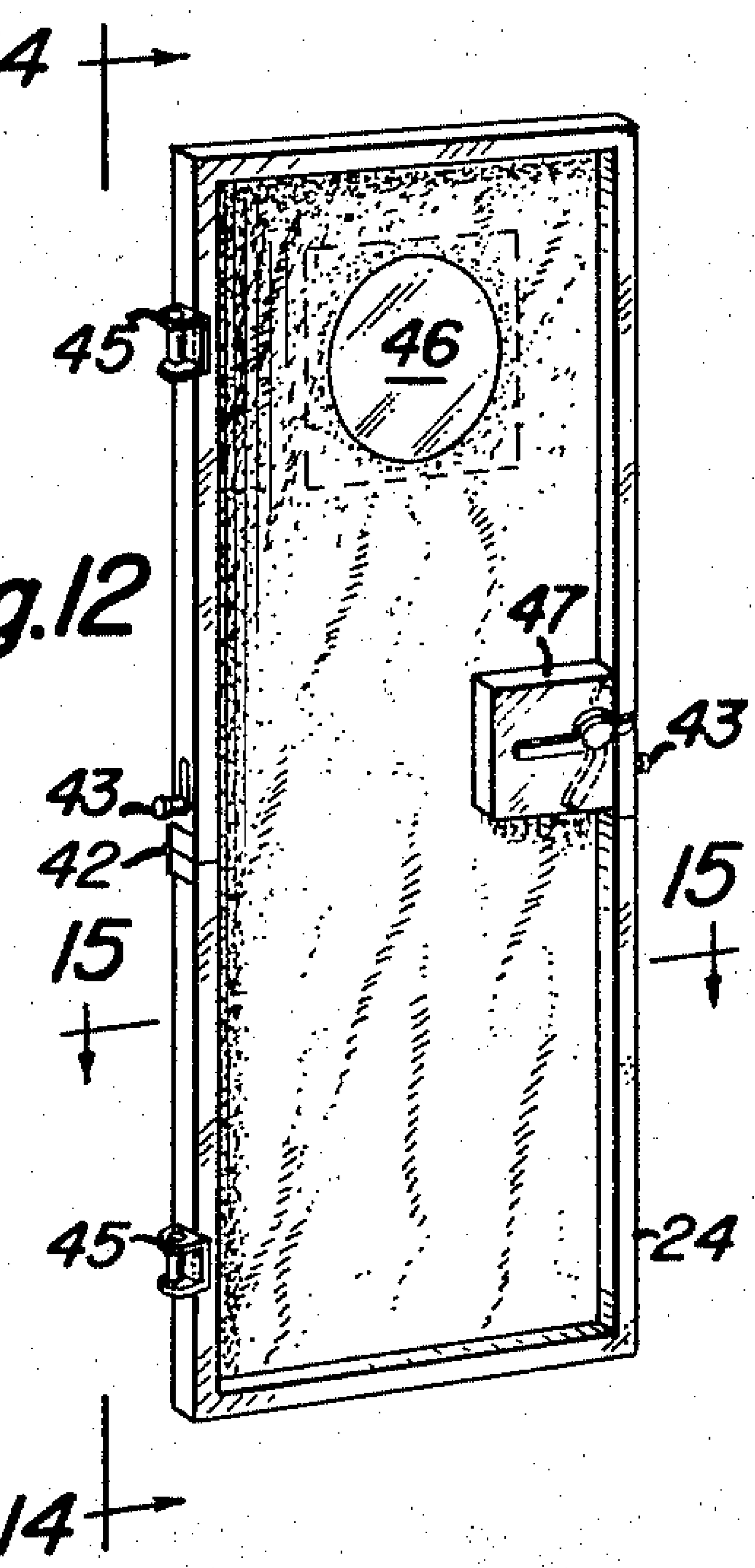

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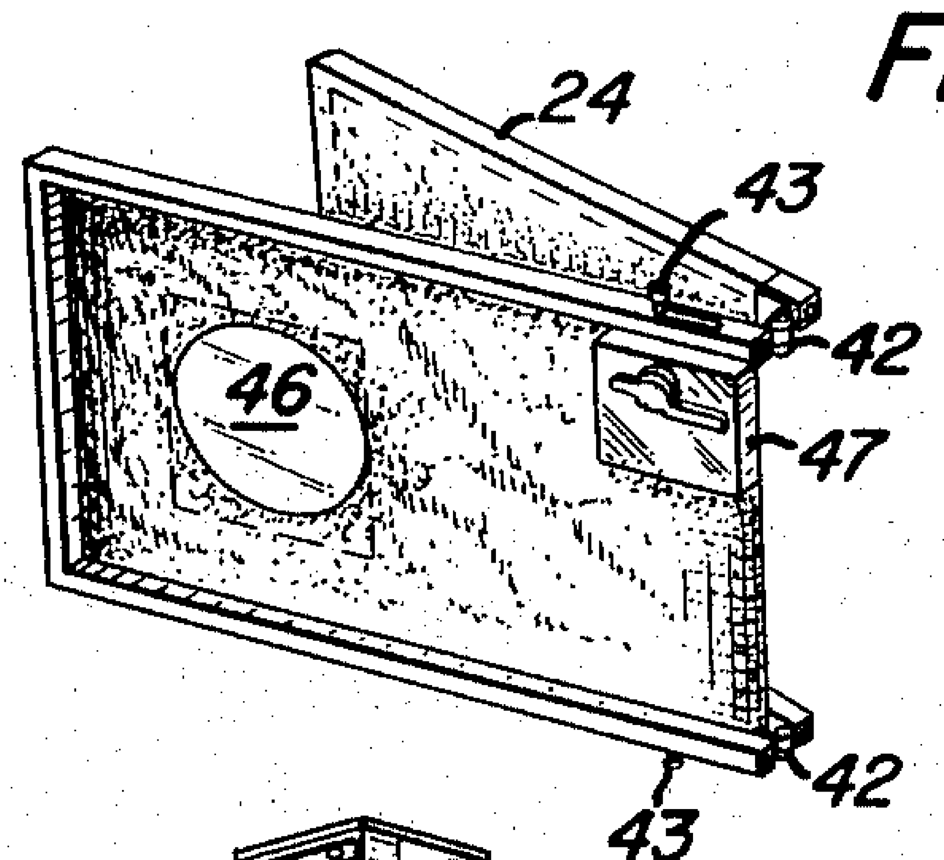

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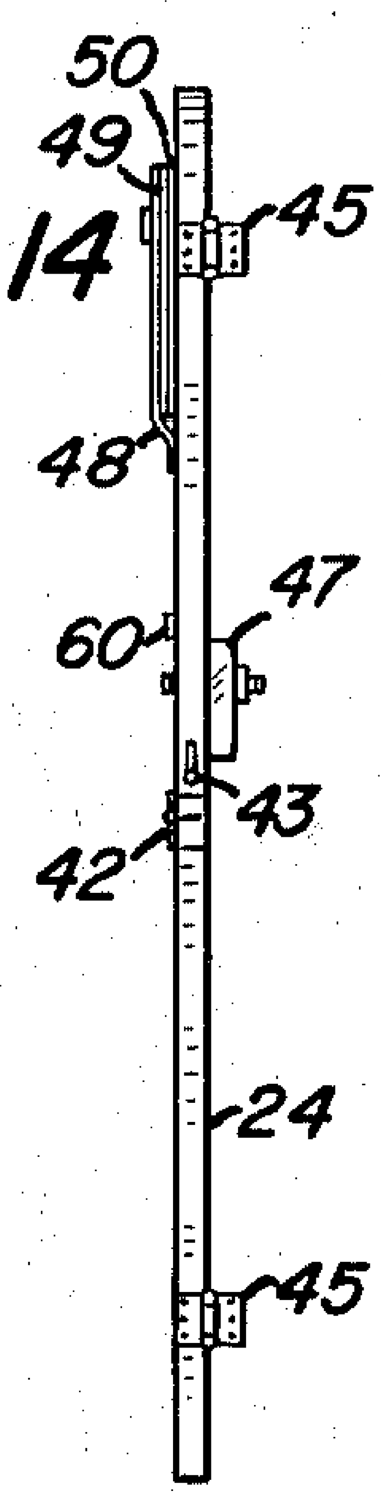

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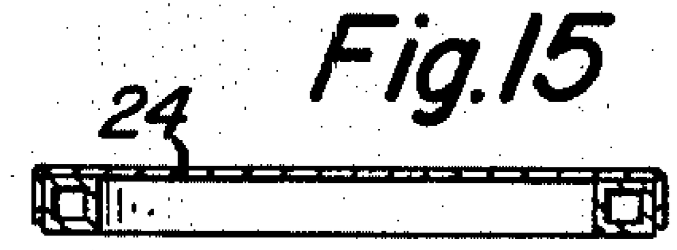


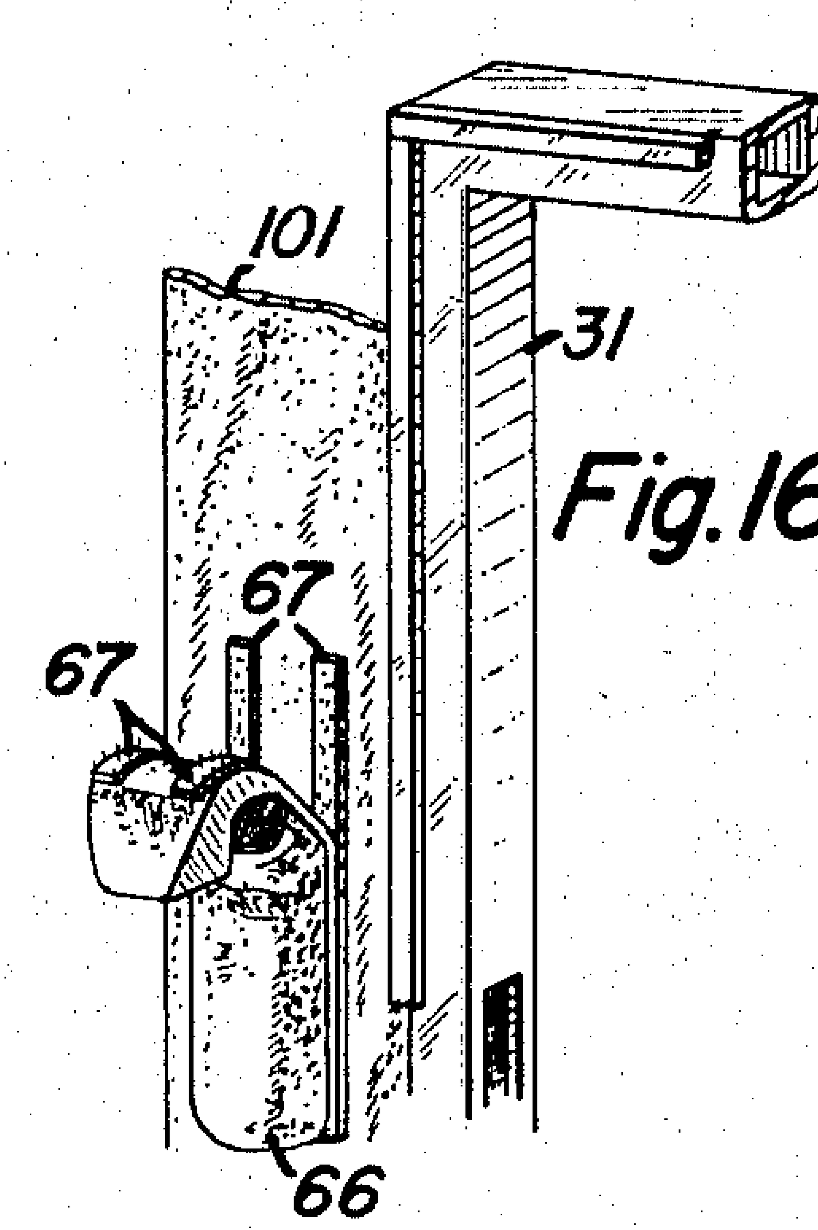
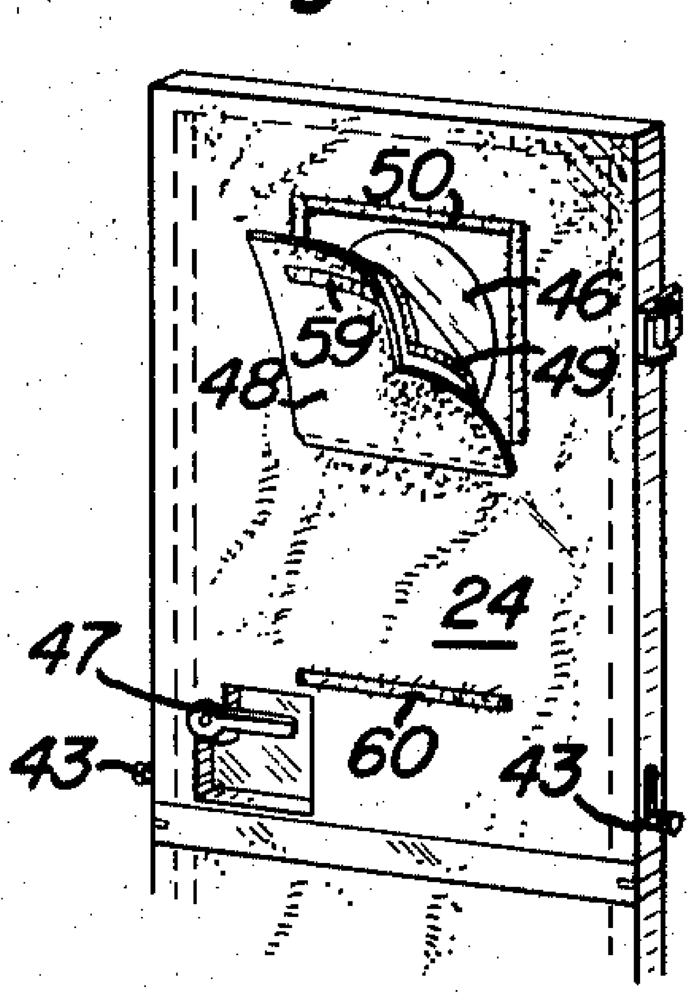


Fig. 16

Fig. 17



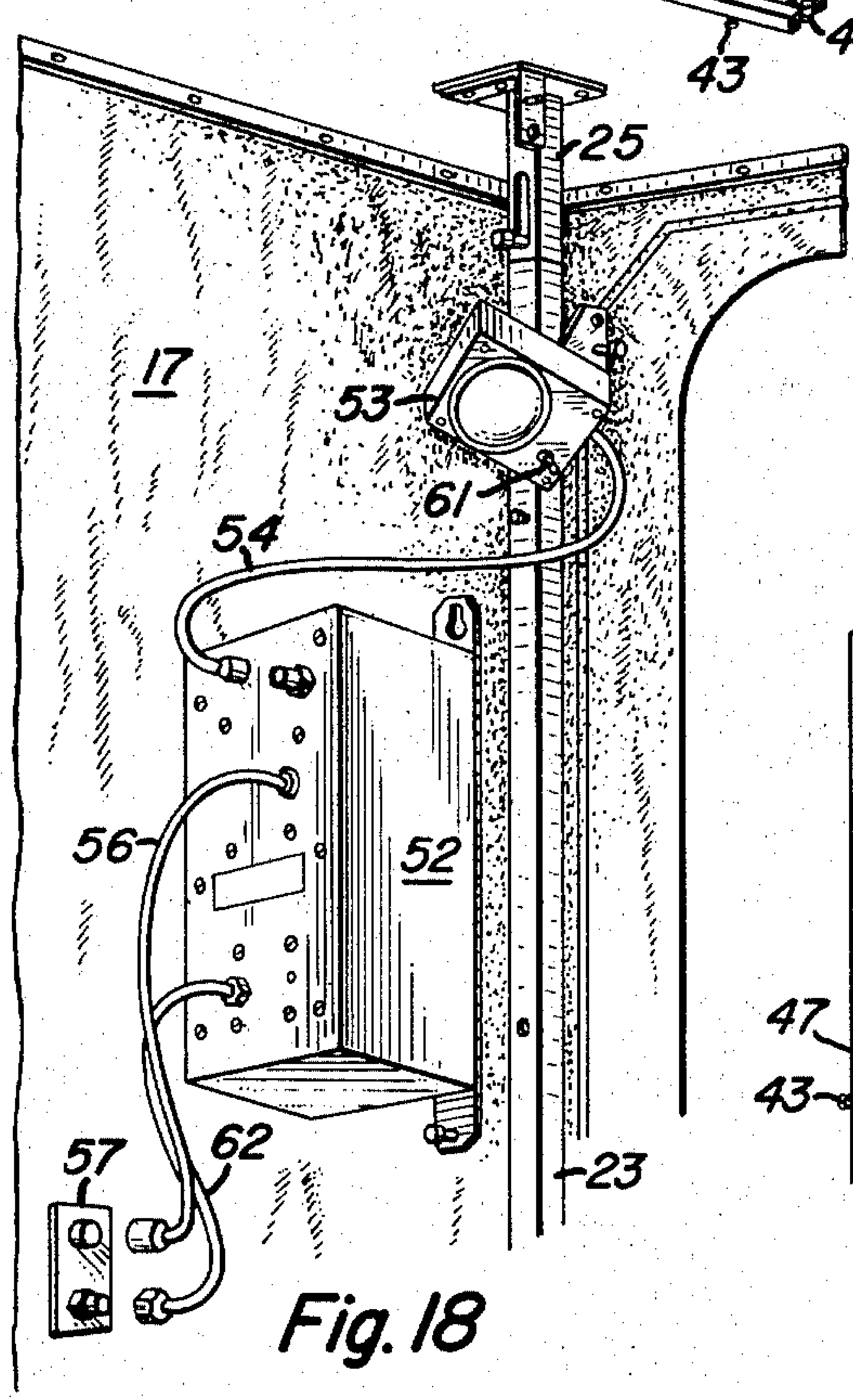


Fig. 18

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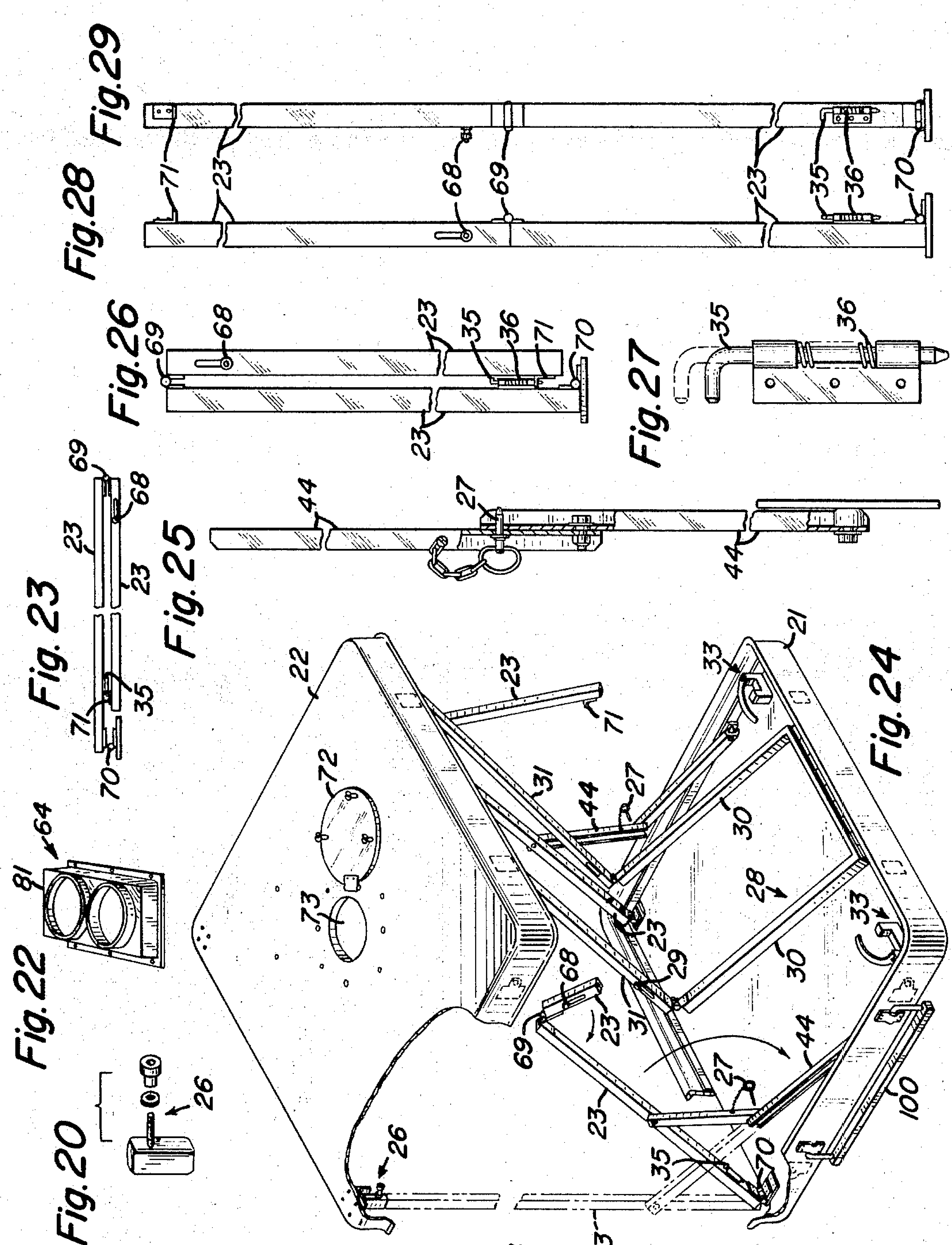

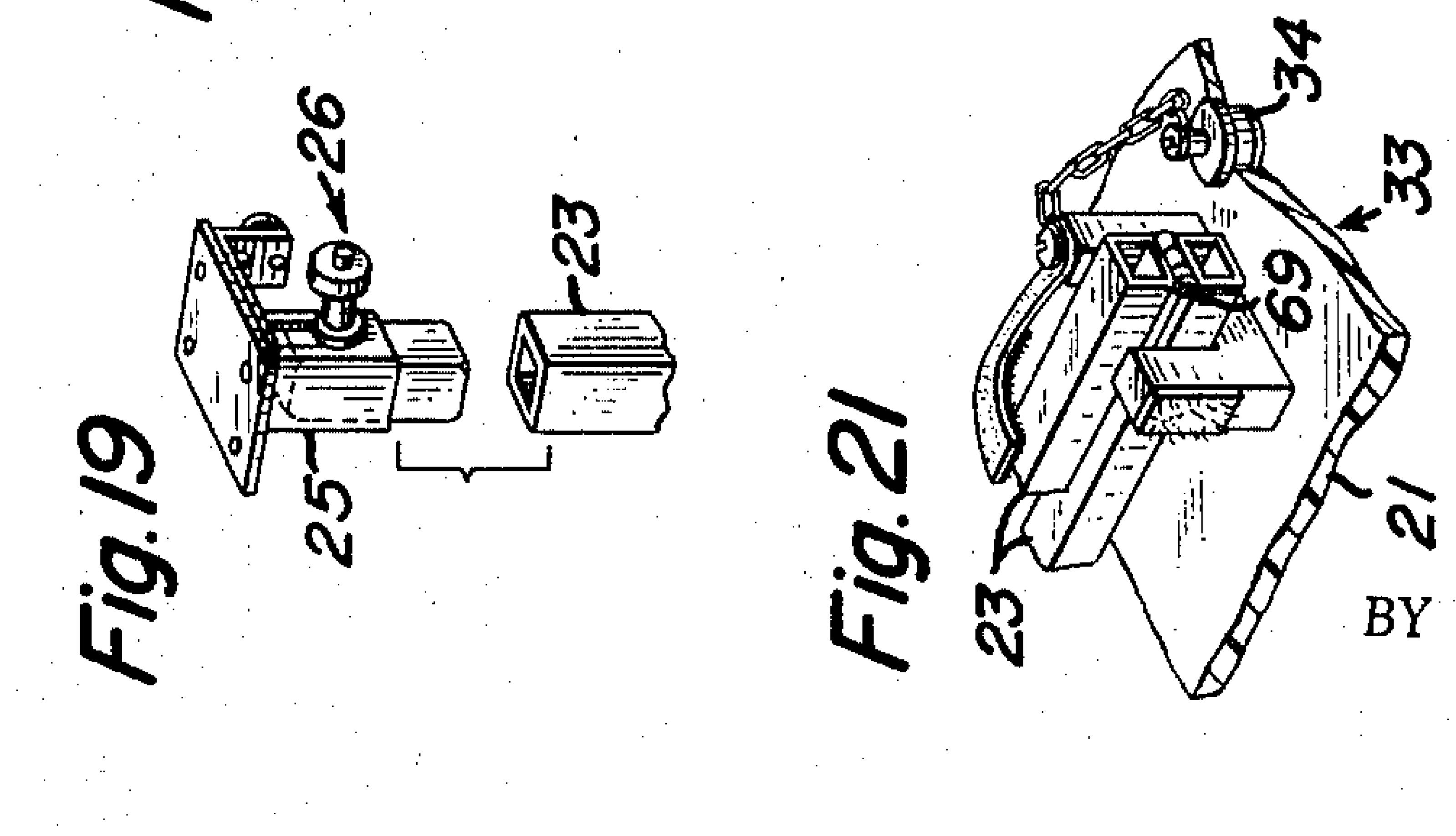

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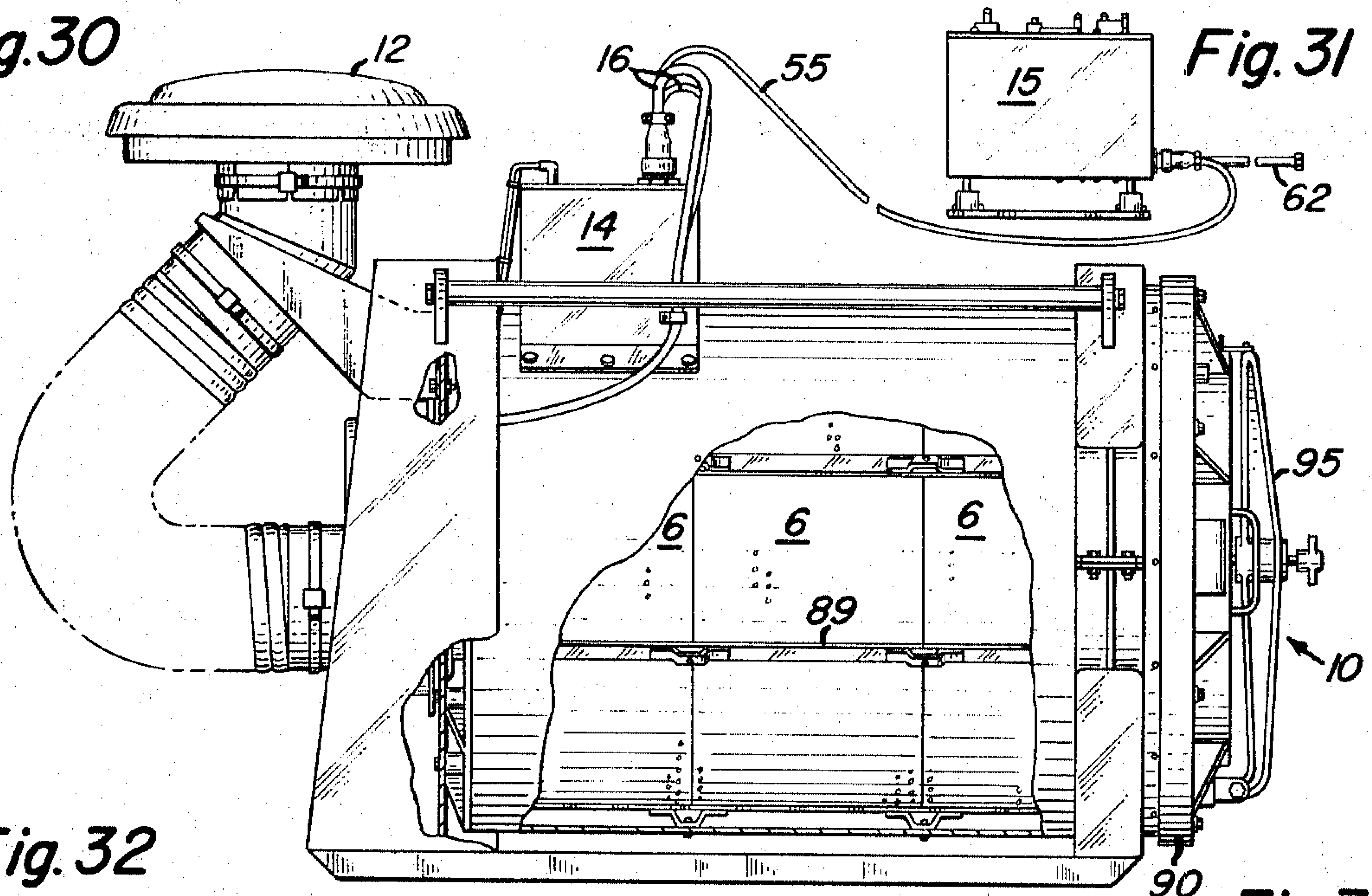
Fig.30

Fig.31



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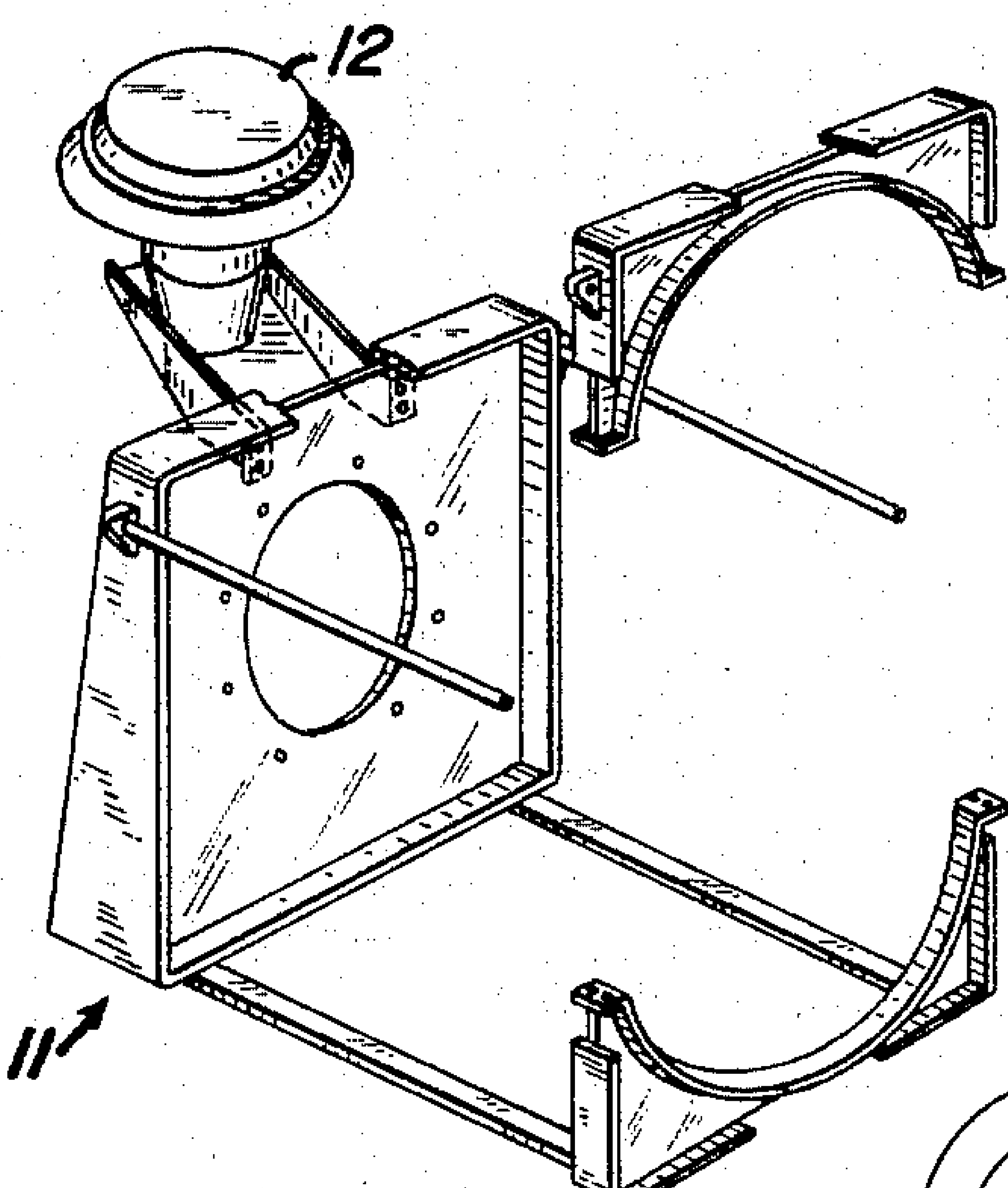

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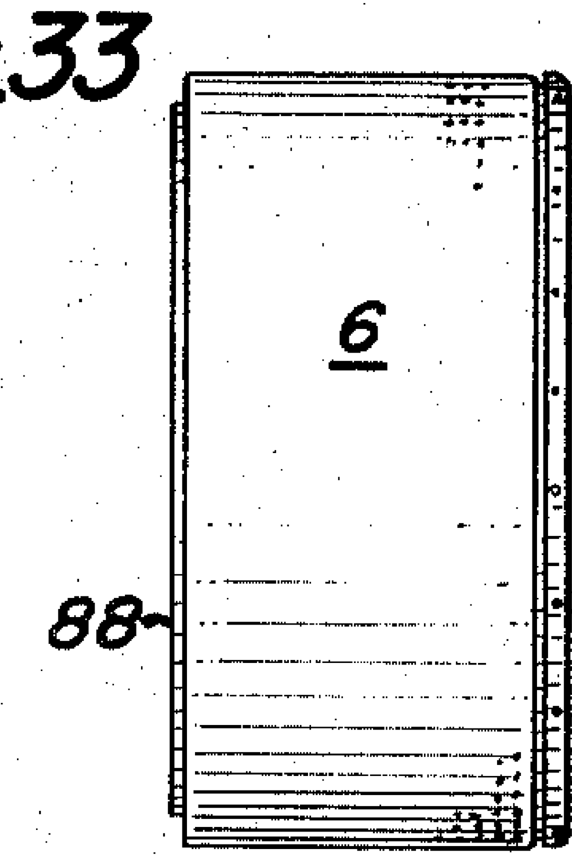

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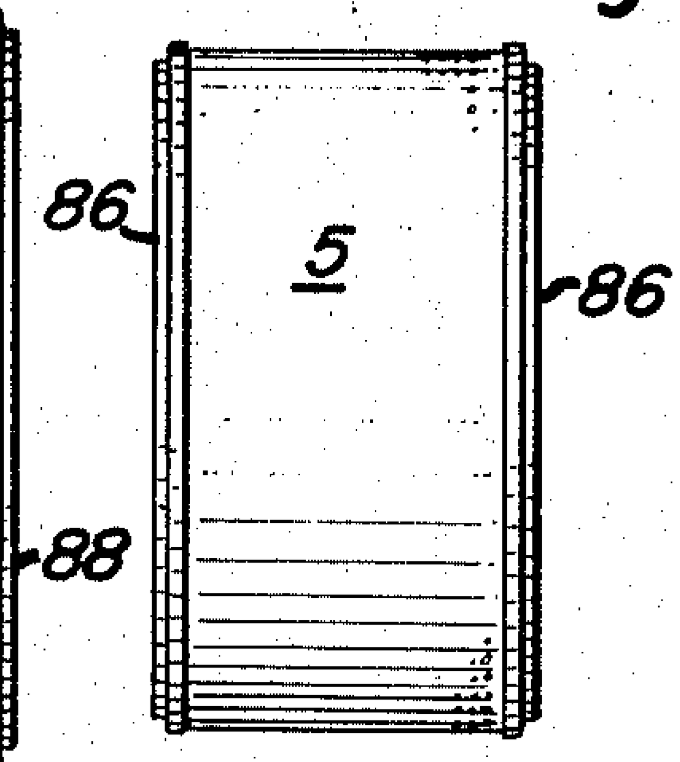

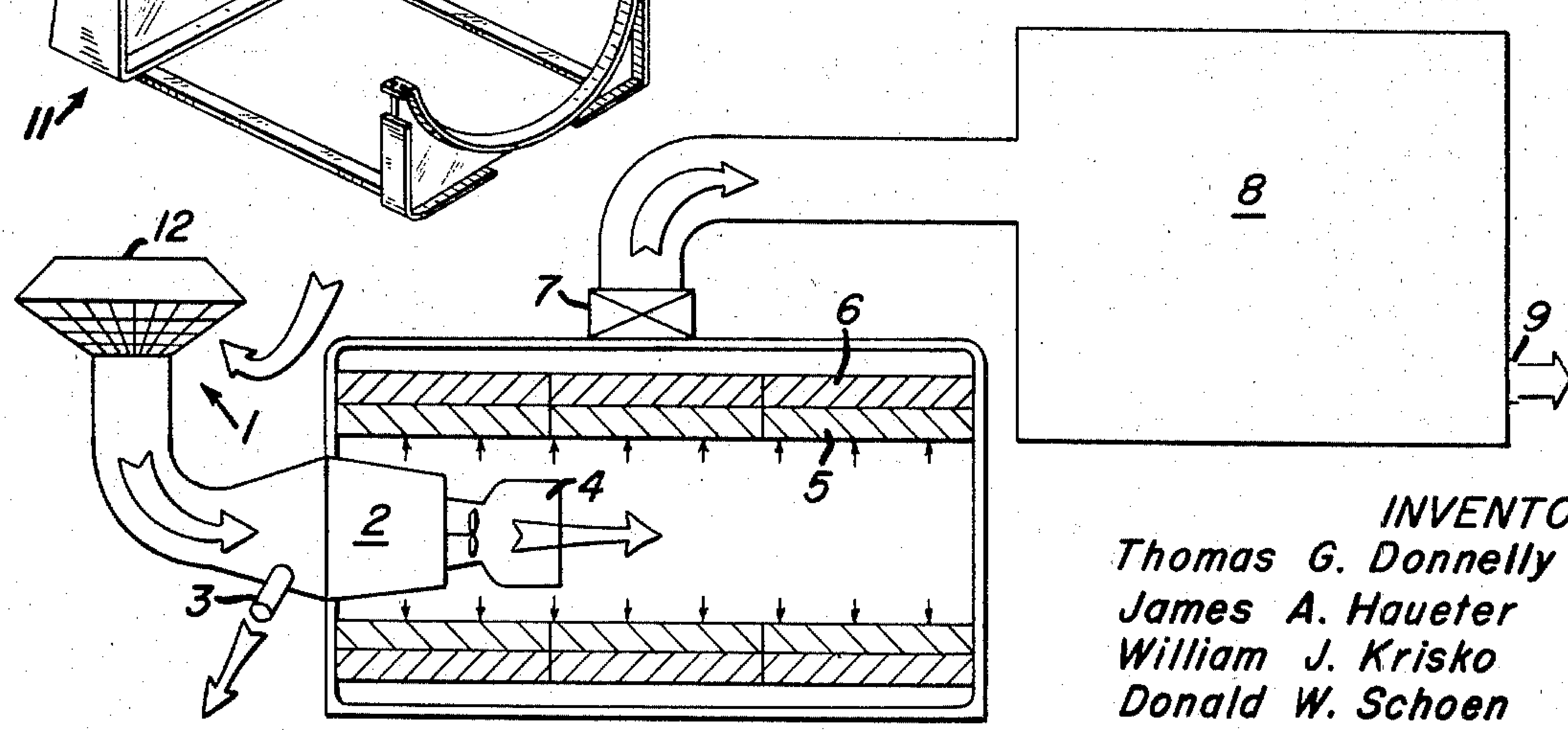

Fig.35

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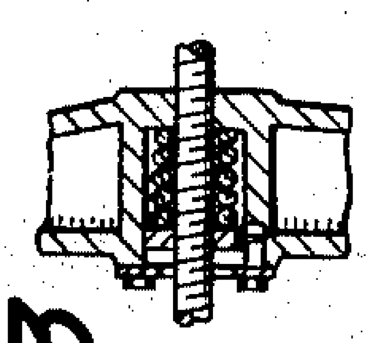

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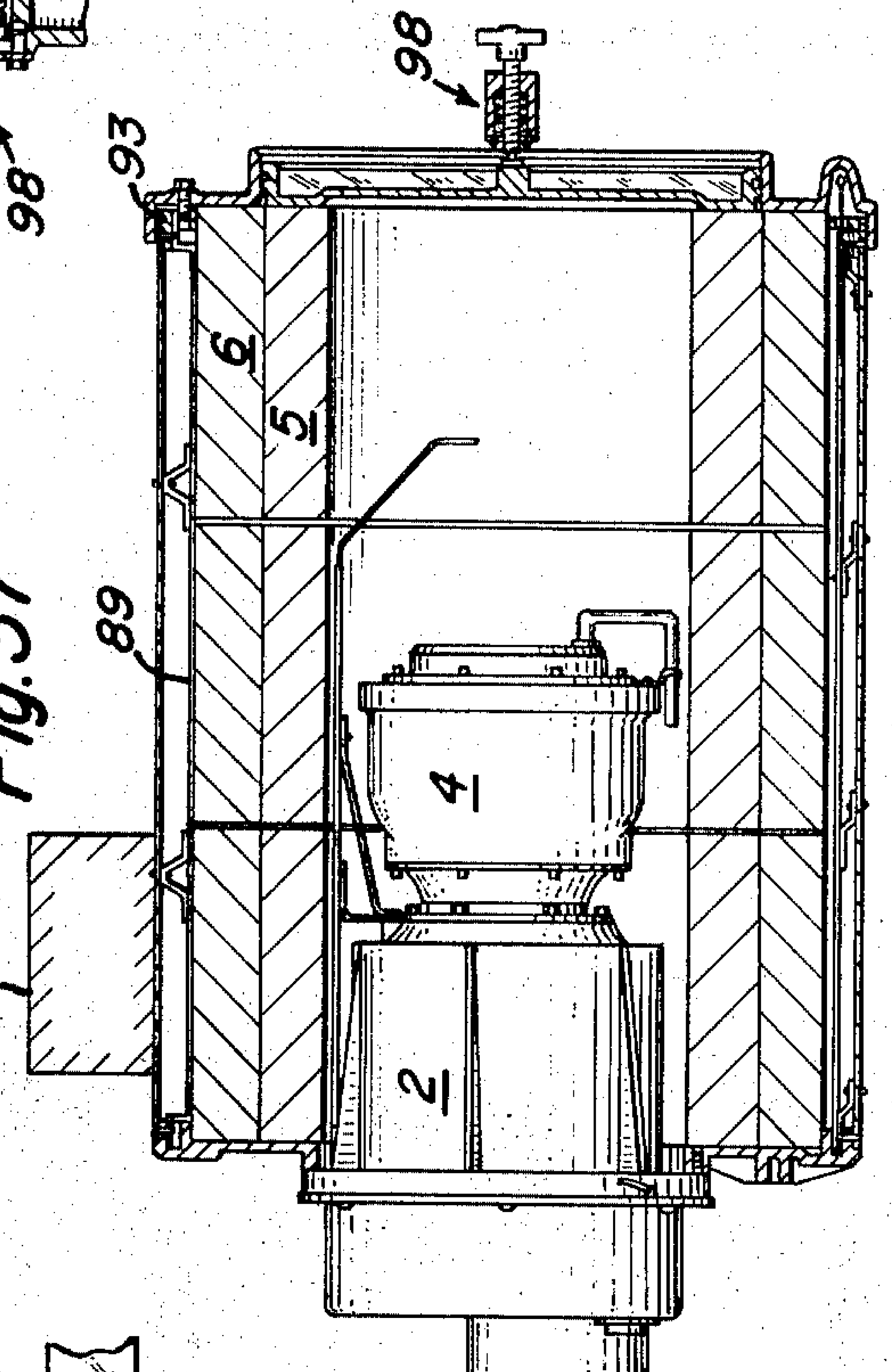

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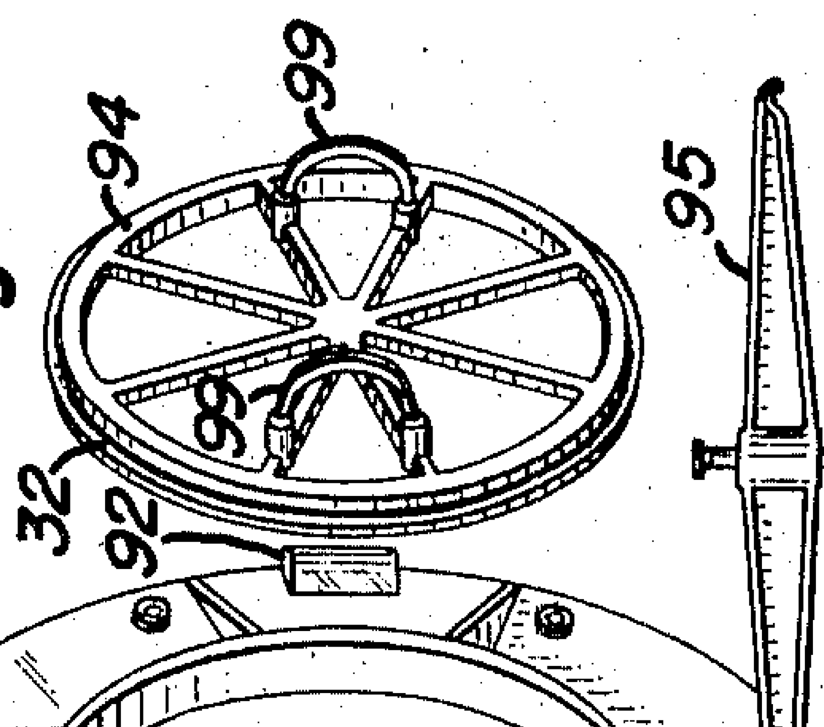

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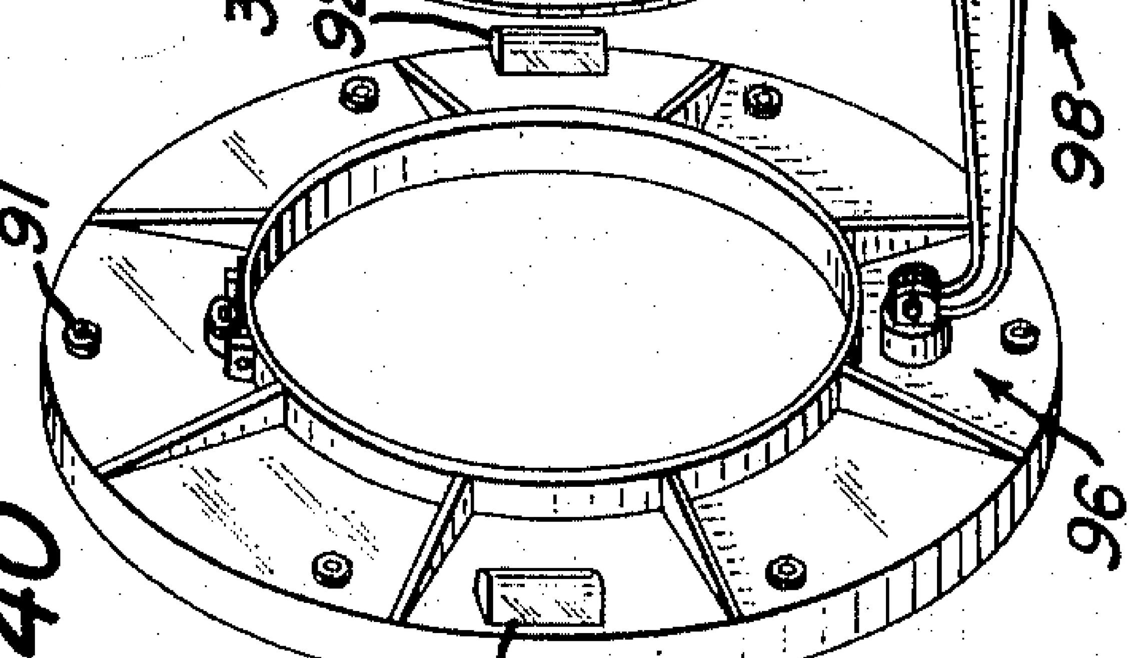

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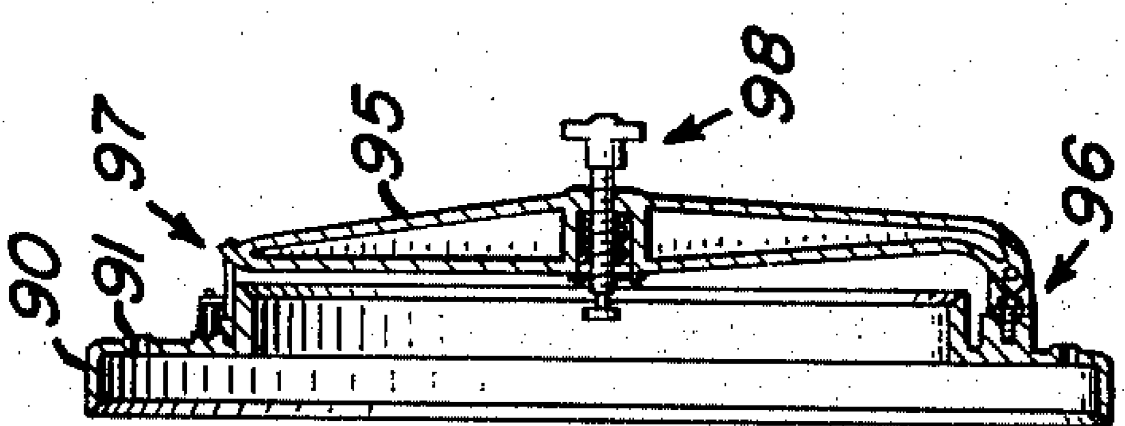

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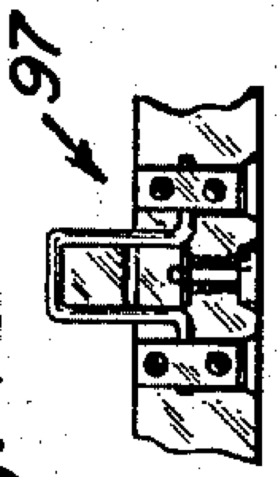

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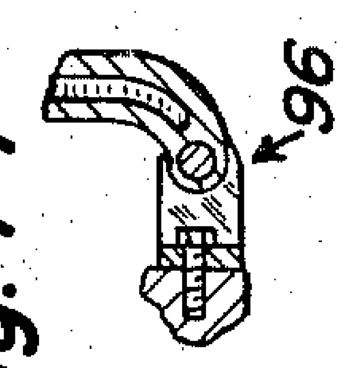

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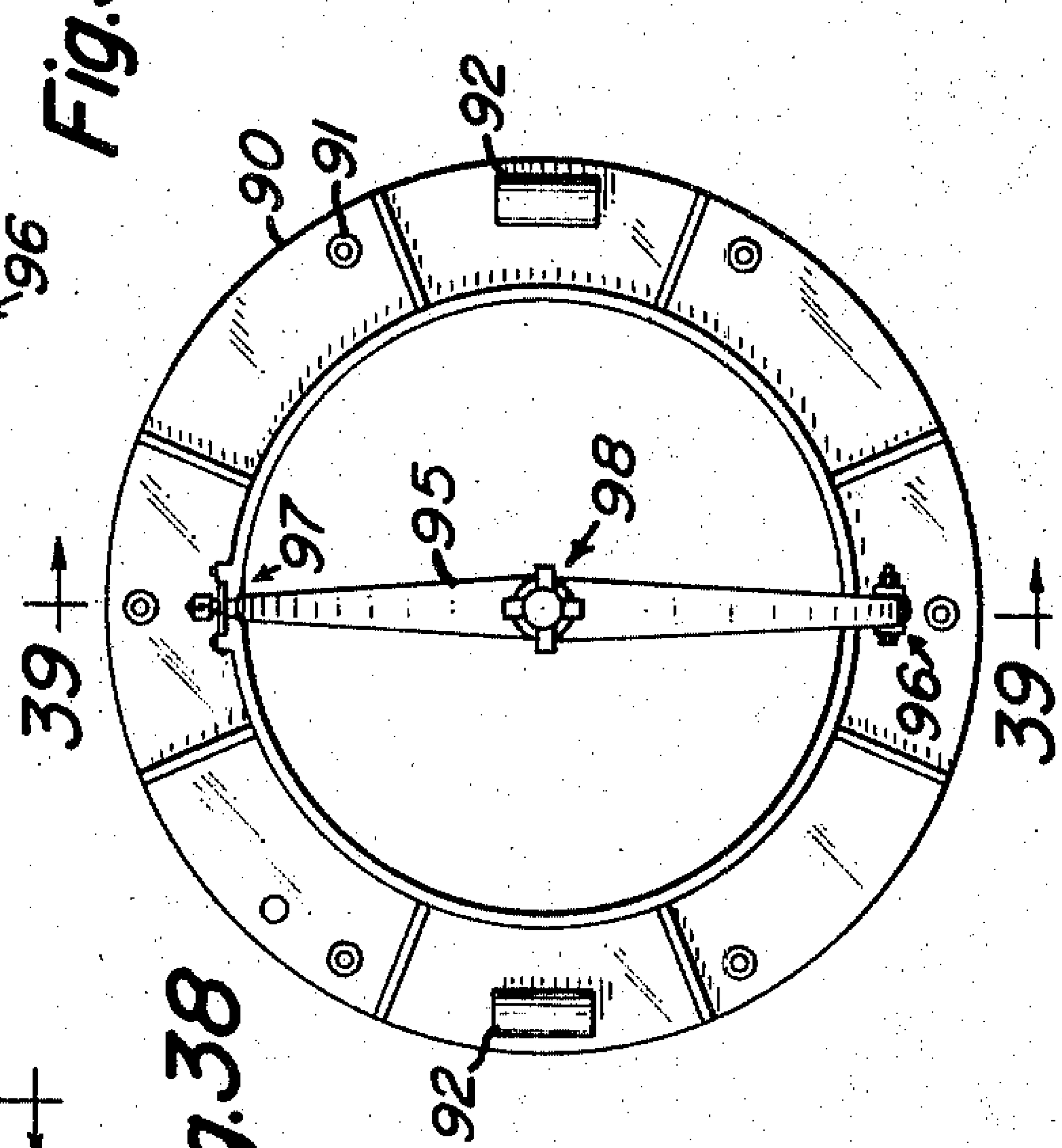

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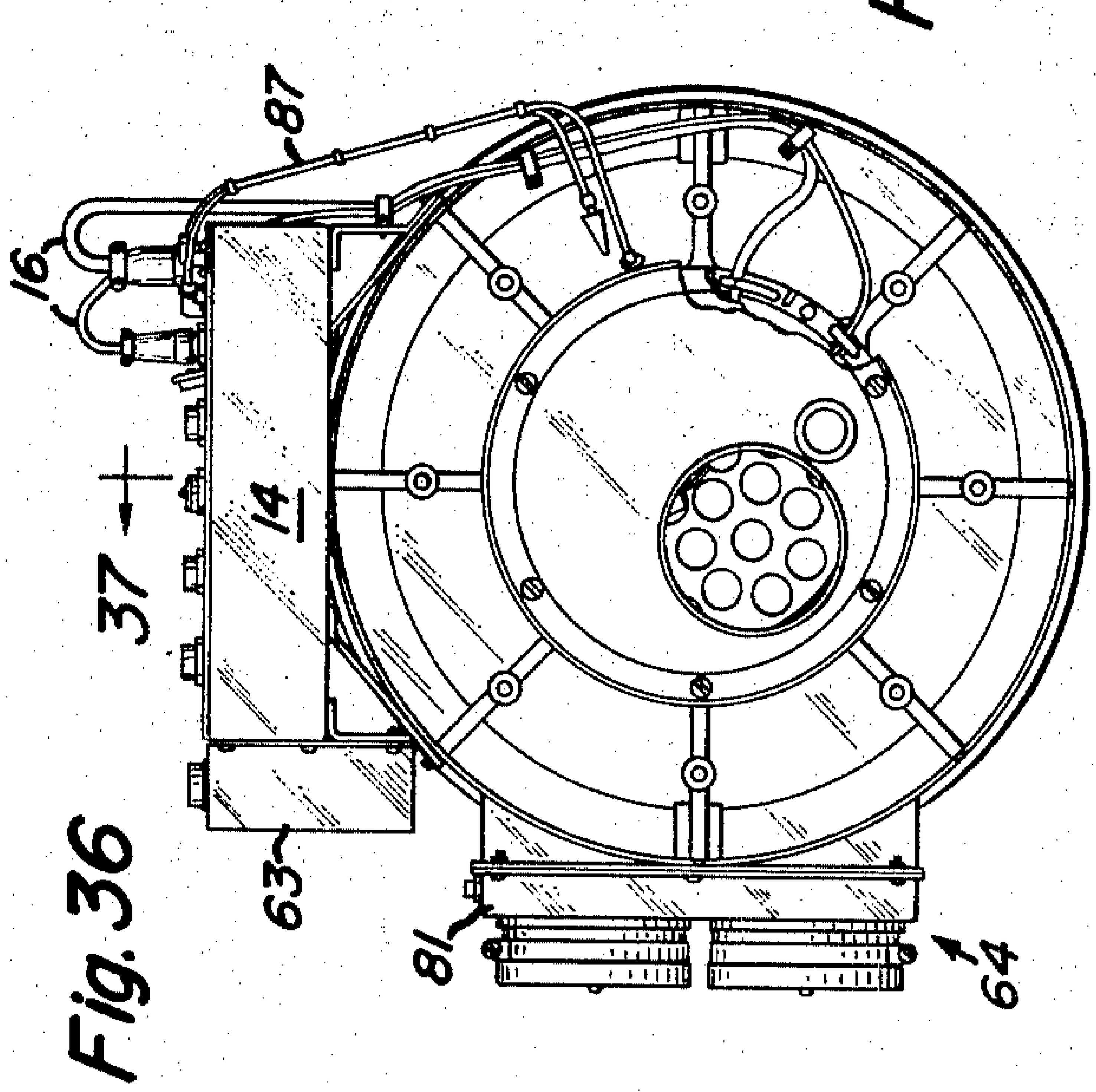

Fig.36

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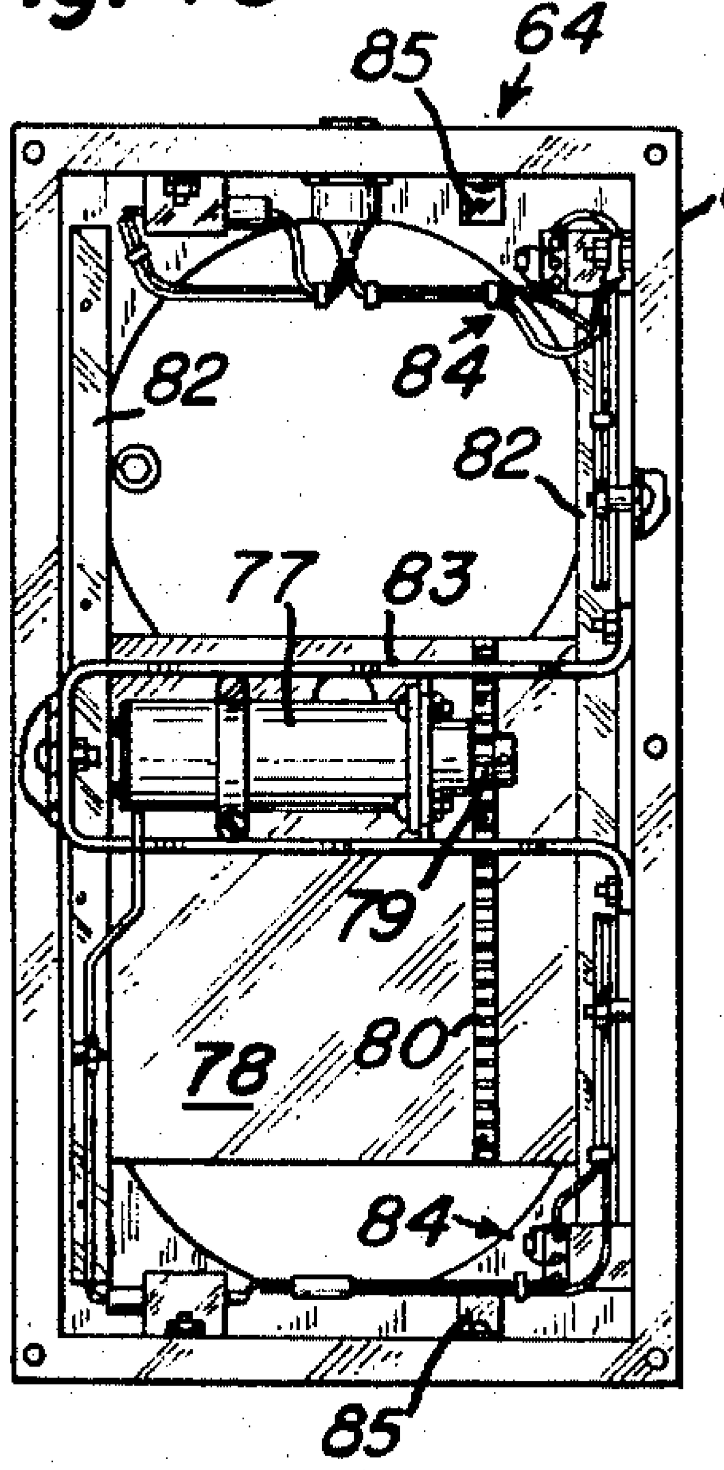
Fig. 45



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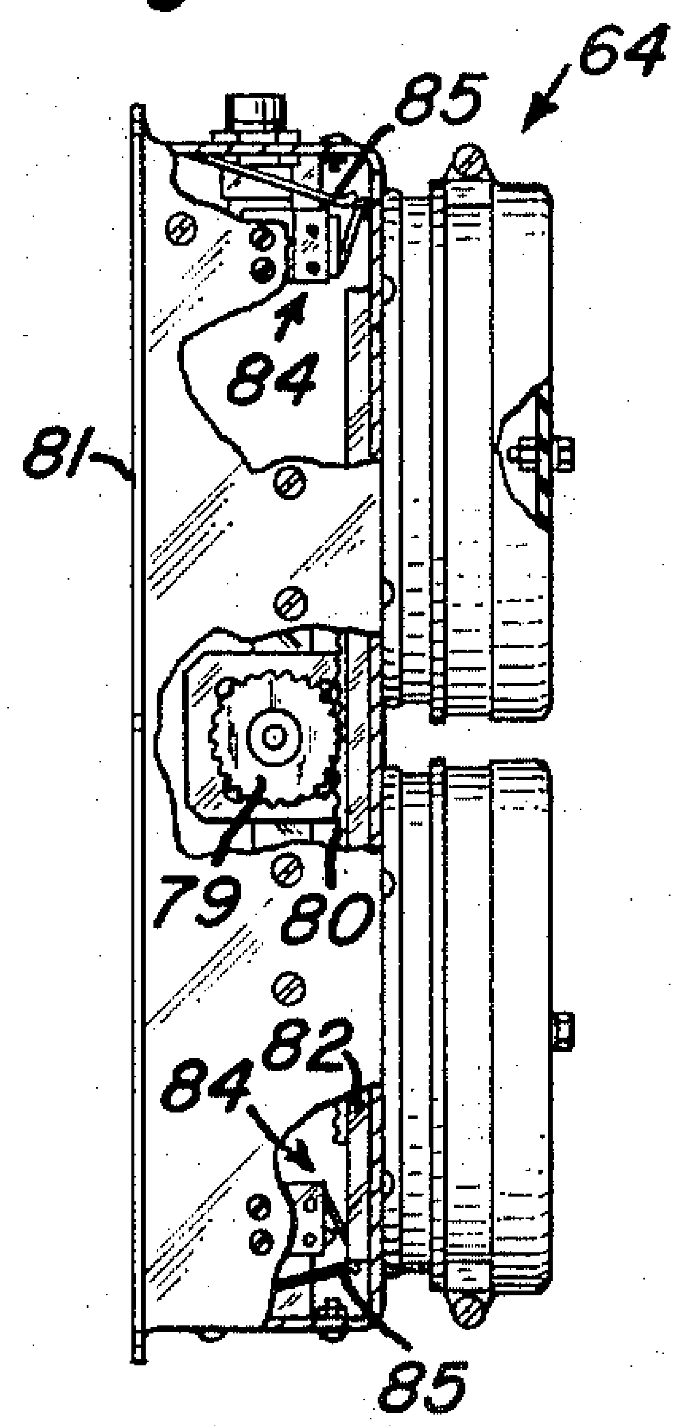

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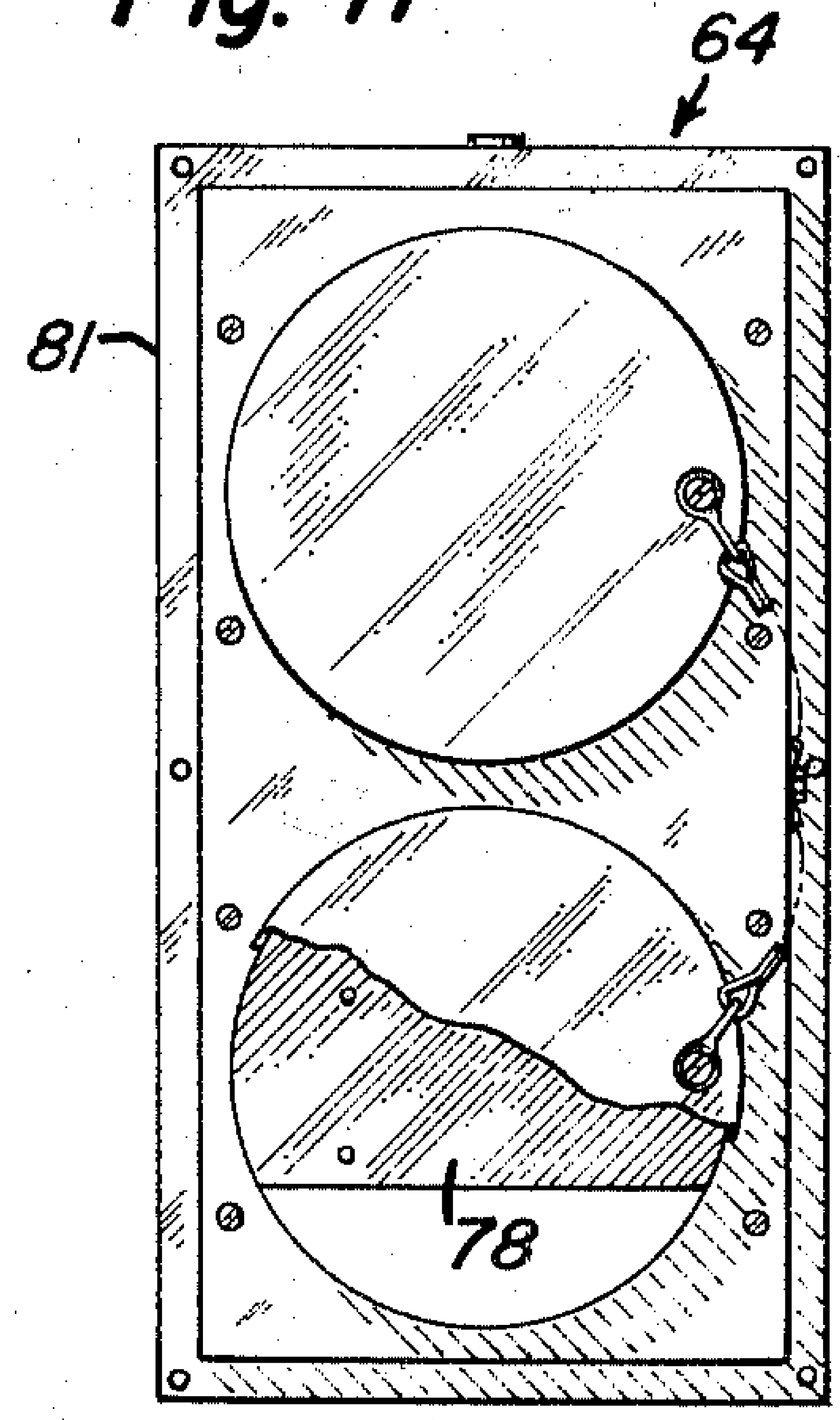

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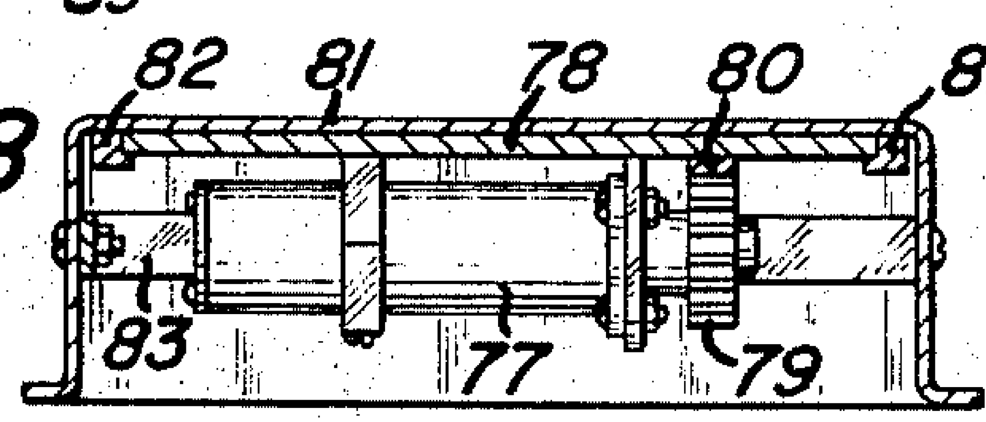

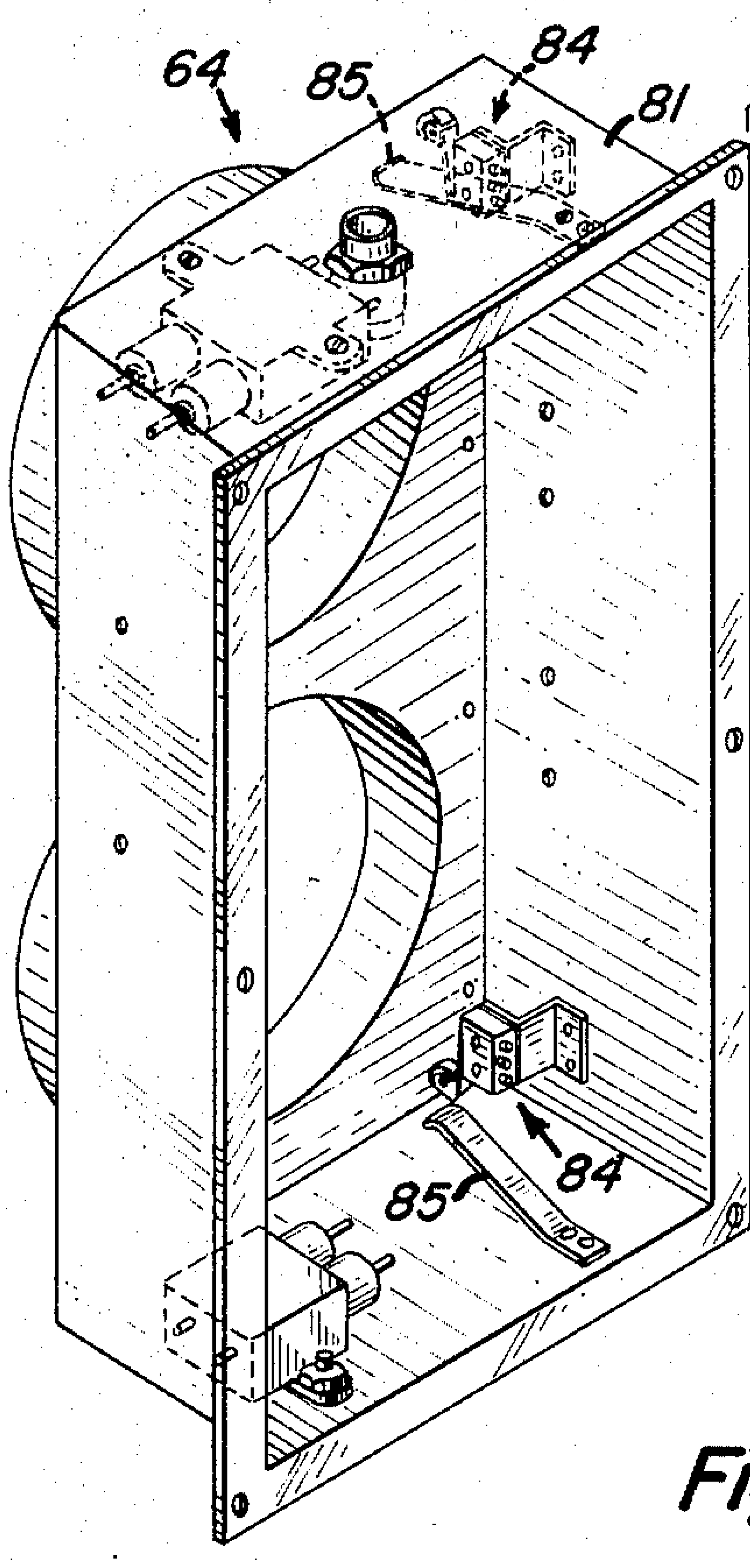

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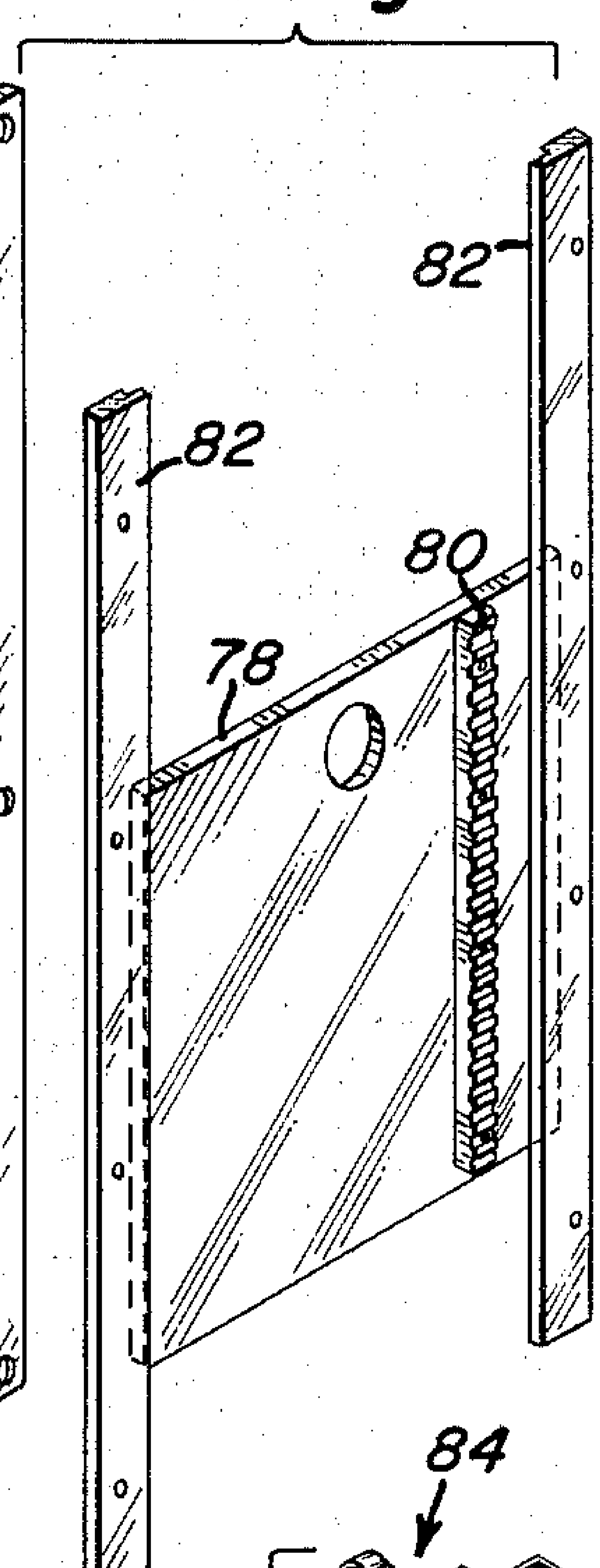

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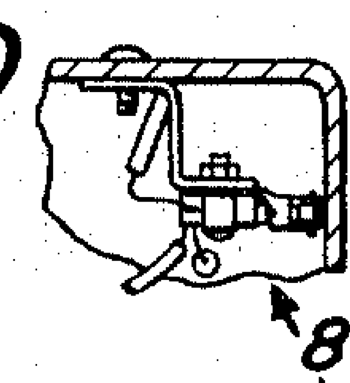

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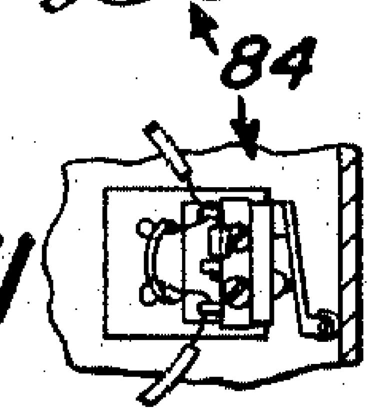

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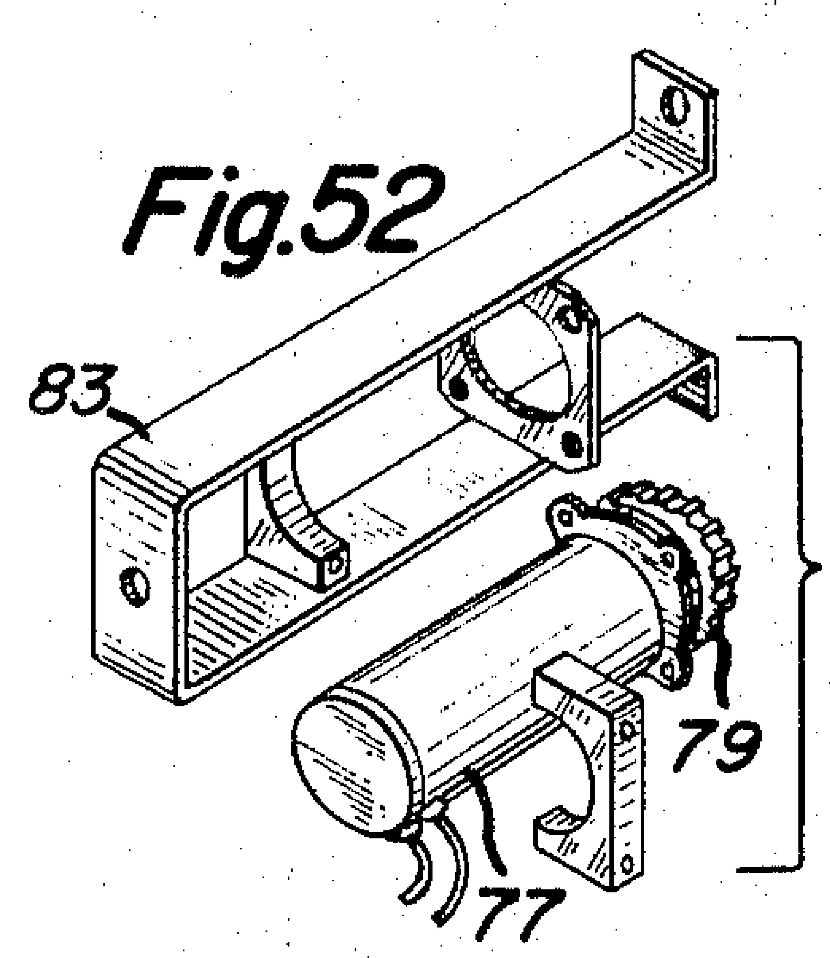

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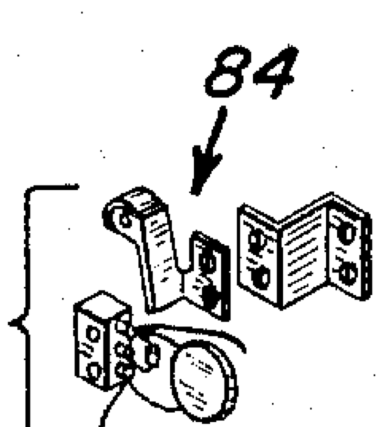

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Fig.54

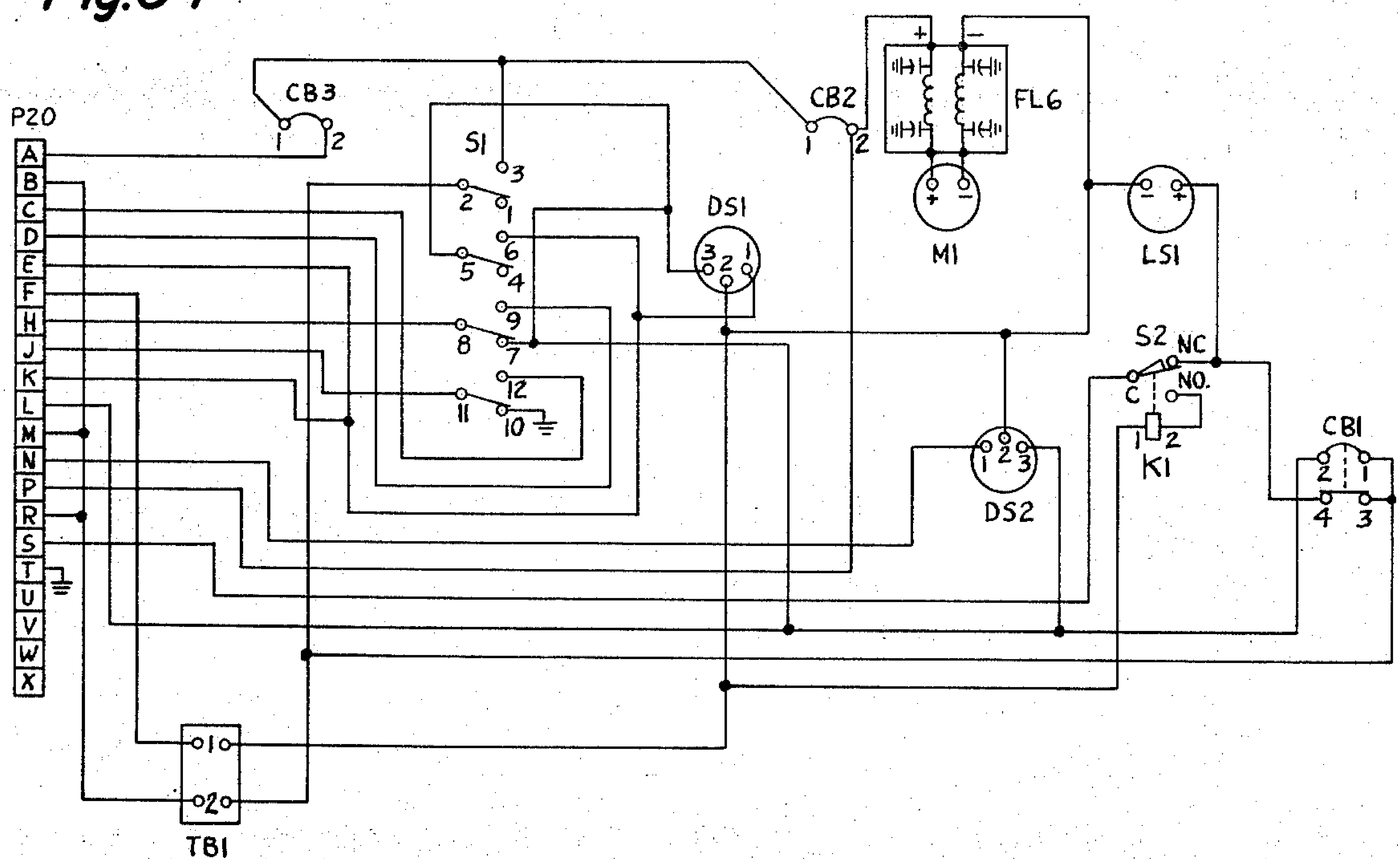

Fig.55

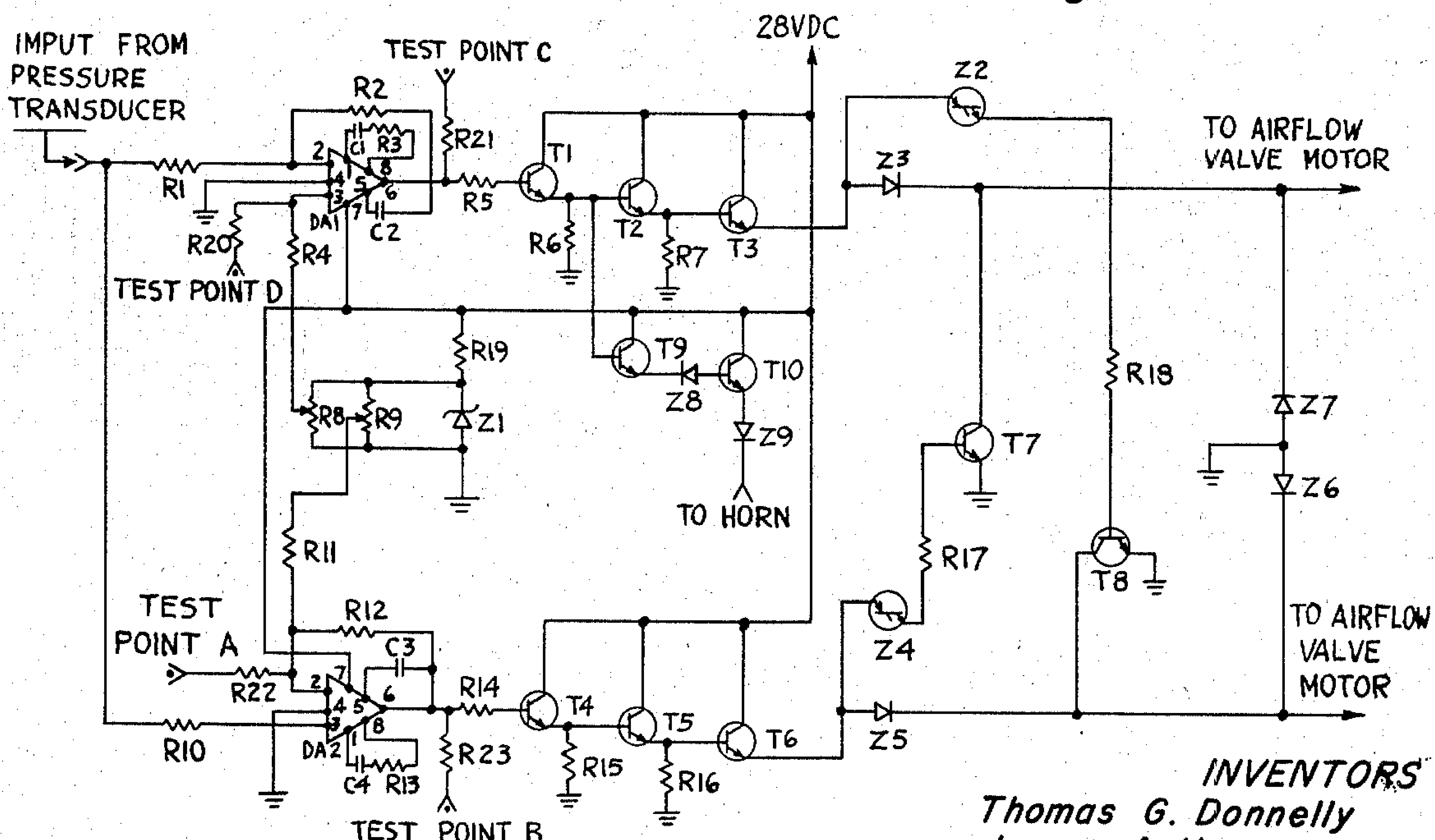

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Fig. 56

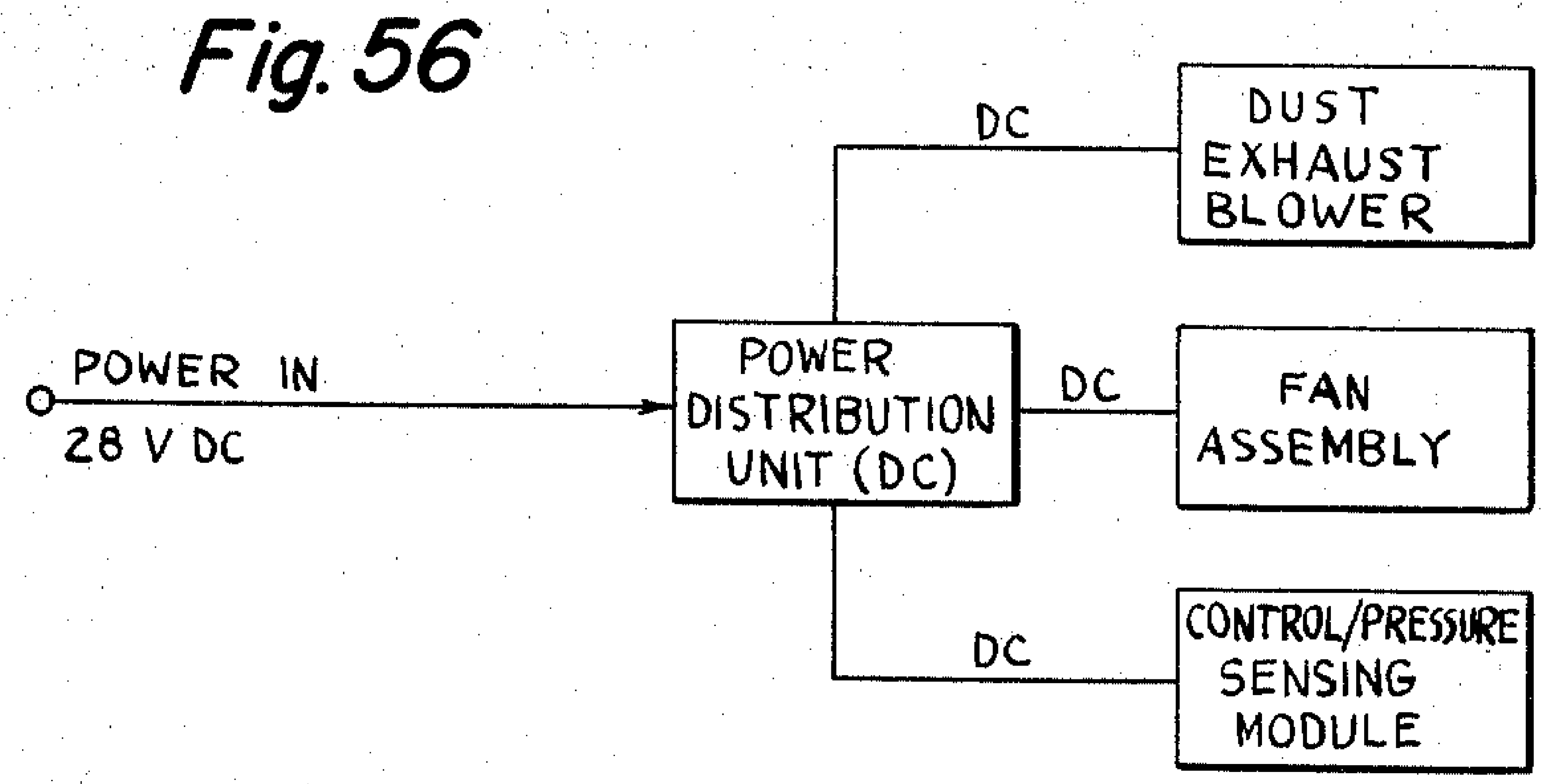
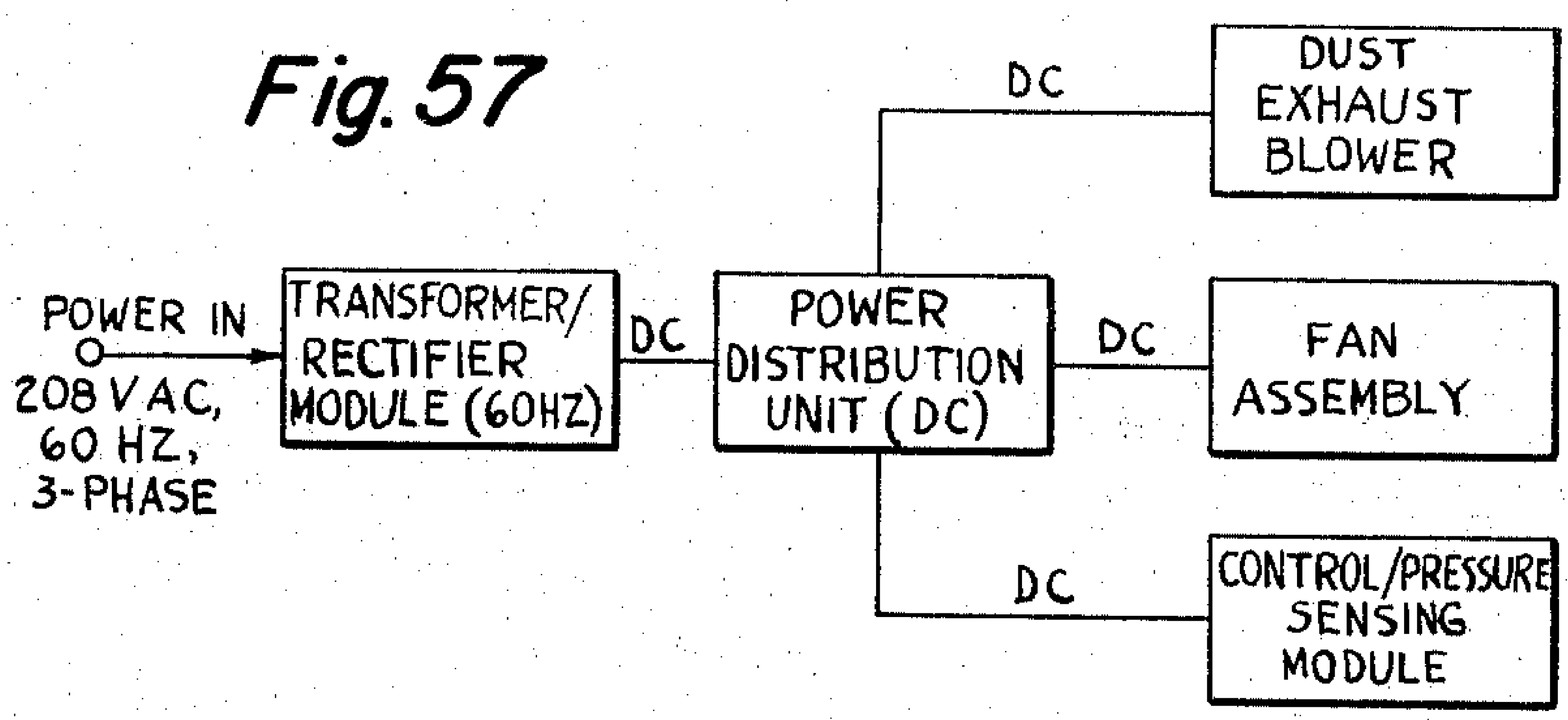


Fig. 57



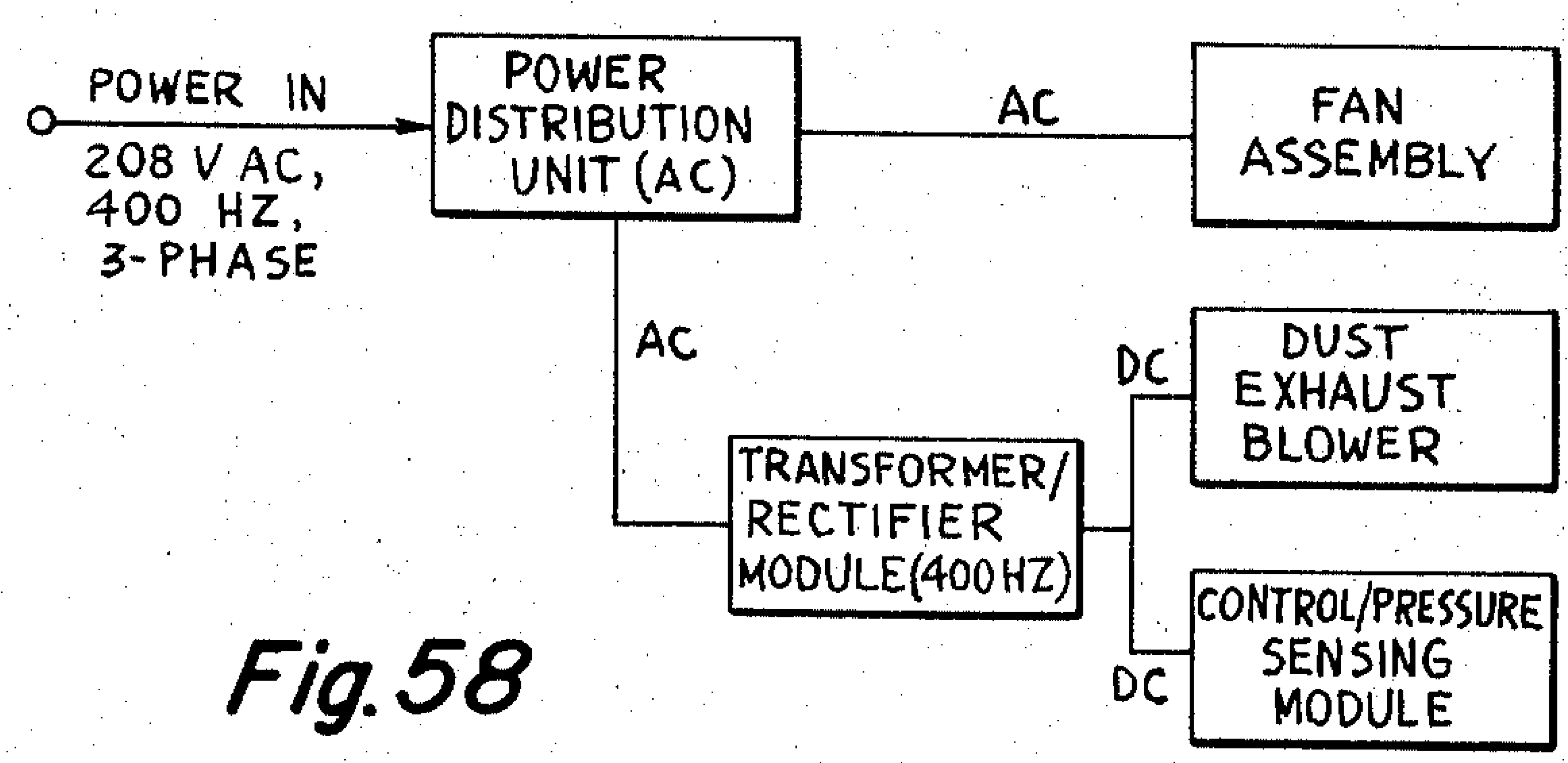


Fig. 58

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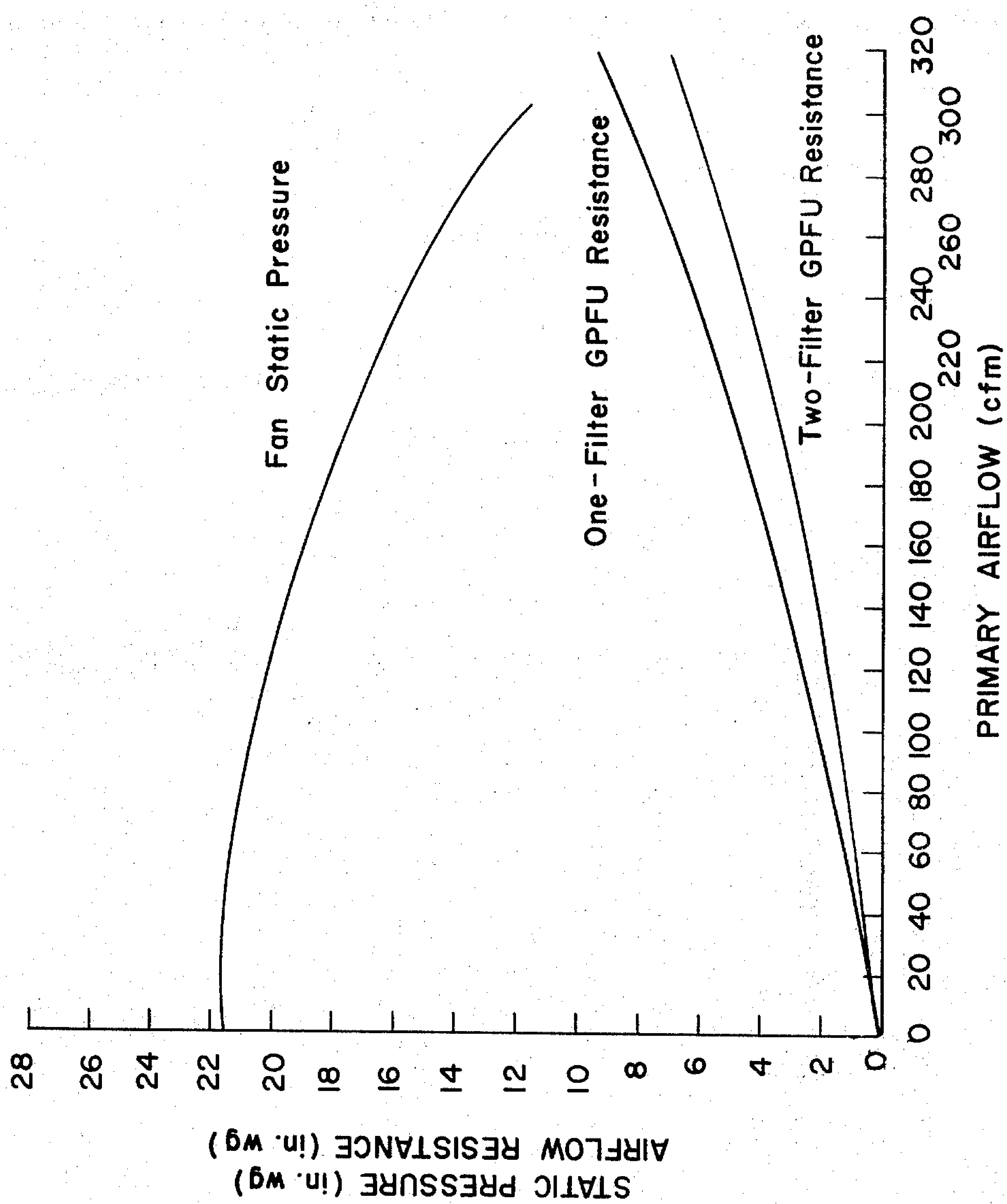

Fig. 59

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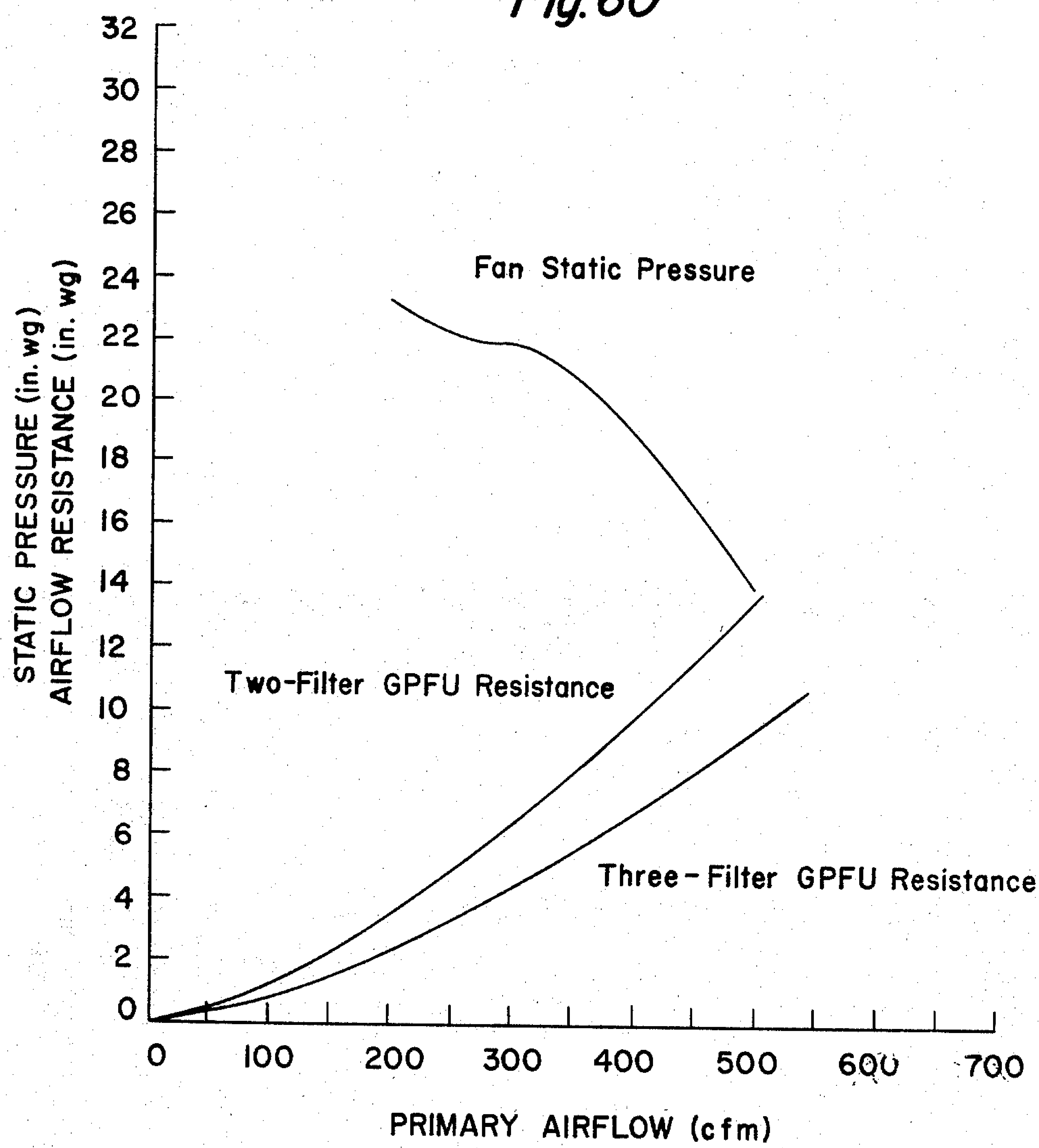
Fig. 60



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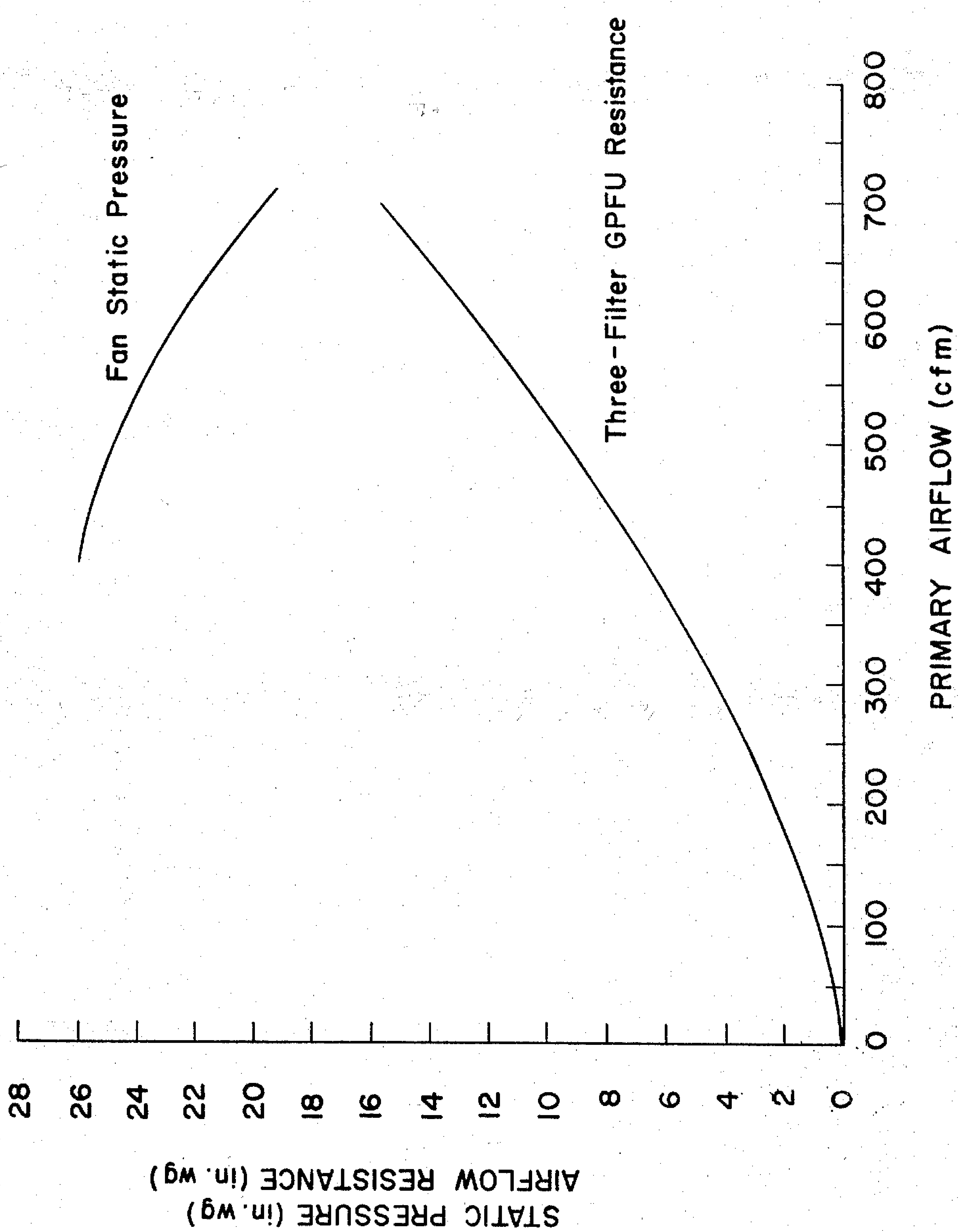

Fig. 6I

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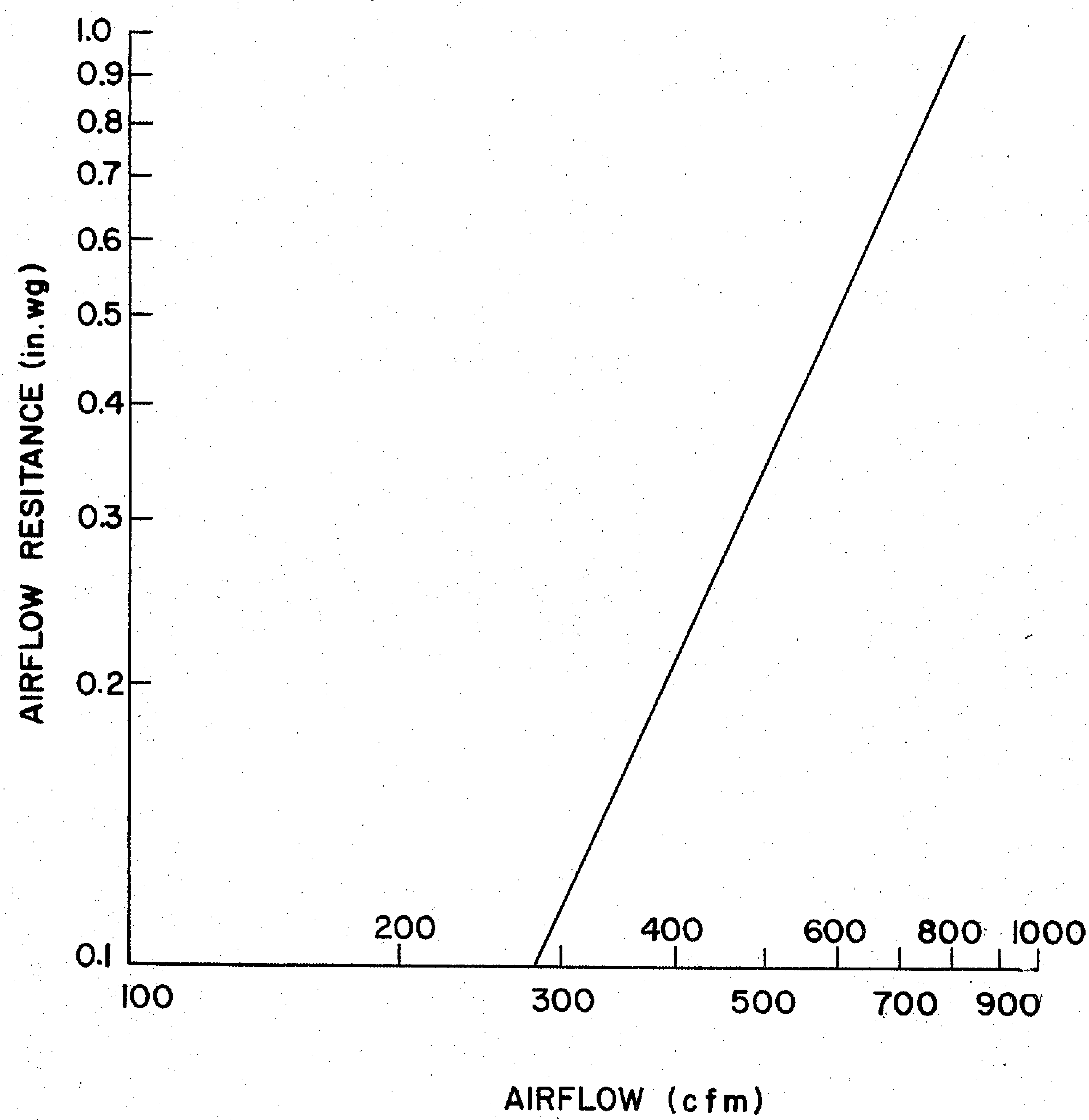
Fig. 62



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PROTECTIVE SYSTEM FOR CONTAMINATED ATMOSPHERE

DEDICATORY CLAUSE

The invention described herein may be manufactured, used, and licensed by or for the Government for governmental purposes without the payment to us of any royalty thereon.

Our invention relates to a new method and system having utility for providing protective shelter in a contaminated atmosphere.

A problem has long existed to provide an easily erected means and simple method for providing protective shelter in contaminated atmosphere areas; including means for personnel to perform necessary decontamination procedures before entering a protective shelter while not in a contaminated atmosphere and a means and method to permit personnel to enter and exit the protective shelter without loss of compartment pressurized protection. Our invention was conceived and reduced to practice to solve the aforementioned problem and to satisfy the long felt need for the aforementioned protective shelter and method.

A principal object of our invention is to provide an apparatus and method which is easily erected and simple to use to permit performance of decontamination procedures outside of a contaminated atmosphere but prior to entering a protective shelter.

Another object of our invention is to provide an apparatus and method to permit personnel to enter and exit a protective shelter witout loss of compartment pressurized protection.

Other objects of our invention will be obvious or will appear from the specification hereinafter set forth.

FIG. **1** is a view showing the utility of our apparatus.

FIG. **2** is a schematic top view of the apparatus shown in FIG. **1**.

FIG. **3** is a view of the storage or transit package of our apparatus.

FIG. **4** is a cutaway view of our apparatus and the entrance to a protective shelter.

FIG. **5** is a view through **5—5** of our apparatus shown in FIG. **4**.

FIG. **6** is a view of the pin locking means to connect our apparatus to a protective shelter as shown in FIG. **1**.

FIG. **7** is an exploded view of the components shown in FIG. **6**.

FIG. **8** is a view through **8—8** of our apparatus shown in FIG. **4**.

FIG. **9** is a view through **9—9** of our apparatus shown in FIG. **4**.

FIG. **10** is a view of the inlet airflow valve with dust cover for our apparatus.

FIG. **11** is a view of the top of our apparatus which also forms one half of the container means of the package shown in FIG. **3**.

FIG. **12** is a view of the door for our apparatus in the assembled mode.

FIG. **13** is a view of the door for our apparatus in the unassembled mode.

FIG. **14** is a view through **14—14** of FIG. **12**.

FIG. **15** is a view through **15—15** of FIG. **12**.

FIG. **16** is a partial view of the frame of the door shown in FIG. **12**, wall, and a storage pocket of our apparatus.

FIG. **17** is a view of the door shown in FIG. **12** and a cover means for the door window.

FIG. **18** is a view of the pressure sensing module mounted within our apparatus.

FIG. **19** is a view of the asembly means for our apparatus to connect the supports to the top shown in FIG. **11**.

FIG. **20** is a view of the connector means shown in FIG. **19**.

FIG. **21** is a view of the supports for our apparatus in the storage mode in the bottom of our apparatus.

FIG. **22** is a view of the sliding-plate airflow valve of our apparatus to control the protective shelter pressurization.

FIG. **23** is a view of the supports for our apparatus in the folded or storage mode.

FIG. **24** is a view of the top, bottom and supports of our apparatus in the partially erected mode.

FIG. **25** is a view of the support brace for our apparatus.

FIG. **26** is a view of the support for our apparatus in the partially erected mode.

FIG. **27** is an enlarged view of the pull pin for the support for our apparatus shown in FIG. **26**.

FIG. **28** is a side view of the support for our apparatus.

FIG. **29** is a front view of the support for our apparatus. FIG. **30** is a view of the gas-particulate filter unit assembly of our apparatus.

FIG. **31** is a view of the control/pressure sensing module for our apparatus.

FIG. **32** is a view of the stand for the gas-particulate filter unit of our apparatus.

FIG. **33** is a view of the gas filter for our apparatus.

FIG. **34** is a view of the particulate filter for our apparatus.

FIG. **35** is a schematic view showing the air flow through our apparatus.

FIG. **36** is an end view of our apparatus shown in FIG. **30**.

FIG. **37** is a view through **37—37** of our apparatus shown in FIG. **36**.

FIG. **38** is a top view of the outer access cover which retains the gas filter shown in FIG. **33** within the assembly for our apparatus shown in FIG. **30**.

FIG. **39** is a view through **39—39** of FIG. **38**.

FIG. **40** is a side view of the outer access cover with the bar retaining means in the open position.

FIG. **41** is a view of the inner access cover which retains the particulate filter shown in FIG. **34** within the assembly for our apparatus shown in FIG. **30**.

FIG. **42** is a detail view of the latching means for the bar retaining means shown in FIGS. **38, 39,** and **40.**

FIG. **43** is a view of the inner access cover securing means mounted within the bar retaining means shown in FIGS. **38, 39,** and **40.**

FIG. **44** is a view of the hinge means which connects the bar retaining means to the outer access cover shown in FIGS. **38, 39,** and **40.**

FIG. **45** is a cutaway top view of our apparatus sliding-plate airflow valve showing the internal structure of the valve.

FIG. **46** is a side view of the sliding-plate airflow valve shown in FIG. **45.**

FIG. **47** is a partial cutaway top view of the sliding-plate airflow valve shown in FIG. **45** to show the sliding-plate structure.

FIG. 48 is an end view of the sliding-plate airflow valve shown in FIG. 45 to show the motor means which activates the sliding plate.

FIG. 49 is an exploded view of the sliding-plate airflow valve shown in FIG. 45 to show components in detail and motor gear track integral with the sliding plate.

FIG. 50 is a top view of the micro switch assembly limit stop means to control the travel of the sliding-plate.

FIG. 51 is a side view of the switch means shown in FIG. 50.

FIG. 52 is an exploded view of the motor and motor mount means shown in FIG. 48.

FIG. 53 is an exploded view of the micro switch assembly shown in FIGS. 50 and 51.

FIG. 54 is a schematic electrical diagram of the control panel circuitry of our control/pressure sensing module.

FIG. 55 is a schematic electrical diagram to show the circuitry of our pressure sensing network to operate our sliding-plate valves.

FIG. 56 is a block diagram of the power distribution through our gas-particulate filter unit components for 28 volt direct current input.

FIG. 57 is the same as FIG. 56 for a 208 volt alternating current, 60Hz, three phase input.

FIG. 58 is the same as FIG. 56 for a 208 volt alternating current, 400Hz, three phase input.

FIG. 59 is a graphical representation of a 250 cfm fan airflow resistance through our system.

FIG. 60 is a graphical representation of a 400 cfm fan airflow resistance through our system.

FIG. 61 is a graphical representation of a 600 cfm fan airflow resistance through our system.

FIG. 62 is a graphical representation of flexible duct airflow resistance in our system.

Our invention and FIGS. 1 to 62 will now be described in detail as follows.

Our protective system can be applied to a wide variety of vans, vehicles or shelters. Several application considerations must be evaluated, however, prior to selecting an appropriate system. The considerations to be evaluated include operational structure, performance characteristics, and application of the system. Our invention will be described in the light of the aforementioned considerations to permit those of ordinary skill in the art to determine the applicability of our system to any particular application.

Regarding operational structure, a flow diagram of the gas-particulate filter unit assembly shown at 10 in FIG. 30 is shown in FIG. 35 to illustrate the gas particulate filter unit filtering operation. Air enters the inlet shown at 1 in FIG. 35 and is drawn into dust collector 2 where 90 percent of the airborne dust is separated and exhausted back to ambient through dust exhaust 3. The partially cleaned air is then drawn through fan assembly 4 and forced through the particulate filter 5 and gas filter 6 which removes essentially all the particulate and gas contaminants, respectively. The purified air then passes through outlet airflow valve 7 which controls the airflow quantity required for pressurization of protected shelter 8; air being exhausted from compartment 8 to ambient by conventional exhaust means 9. A preferred arrangement of our system is schematically illustrated in FIG. 2 which shows the gas-particulate filter unit, hereinafter referenced as GPFU, remotely placed outside of a protected shelter. The GPFU is shown mounted in a ground stand 11 and provided with an air inlet protective cap 12. Purified air is pushed through the GPFU by the fan assembly and is ducted through the shelter 8 wall by means of duct 13 and entrance 17 by means of duct 76, as shown in FIG. 1. Electrical power is directed to the power distribution unit 14 mounted on the GPFU. From there, power is distributed through interconnecting cables 16, as shown in FIG. 36, to fan assembly 4, dust exhaust blower in the dust collector 2, GPFU outlet airflow valve 7, as shown in FIG. 35, and control/pressure sensing module 15, as shown in FIG. 30. GPFU operation is controlled and monitored by control/pressure sensing module 15 which, installed within the shelter, senses the pressure differential between the shelter and ambient atmosphere and controls the GPFU outlet airflow valve 7 to maintain the predetermined pressure differential by varying the airflow. The GPFU can be mounted outside or inside shelter 8 and can be operated in either a "push-through" or a "pull-through" structure. When the GPFU is mounted outside of shelter 8, as shown in FIGS. 1, 2, and 35, fan assembly 4, as shown in FIG. 35, is mounted inside the GPFU, and air through the primary filtering elements (gas and particulate filters) is pushed through. When the GPFU is mounted inside shelter 8, not shown in the drawing, fan assembly 4 is mounted downstream from the GPFU and is connected to the GPFU outlet airflow valve by a flexible duct. This is called a pull-through structure, because the fan assembly "pulls" the air through the primary filtering elements. The GPFU can utilize a single, double, or triple filter to suit a given application and airflow requirement; the airflow range in cubic feet per minute for each filter arrangement being as set forth below.

GPFU	Airflow Range (cfm)
One-Filter	Up to 200
Two-Filter	Up to 400
Three-Filter	Up to 600

All of the basic components of the GPFU, except for the housings and stands, are interchangeable from one unit to any other unit. However, fan assembly 4 and power distribution unit 14, as shown in FIG. 2, selected for a given GPFU are interdependent and must be compatible with the electrical power source. The inlet flanges (not shown in the drawing) on fan assembly 4 are identical, so that any fan assembly can be used in any GPFU. The fan assemblies are applies as in Table 1 below.

TABLE 1

GPFU	Primary Fan Assembly	Alternate Fan Assembly
One-Filter	250 cfm ac	
		None
	250 cfm dc	
Two-Filter	400 cfm ac	250 cfm ac
	400 cfm dc	250 cfm dc
Three-Filter	600 cfm ac	400 cfm ac
	600 cfm dc	400 cfm dc

The alternate fan assemblies provide lower flows and power consumptions for each size GPFU as shown in the Summary of GPFU Weight and Power of Table 2 below. Fan assemblies should not be used with GPFUs smaller than those designated in Table 1 above.

TABLE 2

GPFU	Fan assembly, c.f.m.	Maximum airflow, c.f.m.	28 V D.C. power source		400 Hz. A.C. power source		60 Hz. A.C. power source	
			Power (watts)	Weight (lb.)	Power (watts)	Weight (lb.)	Power (watts)	Weight (lb.)
One-filter	250	200	1,050	158.7	1,010	163.3	1,190	238.7
Two-filter	250	300	1,210	201.3	1,150	205.9	1,370	281.3
Two-filter	400	400	1,620	209.2	1,430	214.2	1,840	289.2
Three-filter	400	480	1,660	256.8	1,560	261.8	1,890	336.8
Three-filter	600	600	1,950	263.9	2,930	267.0	3,350	343.9
RCFU*	250	200	500	160.4	470	165.0	560	240.4

*Recirculating filter unit.

The power distribution units used on all arrangements of GPFUs must be selected to be compatible with the type of applied electrical power and fan size as indicated in Table 3 below.

TABLE 3

Power Source	Fan Assembly
208 V ac 400 Hz	250 cfm
208 V ac 400 Hz	400 cfm
208 V ac 400 Hz	600 cfm
28 V dc or 208 V ac 60 Hz	250 cfm
28 V dc or 208 V ac 60 Hz	400 cfm
28 V dc or 208 V ac 60 Hz	600 cfm

FIGS. **56** to **58** show the power distribution through GPFU components for the different types of powers, and the legends thereon are self-explanatory. Protective Entrance **17** and related hardware and airflow and pressure regulating controls is provided as an entry and exit means to shelter **8**; the entrance structure being subsequently described in detail. In addition to allowing entry or exit to shelter **8**, the protective entrance provides a place where personnel can don protective clothing before entering the contaminated environment and to perform decontamination procedures before entering the shelter. The protective entrance is scavenged with purified air to provide a 1000: 1 reduction of a completely airborne contaminant concentration within 5 minutes while retaining protective entrance internal pressure between 0.4 – 0.8 inches *wg*. The purified air may be supplied either by a one, two or three filter GPFU which simultaneously supplies purified air to pressurize shelter **8** or by a separate recirculating filter unit. FIGS. **1** and **2** illustrate a remotely-mounted GPFU in the push through configuration simultaneously supplying purified air to both shelter **8** and protective entrance **17.**

Regarding performance characteristics, FIGS. **59** through **61** illustrate the fan head and the airflow resistance of the GPFUs for push-through operation of a **250** cfm fan, **400** cfm fan, and **600** cfm fan respectively. The difference between the fan head curve and the curve for GPFU airflow resistance is the amount of reserve head available for particulate filter dust loading, duct losses and enclosure pressurization. As an example, in FIG. **59,** at **200** cfm, the pan provides approximately **17.6** in. wg fan head, and the airflow resistance (pressure loss) of the assembled one-filter. GPFU is **5.6** in. wg, approximately composed of:

Air Inlet Protective Cap 0.2 in. wg
Dust Collector 0.3 in. wg
Particulate Filter 1.4 in. wg
Gas Filter 3.7 in. wg
Airflow Valve and Housing 0.0 in. wg
Total 5.6 in. wg

The difference (12.0 in. wg) is available for airflow resistance of air ducts, air conditioner transitions, diffusers, etc., and for increase of particulate filter airflow resistance as particulate matter is accumulated on the filter. Table **2** above illustrates the weight and power requirements for variations of each of the three GPFUs. The data includes the basic GPFU in push-through configuration with the fan assembly and all of the controls required for system operation, without a protective entrance.

Regarding application considerations, the GPFU size or airflow capacity is dependent on numerous considerations; discussed subsequently and individually below. Airflow requirements for the user should be determined initially for the ventilation requirement for personnel in the shelter per Human Factors guidelines, the equipment cooling requirements if ventilated with purified air, heater combustion air requirements, the flow necessary to pressurize the shelter to 1.2 in. wg minimum, and necessary scavenging for any internally generated noxious gases. The GPFU size required is based on the maximum of the flow requirements and whether a protective entrance is employed. Application considerations of mounting location, personnel ventilation, equipment ventilation, leakage of the protected compartment, heaters, air conditioners, and protective entrances are disucssed below; and an example of a typical shelter analysis is included last.

Gas-particulate filter unit (GPFU) assembly **10** can be mounted in the interior of shelter **8,** on the exterior wall of shelter **8,** or ground-mounted externally of shelter **8.** The selection of location depends on several factors, such as weight distribution, space limitations, structural strength, shelter mobility, etc. Where mobility and protection of the system are prime requirements and space is available, internal mounting is the most advantageous. Specific location of the unit within the enclosure will be dictated by possible restrictions of center of gravity, wall/ceiling structural strength, internal system equipment configuration, location of heaters, air conditions, etc. When internal space is not available, but mobility is critical, an external mounting to the shelter may provide the best solution. Here, again, weight, center of gravity and structural strength are of prime consideration, especially in regard to shelters mounted on trailers or trucks. In addition, locating the GPFU on the outside of a trailer-mounted shelter may interfere with the vehicle which pulls the trailer. Here the various departure angles between the trailer and the vehicle must be considered. When mobility and quick reaction are secondary considerations or when no shelter mounting locations are available, ground mounting of the GPFU in a stand may be the best solution, as shown in FIGS. **1** and **2.** When ground mounting a GPFU, the usual problems of weight and volume are not so severe. The location of the GPFU assembly **10** with reference to shelter **8** must also be considered as excessive duct lengths or bends will reduce the GPFU airflow capactiy due to increased airflow resistance. FIG. **62** demonstrates the airflow resistance of a 6 in. diameter flexible duct 20 ft. long or a 6 in. diameter flexible duct 10 ft. long and curved in an 8 ft. radius.

When using protective entrance 17, several GPFU application choices are available. If it is envisioned that shelter 8 may require protection at times when the protective entrance is not utilized, a standard GPFU shelter application could be used in any of the above GPFU locations, and a protective entrance and recirculating filter unit (for pressurization and scavenging of the protective entrance) could then be provided and used only when necessary. If the protective entrance is required under all operating conditions, one GPFU providing protection for both the protective entrance and shelter is the best selection; as shown in FIGS. 1 and 2. Application of our system to two shelters, one for personnel and one for equipment, is also possible. A single GPFU of the appropriate size can be used for both shelters with the personnel shelter containing the controls and having priority on the airflow from the GPFU. A modification to the GPFU application configurations is possbile, to extend filter life when a protective entrance is used, by using a recirculating duct from the protective entrance outlet to an adapter on the GPFU inlet. All applications of our system to shelters require air duct and electrical feedthrough in the shelter walls, as well as internal space for mounting of the control module(s). When an air conditioner is used, filtered air may be directed to an air makeup intake port through an adapter.

Personnel ventilation requirements for a given shelter are set by human engineering requirements, and the requirements are dependent on the number of people operating within the shelter and the types of activities that the personnel might be performing during their normal mission. The general fresh air requirements range from 10 to 25 cfm per person, depending on the energy expended due to physical exercise or metabolism rate. Ventilation air should also be sufficient to remove any fumes or odors to an acceptable level of concentration. Normally, in a shelter without protection equipment, this ventilation is supplied by ventilation fans. However, when protection equipment is installed, all of the air entering the compartment must be filtered. The ventilation requirement defines the minimum requirement for leakage from the shelter. For example, assume a situation where the shelter houses only personnel, with no heat generating equipment, and only wind and diffusion conditions are considered. The optimum condition would be an airflow into the shelter of a value just sufficient to meet the personnel ventilation requirements while maintaining shelter pressurization. The situation may arise where the shelter leakage is below the ventilation requirements of the personnel. In such a situation, leakage must be created in the shelter if it does not exceed make-up air requirements for an air conditioner. In order not to waste purified air, the purified air should be ducted through the personnel door of the shelter and into the protective entrance, if used, to assist in the scavenging of the protective entrance. Such a built-in leakage device should be designed so as to allow passage of the desired flow rate of air and also serve as a check valve to prevent flow of air from the protective entrance back into the shelter.

Equipment associated with the function of our system may be cooled by means of an air conditioner or with ambient air. When cooled by an air conditioner, the equipment can be located within the same enclosure as the personnel. The cooled air from the air conditioner is directed to the personnel area from which it is drawn through equipment cabinets and to the return of the air conditioner to be recirculated. Outside make-up air is provided to satisfy personnel ventilation requirements. When protection equipment is used, the filtered air is introduced into the air conditioner outside air intake port. The air conditioner should have sufficient capacity to cool the additional air required to pressurize the enclosure. When ambient air is used for cooling, the equipment can be located as an integral part of the personnel compartment or may be in a separate adjacent compartment with interconnecting cabinet doors. When protection equipment is used in a personnel compartment with integral equipment, the use of an air conditioner as compared with the large volume of filtered air required to cool the equipment should be considered. When protection equipment is used in a personnel compartment with integral equipment, the use of an air conditioner as compared with the large volume of filtered air required to cool the equipment should be considered. If the equipment is in a separate compartment and requires access through interconnecting cabinet doors during operation, the equipment should be cooled and pressurized with filtered air. The filtered air requirement may be high if an air conditioner is not added. If access to the adjacent compartment is not required during operation and the adjacent compartment is protected from direct contamination, filtered air is not essential. However, the cooling fan should be located so that the adjacent compartment is under negative static pressure. It should be noted in these considerations that air passing through the GPFU increases in temperature 10 to 15° F., depending upon the size unit and airflow rate.

In order to prevent the migration of contaminants into the shelter, the protection equipment must be capable of providing pressure within the compartment which is greater than the stagnation pressure which could be encountered due to external wind conditions and/or the diffusion pressure which could be encountered from the difference in concentration internally and externally of the protected compartment. To prevent the migration of contaminants into the shelter, a positive pressure, ranging from 1.2 to 1.7 in. wg above atmospheric pressure, is maintained in the shelter. The range of internal pressures is dictated by the requirement that shelters must be protected under operational conditions of a 50 mph wind. Such air velocity value causes a stagnation pressure on the upstream face of the shelter of approximately 1.2 in. wg. A second consideration is the transfer of contaminants from the outside to the inside of the shelter through gas diffusional forces. In this case, one must consider the velocity of the air through a given opening and ensure that the air velocity developed from the pressure gradient is greater than the diffusion velocity of the contaminants from the concentration gradients. The internal pressures necessary to overcome these gas diffusion forces are generally lower than the internal pressures required to exceed wind stagnation pressure. The two foregoing phenomena require that the pressure within a protected shelter be maintained in the range given. Further, the pressure must be maintained above the pressures of any contaminated area in or around the shelter. Another consideration is the possibility of high pressure areas within environmental control equipment when this equipment is operating in contaminated air. The latter situation arises in the combustor/heat exchanger section of heaters or in the condenser section of air conditioning units. Leakage reduction measures may have to be performed on a particular shelter to keep the filter unit to a minimum capacity for air conditioner or heater make-up air and to keep the volume, weight and power requirements of the GPFU to a minimum. However, for non-environmental controlled shelters, the cost of reduction may surpass the additional cost of a larger filter unit that would accommodate the higher leakage. This condition must be considered when leakage reduction measures are evaluated. In order to reduce leakages and locate the major sources thereof, one must first be able to detremine the magnitude of the leakage. The method used to determine magnitude is to pressurize the compartment to a constant pressure and monitor the air flow required to maintain pressure in the compartment when various areas in the shelter are covered with impermeable material. By recording the reduction in leakage after each major step in sealing leakage paths, all of the significant shelter leakages can be accounted for and the magnitude of leakage determined. Leakage areas can also be located visually in some cases, such as by introducing highly visible, persistent smoke into the pressurized compartment. Another method is to use an ultrasonic leak detector in conjunction with an ultrasonic sound generator. The generator is placed on one side of the shelter, such as inside, and the detector is used on the opposite side of the shelter, such as outside the shelter, to locate the transmission of sound through leak passages. Some common leakage shelter components are ceiling panels and filters, conventionally-hinged doors, bi-fold doors, door knobs, locks, handles, windows, hinges, heating ducts, heating plant, water pipes, wires, cables, light switches, fixtures, electrical receptacles, air exhausts, vents in eaves and roof, root hatches, air conditioners, etc. Sealing materials that minimize air leakage and provide protection against contamination must be impermeable to air, resistant to the contaminant and easily installed. Furthermore, sealing materials must be durable enough to meet environmental extremes and field operation conditions, and they must have shelf lives compatible with normal procurement and usage practice. Use of toxic, flammable, or explosive compounds should be avoided. Many materials can be used for sealing leakage areas in shelters, either permanently or temporarily, such as caulking compounds, non-hardening extruded tapes. non-hardening mastics, spray coatings, pressure sensitive tapes, gaskets, adhesives, plugs, fabrics, and films.

Air conditioning units must be carefully evaluated when installing protection equipment as their design and performance have considerable influence on the selection and installation of protection equipment. Air conditioner parameters which must be defined include leakage, internal pressure variations, make-up air requirements, cooling capacity, and provisions for make-up air. Air conditioners are limited in the quantity of make-up or ambient air they can use while providing their required temperature reduction for a given compartment heat load. For example, the 18,000 and 36,000 Btu equipment currently in use are rated at a maximum make-up air capacity of 90 and 150 cfm, respectively. If more flow than this is required to pressurize the shelter for protection, the air conditioner may not be able to sufficiently cool the shelter equipment under high ambient temperatures. If shelter leakage cannot be reduced, a larger air conditioner may be required. Our system fan assembly is cooled by the filtered air and adds about 10° F to 15° F temperature to this air, depending on fan size and flow. This effectively increases the temperature of the make-up air to the air conditioner when the GPFU is operating and must be considered when sizing the air conditioner. An effective interface must be assured for compatible operation of the air conditioner and our system. Two approaches are available, namely; duct the filtered air directly into the shelter and operate the air conditioner in the recirculation mode, or duct the filtered air into the air conditioner external make-up air port and operate the air conditioner with make-up air. In the first case, the two units are operated in parallel, and, in the second, they are in series. With the FPFU mounted within the shelter, the first method would be required; with the FPFU external, either method could be used. The second method is preferred because it allows the air to be conditioned prior to entry into the personnel compartment. Provisions should always be made to ensure that air conditioner ambient make-up ports are sealed during system operation in either installation.

When using our protective entrance **17** with shelter **8**, one must consider airflow capacity required for scavenging the protective entrance within the specified essential time limit of 5 minutes, space available around the personnel entry door for an interface, and provision for supporting the floor of the protective entrance when used on a shelter that has the entry door higher than 8.5 in. off of the ground. The minimum airflow required to scavenge the protective entrance within the specified 5 minutes is 150 cfm at 0.4 in. wg. and a maximum of 200 cfm at 0.9 in. wg. Consequently, when determining the GPFU size for protecting both a compartment and the protective entrance at least 150 cfm must be allowed for the protective compartment. The alternative is to use a recirculating filter unit for the protective entrance. Space must be allowed around the shelter door for a protective entrance interface. In some cases this cannot be done if there is equipment mounted close to the door hinges or in an area needed to mount the interface channel. It may be necessary to make provisions for supporting the floor of the protective entrance on some shelters. For example, the personnel door of the shelter that is trailer-mounted could be as much as 40 in. off of the ground. Our present interface design can accomodate a door which is 37 in. wide, 66-½ in. high and whose lower edge is less than 8-½ in. off of the ground. Should this door be off of the ground more than 8-½ in., the interface will no longer align, unless the top of the door is an equal amount shorter. A platform also precludes the need to level the ground under the protective entrance. However, there can be instances where the protective entrance must be used directly on the ground. When the entrance is used directly on the ground, large projections under the floor, such as rocks, must be removed.

The following example demonstrates the preliminary analysis which one might make in selecting the proper protective system for a specific application. Assume that one knows the compartment type, such as a **S-280** shelter; the environmental control unit (heater/air conditioner): 18,000 Btu compact horizontal; personnel ventilation: 3 men (1000 cu. ft./person/hr., per HEL-STD-S-3-65); protective entrance required; and shelter leakage with equipment installed: 130 cfm. The airflows as follows can be determined from the foregoing known information.

Item	Required Flow at 1.5 in. wg.
Heater	0 (electric)
Air Conditioner	90 cfm (maximum)
Personnel	50 cfm
Protective Entrance	150 cfm
Shelter Leakage	130 cfm

The minimum required shelter flow is defined by the personnel ventilation requirement of 50 cfm. If the shelter leakage can be reduced by sealing to less than 90 cfm, the present air conditioner can be retained. A one-filter GPFU then can be used for the combined shelter and protective entrance protection. If shelter leakage cannot be reduced, a large air conditioner and larger or more GPFUs are necessary. This could be accomplished by providing the protective entrance with a recirculating filter unit or by using a two-filter GPFU. Should equipment cooling requirements exist, a larger GPFU and air conditioner are necessary.

To assemble our system, shelter **8** is constructed in the conventional manner, but it is provided with an interface **18** fixedly attached around the perimeter of door **19.** The case shown at **20** in FIG. **3** is opened, as in FIG. **24,** so that section **21** of case **20** forms the bottom and section **22** of case **20** forms the top of protective entrance **17.** Impermeable fabric, such as butyl coated cloth **101,** which forms the walls of the protective entrance, as shown in FIGS. **1** and **4** for example, is not shown in FIG. **24** for clarity purposes, but the impermeable fabric is fixedly sealed to supports **23** and the door frame shown at **28** and stored in a folded posture in bottom **21.** Also, door **24,** shown in FIGS. **12, 13,** and **17,** is stored in bottom **21** in the folded position shown in FIG. **13.** Supports **23** are opened by hinge means **69** and **70,** as shown in FIGS. **23, 26** to **29,** and top mounts **25** are inserted within support **23** and secured therein by the thumb nut connection shown at **26,** as shown in FIGS. **19** and **20.** There are two top mounts **25** fixedly connected to top **22,** as shown in FIG. **24,** at the side of protective entrance **17** which connects to shelter **8.** Supports **23** are opened from the folded position shown in FIG. **26** to the open position shown in FIGS. **28** and **29** and maintained in the open position by knobs **68** in the same manner as discussed below regarding knobs **29.** Support braces **44** are opened, as shown in FIGS. **24** and **25,** and the braces are held in open position by retaining pin **27.** Top **22** is supported on the side opposite to supports **23** by the door frame shown at **28** which is opened, as shown in FIG. **24,** and locked in the open position by pushing down on knob **29** which causes a protrusion fixedly connected to knob **29** to be inserted within member **30** to lock member **30** to member **31.** Support braces **44** are similarly locked by pin **27.** Anchor means shown at **33** in FIG. **21** are utilized to store the supports in bottom **21** in the storage mode, and valve **34** is provided to eliminate any water that may accumulate in protective entrance **17.** Supports **23** are locked in the storage position by pull pins **35** held within retainer means **71** under tension by springs **36,** as shown in FIGS. **23** and **25** to **29.** After assembly of entrance **17,** as described above, the entrance is attached to interface **18,** as shown in FIGS. **1** and **4,** by inserting pin **37** within notch **38** and mating hole **39** with holes **40** and inserting pin **41** through the mated holes, as shown in FIGS. **6** and **7.** Door **24** is assembled, as shown in FIGS. **12** and **13,** by opening from the folded position shown in FIG. **13** to the standard door mode position shown in FIG. **12** by means of hinges **42** mounted in the middle of the door and securing the door in the open position by thumb nut means **43** in the same manner discussed above regarding knob **29** for lokcing the door frame member **30** and **31** together. Door **24,** after assembly as described above, is hung in the door frame, shown at **28** in FIG. **24,** in the conventional manner by means of hinges **45.** Door **24** is provided with conventional window **46,** conventional door knob and latching mechanism **47,** and a window cover **48** to use as desired;

window cover **48** being removably attached by means of conventional fabric fastener means member **49** sewed to cover **48** and conventional fabric fastener member **50** sewed to the butyl coated cloth fabric of the door, as shown in FIG. **17.** Cover **48** is held in the open position by fastening fabric fastener **59** to fabric fastener **60.** Pressure sensing module **52** and entrance light **53** are mounted within protective entrance **17,** as shown in FIGS. **4** and **18.** Electrical power is supplied to light **53** by electrically connecting, in the conventional manner, the light to module **52** by means of electrical cable **54,** and module **52** is in turn electrically connected, in the conventional manner, to power distribution unit **14** by means of electrical cable **56** through conventional electrical feed through **57.** Light **53** is provided with a conventional three position switch **61** and a conventional white and red bulb, not shown in drawing, to permit use during blackout conditions; the light having electrical requirements of one ampere at 28 volts direct current. Conventional pneumatic tube **62** is connected to control/pressure sensing module **15,** mounted within shelter **8** in any convenient location, through feed through **57,** as shown in FIG. **18.** Pressure sensing module **52** contains the pressure sensing electrical network shown in FIG. **55** which senses and controls the pressure differential between **17** and ambient to operate the sliding-plate airflow valve shown at **64;** module **52** pressure sensing network being adjusted to control the pressure within entrance **17** at 0.4 to 0.8 inches wg. and having an electrical power input of 28 volts direct current and a power consumption of less than one ampere. Control/pressure sensing module **15** contains the main GPFU control panel having the electrical circuitry shown in FIG. **54** and the pressure sensing network shown in FIG. **55** which monitors the pressure differential between shelter **8** and ambient; the pressure sensing network of module **15** being present to maintain pressure in shelter **8** between 1.2 inches wg and **1.7** inches wg. The designations on FIG. **54** are as set forth in the legend below, and the electrical component values in FIG. **55** are as set forth below.

ELECTRICAL COMPONENT VALUES (FIGURE 55)

Resistors, ½ watt		Capacitors	Diodes	Operational amplifier	Transistors
R1-10K	R13-1.5K	C1-470PF	Z1-IN751	DA1-U5B770931X	T1-2N3568
R2-330K	R14-470	C2-22PF	Z2-IN5158	DA2-U5B770931X	T2-2N3568
R3-1.5K	R15-50K	C3-22PF	Z3-IN5059		T3-2N1485
R4-10K	R16-10K	C4-470PF	Z4-IN5158		T4-2N3568
R5-470	R17-1K		Z5-IN5059		T5-2N3568
R6-50K	R18-1K		Z6-IN5059		T6-2N1485
R7-10K	R19-1K		Z7-IN5059		T7-2N1485
R8-1K	R20-1K		Z8-IN3026		T8-2N1485
R9-1K	R21-1K		Z9-IN5059		T9-2N3568
R10-10K	R22-1K				T10-2N3568
R11-10K	R23-1K				
R12-330K					

LEGEND (FIG. 54)

		FL6-Filter
CB1-Circuit Breaker	DE2-Indicator Light	P20-Connector
CB2-Circuit Breaker	K1-Holding Coil	S1-Power On Switch
CB3-Circuit Breaker	LS1-Audible Alarm	S2-Horn Off Switch
DS1-Indicator Light	M1-Hour Meter	TB1-Terminal Board

The GPFU control panel of module **15** contains the system main power switch, a conventional low pressure warning horn with a silencing button, an elapsed time meter, circuit breakers as required, and any other suitable and desirable accessories within the skill of the art. Module **15** is provided with means to connect to pneumatic tube **62** from module **52** to sense ambient air pressure by the network shown in FIG. **55** and conventional 28 volt direct current electrical cable **55** to connect to power distribution unit **14.** The electrical power supply to module 15 to 28 volt direct current input, and the power consumption is a maximum of one ampere. Power distribution unit **14** is a 28 volt direct current and 3.5 KW capacity power supply which can utilize 60Hz , 208 volt alternating current, three phase power converted to the 28 volt direct current by transformer/-rectifier unit **63**, as shown in FIGS. **1** and **36**, electrically connected to power distribution unit **14** in the conventional manner. Power from distribution unit **14** is utilized to operate fan assembly **4**, the dust exhause blower (not shown in the drawing), control/pressure sensing module **15**, pressure sensing module **52**, and sliding plate airflow valves shown at **64** in FIGS. **1**, **4**, **22**, **45** to **47**, and **48.** If 400Hz three phase input power is utilized, transformer/rectifier unit **63** must have an output power capacity of 7.0 amperes at 28 volts direct current and 4.0 maximum peak to peak ripple voltage. 60Hz three phase input power requires transformer/-rectifier unit **63** to have an output power capacity of 110 amperes at 27 volts direct current and 4.0 maximum peak to peak ripple voltage. Electrical cables are utilized as set forth in Table **4** below. Where jacks are not indicated in Table **4**, individual terminal connections are provided.

TABLE 4

Cable type	From	To	Use
AC	Power source, 60 Hz. or	Transformer/rectifier, 60 Hz. (jack)	GPFU with 60 Hz. input power.
	Power source, 400 Hz.	Power distribution unit, AC (jack)	GPFU with 400 Hz. input power.
DC	Power source, DC	Power distribution unit, DC (jack)	FPFU with 28 v. DC input power.
AC	Power distribution unit, AC (jack)	Transformer/rectifier, 400 Hz. (jack)	GPFU with 400 Hz. input power.
DC	Power distribution unit, (jack)	Control/pressure sensing module and GPFU outlet airflow valve (jack).	All GPFU.
DC	Transformer/rectifier, 60 Hz. (jack)	Power distribution unit, DC (jack)	GPFU with 60 Hz. input power.

Port **65** is provided in entrance **17** in case it is desired to use a separate recirculating filter unit as discussed above. In the event that a separate recirculating filter unit is used for entrance **17**, a conduit the same as conduit **13** shown in FIG. **1** would be connected between port **65** and the recirculating filter unit. Storage pockets **66** can be provided in any location and number, as desired, by mounting the pocket on the butyl cloth by means of conventional fabric fasteners **67** sewn to the butyl cloth and pocket **66**, as shown in FIGS. **1**, **4**, and **16.** After entrance **17** is attached to shelter **8**, as described above, dust cover **72** is removed to expose opening **73** with diffuser means **74** therebelow, as shown in FIGS. **11** and **24**, and sliding-plate airflow valve shown at **64** is mounted over opening **73**, as shown in FIG. **4**. Dust covers, such as cover **75** shown

in FIG. **10**, are then removed from each sliding-plate airflow valve at **64**, on top of entrance **17** and mounted on FPFU **10** as shown in FIG. **1**; port **65**; and the port to which conduit **13** is connected. After removal of the dust covers, conduits **13** and **76** are connected, as shown in FIG. **1.**

To place our system in operation, power as described above is supplied to our system by turning on the main power switch of control/pressure sensing module **15** to cause power distributon unit **14** to supply the necessary electrical power to system components as described above. Purified airflow begins to circulate through our system as shown in FIG. **35**, and the airflow is controlled by the pressure sensing network, described above, which in turn operates the sliding-plate airflow valves. When a pressure change occurs in shelter **8** or entrance **17**, the change is monitored by the pressure sensing network shown in FIG. **55**, and an electrical signal from the network activates drive motor **77** which causes door **78** to open or close, depending on the direction motor **77** is driven by the pressure sensing network, to supply more airflow to increase the pressure or to decrease airflow as required; door **78** being operated by connection of the door with the motor through cooperation of spur gear **79** of motor **77** with gear rack **80** fixedly connected to door **78**; the valve structures being shown in FIGS. **45** to **53.** Door **78** is slidably mounted within housing **81** by means of rails **82** fixedly mounted within housing **81**, and motor **77** is fixedly mounted within housing **81** by means of motor mount **83.** Limit switch assemblies shown at **84**, fixedly mounted within housing **81**, stop the travel of door **78** in the fully closed and fully open positions, but leaf spring **85**, fixedly mounted within housing **81**, provided as a safety means in the event of failure of switch assembly **84** to permit spur gear **79** to run off of gear rack **80** and allow motor **77** to continue to run without damage to the motor or the valve shown at **64.** When motor **77** receives an electrical signal from the network shown in FIG. **55** to reverse direction when gear **79** is off of rack **80**, pressure by leaf spring **85** causes spur gear **79** to again engage rack **80**, and the valve shown at **64** continues to function. Regarding GPFU shown at **10**, particulate filters **5** nest within gas filters **6**, and each particulate filter contains a gasket **86** at each end of the filter within a recess in the end of the filter to permit installation of the filter within the GPFU with either end first. Filters **5** are made of two layers of conventional filtering media similar to an automobile carburetor air cleaner; a secondary layer being a relatively coarse material to extend dust loading and to serve as a support for the primary layer, and the other layer being a high efficiency material for primary particulate filtration and to serve as a backing to the coarse layer. Filters **5** have an airflow resistance of 2.0 inches WG at 2000 cfm and a 99.97 percent collection efficiency on 0.3 micron particles. Pressure taps are mounted within the GPFU and connect to power distribution unit **14** by means of tubing **87** to indicate when filter **5** airflow resistance is at a high level due to dust loading in order to monitor our system to determine when filters **5** should be replaced. Filters **6** have gaskets **88** mounted on the ends thereof in the same manner and for the same purpose described above regarding filters **5** and gaskets **86**, and filters **6** contain conventional ASC Grade **1** activated, impregnated charcoal as the filter medium. Filters **6** have an airflow resistance of 4.0 inches WG at described above regarding filters **5** and gaskets **86**, and filter **6** contain conventional ASC Grade **1** activated, impregnated charcoal as the filter medium. Filters **6** have an airflow resistance of 4.0 inches WG at 200 cfm, and they are supported and positioned radially by means of guides **89** and held in position longitudinally by means of cover **90** removably attached to the GPFU housing by bolt means, not shown in the drawing, through boss **91**; handles means **92** being fixedly attached to cover **90** to permit a grasping means for removal or placement of cover **90** and conventional gasket means **93** fixedly attached to cover **90** as a sealing means. Filters **5** are radially positioned by insertion within filters **6**, and they are held longitudinally in position by means of access cover **94** held in place by retaining member **95**, which is fixedly attached to cover **90** by the swivel joint shown at **96**, as shown in FIGS. **38** to **40** and **44**, which is closed by means of the latching assembly shown at **97** in FIG. **42** and the hand screw spring loaded assembly shown at **98** in FIG. **43** for preloading filter(s) **5** to assure positive compression on gaskets **88**; access cover **94** having handles **99** fixedly attached thereto for removal and positioning of the cover and conventional gasket means **32** fixedly mounted thereon as shown in FIG. **41** for sealing purposes. In the closed position shown at **20** in FIG. **3**, our apparatus is transported by means of handle **100**.

It is obvious that other modifications can be made of our invention, and we desire to be limited only by the scope of the appended claims.

We claim:

1. A system to provide protection in a contaminated atmosphere area comprising: a protective shelter means; a portable protective entrance means adapted to be connected to the shelter means, said entrance means having a top and bottom and flexible, foldable sidewalls and adapted to contain all entrance structure members and to be closed into a suitcase-like container with the structure members therein for transport from place to place; a gas-particulate filter unit adapted to be connected to the shelter and entrance means to purify contaminated air for supply of pure air to the shelter and entrance means; conduit means adapted to connect the gas-particulate filter unit to the shelter and entrance means, a power distribution unit to supply electrical power to all electrical components of the system; a pressure sensing network adapted to sense and control the pressure differential between ambient and the shelter means and the entrance means and to transmit an electrical signal to activate a plurality os sliding-plate valves, and a plurality of sliding-plate valves adapted to control the air flow through the system.

2. The system of claim **1** wherein the entrance means structure members comprise a pair of support members adapted to be erected between said top and bottom; a door frame means adapted to be erected between the top and bottom opposite to the support members; a pair of brace means adapted to be erected between the midpoint of the support members and the bottom; means adapted to permit the support members, the door frame means, and the brace means to be folded for storage in the bottom; locking means adapted to maintain the suport members, the door frame means, and the brace means in the erected position; a door adapted to be erected on the door frame means to provide an airtight seal for the entrance means, means adapted to permit the door to be folded for storage in the said bottom; means adapted to maintain the door in an erected mode; an opening defining means in the said top to permit a sliding-plate valve to be superimposed thereon; and wherein said side walls comprise a butyl coated cloth fixedly and sealingly attached to the top, bottom, support members, and door frame means and adapted to be folded and stored in the bottom, and sealing means to prevent contaminated air leakage into the entrance.

3. The system of claim **1** wherein the gas-particulate filter unit comprises a mount means, a housing means, an air inlet means integral with one end of the housing means, an air outlet means integral with a side of the housing means adapted to have a sliding-Plate valve superimposed thereon, dust exhaust means integral with the air inlet means, dust collector means integral with an end of the air inlet means and within the housing means, fan means integral with the dust collector means at the end opposite to the air inlet means and within the housing means, gas filter means adjacent to the housing inner wall, particulate filter means nested within the gas filter means and surrounding the dust collector means and the fan means, a plenum chamber means located between the inner wall of the housing means and the outer wall of the gas filter means, and access cover means to retain the gas filter means and the particulate filter means within the filter unit.

4. The system of claim **3** wherein the particulate filter means comprises a course material backing media to support a high efficiency filtering material, said particulate filter means having an airflow resistance of 2.0 inches wg at 200 cfm and 99.97 percent collection efficiency on 0.3 micron particles.

5. The system of claim **3** wherein the gasfilter means contains activated impregnated charcoal and has an airflow resistance of 4.0 inches wg at 200 cfm.

6. The sytem of claim **1** wherein the power distribution unit is a 28 volt direct current source.

7. The system of claim **1** wherein the power distribution unit is a 208 volt alternating current, 60Hz, three phase source having a 60Hz transformer/rectifier system in combination therewith to convert the alternating source current to 28 volts direct current.

8. The system of claim **1** wherein the power distribution unit is a 208 volt alternating current, 400Hz, three phase source having a 400Hz transformer/rectifier system in combination therewith to convert the alternating source current to 28 volts direct current.

9. The system of claim **1** wherein the sliding-plate valves comprise a housing means; a pair of ports within the housing means; a pair of rail means fixedly mounted to the housing means adjacent to the ports to permit travel of a door means therebetween; a door means to travel between the rail means to open and close the ports; a gear rack fixedly mounted on the door means on the side thereof opposite to the ports; a motor means fixedly mounted within the housing means above the horizontal plane of the door means and adjacent thereto; a spur gear integral with the motor means adapted to engage the gear rack and activate the door means upon receipt of an electrical signal by the motor means from the pressure sensing network; a pair of limit stop switches fixedly mounted on a side of the housing, one switch being located adjacent to each end of the housing means; and a leaf spring fixedly mounted on each end of the housing means adjacent to the switches.

10. The system of claim 1 having a control panel in combination therewith, the panel comprising an electrical terminal board means; an electrical connector means; a main electrical power switch; an audible alarm means; an alarm means switch; an hour meter; a holding coil means; an indicator light means; a plurality of circuit breaker means; and an electrical filter means.

11. The system of claim 1 wherein the pressure sensing network comprises a pressure transducer means, a first electrical connector means to connect the transducer means to an electrical circuit means, an electrical circuit means to receive imput from the transducer means and to transmit an electrical signal to operate the sliding-plate valves, and a second electrical connector means to connect the electrical circuit means to the sliding-plate valves.

12. The system of claim 11 wherein the electrical circuit means comprises a plurality of capacitor means, a plurality of diode means, a plurality of resistor means, a plurality of transistor means, and a plurality of operational amplifier means.

13. A method of providing protection in a contaminated atmosphere area comprising the steps of: erecting a protective shelter, with an access way; providing a collapsed suitcase shaped entrance means having a top and bottom encasing joined folded support members and folded coated cloth walls connecting said top and bottom and the support members, said entrance means also having folded door and frame means and associated folded coated cloth covering said door; unfolding the support members and door frame thereby moving the said top and bottom away from each other to erected position while contemporaneously unfolding the associated said cloth and securing said support members and door frame in the unfolded erected position; connecting the erected entrance means to the shelter at said access way in sealing engagement to prevent the entrance of contaminated air therein; connecting electrical component means of the shelter and the entrance to a power distribution unit, activating the power distribution unit, passing contaminated air through a gas-particulate filter unit to purify the air for supply to the shelter and the entrance, monitoring the pressure within the shelter and the entrance to control the airflow therein; transmitting the monitored pressure to an electrical circuit means to convert the pressure to an electrical signal to activate sliding-plate valves; transmitting an electrical signal from the electrical circuit means to the sliding-plate valves to activate the valves, and activating the valves to control the airflow through the shelter and the entrance.

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