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(71) Applicant:
Respirex International Limited
Tunbridge Wells, Kent TN4 9SB (GB)

(72) Inventor: **Musgrove, Chris Alan**
Redhill, Surrey RH1 4AS (GB)

(74) Representative:
Copsey, Timothy Graham et al
Kilburn & Strode,
20 Red Lion Street
London WC1R 4PJ (GB)

(54) Airflow management system

(57) The present invention relates to air flow control apparatus comprising an air inlet, a pressure responsive air flow control means, and an air outlet. The air flow in the outlet is maintained above a critical value across a range of pressures by means of the air flow control means.

EP 1 093 830 A1

Description

[0001] The present invention relates to air flow management systems, in particular for use in association with protective clothing used in the chemical, pharmaceutical, petrochemical and fire service industries.

[0002] Air flow systems for use with protective clothing comprising an air inlet, an orifice, a warning device, an air distributor and at least one air outlet to the hood and optionally including a ventilation system for the arms and legs of the clothing are known. However, in these systems the air flow rate is fixed for a given air supply pressure by the dimensions of the orifice fitted in the air supply line. Therefore, if there is a sudden change in pressure, the flow rate of air to the hood changes. This is particularly dangerous if the pressure of the air supply drops dramatically causing the air flow rate to the hood to drop below a critical level. This sudden loss of air flow would force the user to exit the area in which he is working immediately to correct or restore the air flow.

[0003] Another problem of this prior art system is that if there is a permanent change in the pressure of the air supply, the orifice has to be changed for all units running off that supply to maintain the flow rate of the air to each of the hoods. This may involve a recalculation to determine the size of the orifice required for the diameter of pipe used and the new air supply pressure. A still further problem with this system stems from the fact that the warning device, air distributor and outlets are all contained within the protective clothing having a single exit to an external air source. This arrangement makes the clothing expensive to manufacture and makes them difficult to clean.

[0004] The present invention seeks to overcome the problems of the prior art. A first object is to provide a system which can react quickly to a change in the pressure of the air supply. A further object is to provide an air flow system which is separate from the protective clothing and may be worn externally.

[0005] According to the invention, there is provided an air flow control apparatus comprising an air inlet, a pressure responsive air flow control means, and an air outlet, in which air flow in the outlet is maintained above a critical value across a range of pressures by means of the air flow control means. The pressure responsive air flow control means are capable of reaction to a change in the pressure of the supplied air. In particular, the flow rate of air is maintained at a safe level over a wide range of pressures without the need to exit the dangerous area to change a component of the apparatus to compensate for a change in the supply pressure. The apparatus responds equally efficiently for both an increase and a decrease in the air supply pressure.

[0006] Preferably, the air flow control means comprises piston means and associated channel means, the position of said piston means controlling the flow of air through the channel. More preferably, the piston means incorporate a further channel through the piston through which air flows to a chamber at the rear of the piston. The position of the piston is thus controlled by the air pressure in said chamber, and is preferably balanced by a spring acting on the front of the piston and the air pressure in the chamber on the rear. It is the equilibrium between the force from the spring and the pressure of the air on the base of the piston which determines the position of the piston in the channel, and hence the air flow to the outlet. An increase in either will result in movement of the piston one way or the other until a new equilibrium is reached.

[0007] Preferably the apparatus further includes a low flow monitor, which optionally includes a whistle arranged to sound if the flow rate drops below a predetermined value. Optionally this value is 180 l/min. This value will be determined by a number of requirements which may include statutory regulations for specific uses of this apparatus.

[0008] Preferably the apparatus further includes a cooling system, which is preferably controlled by piston means and associated channel means, the position of said piston means controlling the flow of air through the channel. This cooling system is preferably a smaller arrangement of the air flow control apparatus. The change in size occurs because the flow rate for the cooling system does not have to be as high as that for the breathing apparatus.

[0009] Preferably the apparatus further includes a filter before the pressure responsive air flow control means. This filter will serve to reduce damage to the air flow control means by removing all solid particles greater than a predetermined size from the air supply. A filter element is easily replaced and it is therefore recommended to include such an element at the front end of the apparatus. The filter is preferably a 5 micron filter.

[0010] The apparatus preferably also includes silencing means. Such means may be either or both of a silencer attached to the outlet of the pressure responsive air flow means and a foam baffle. Silencing means are included to make the device more comfortable in operation for a user. Preferably the noise is reduced to a level of less than 80dB.

[0011] The air flow rate at the outlet leading to the breathing tubes is preferably in the range of from 180 to 250 l/min. The lower limit is set by a statutory requirement to maintain the level of carbon dioxide in the hood at less than 1% by volume. If this statutory value changes, the critical value referred to above will change accordingly.

[0012] Preferably the air flow control apparatus is enclosed within a unit which can be worn externally of the protective clothing. This makes the clothing easier to manufacture and both the unit and the protective clothing easier to clean. This may be of particular importance in the nuclear industry where the protective clothing may be disposed of at the end of use rather than being cleaned. The independent units could be sealed and cleaned before reuse with a new set of clothing. This enables users to purchase cheaper disposable clothing without throwing away the more expensive air flow control unit which was previously part of the clothing.

[0013] The unit may also be used internally of the protective clothing as an independent unit, thereby still making the clothing easier to manufacture and clean. The unit would also be interchangeable between different sets of clothing.

[0014] The connection of the breathing tube to the hood is preferably made by a seal without the use of adhesives or stitching and is preferably by use of a mechanical connection as set out in the following description.

[0015] The invention may be put into practice in various ways and a specific embodiment will be described by way of example to illustrate the invention with reference to the accompanying drawings, in which:

Figure 1 is a block diagram representation of an airflow system of the prior art;
Figure 2 is a view of the airflow management system of the present invention;
Figure 3 is an exploded view of the filter arrangement at the entry to the air flow control means;
Figure 4 is an exploded view of the air flow control body and the air flow control means;
Figure 5 is a partial cross section view of the air flow control means;
Figure 6 is a partial cross section view of the cooling control body;
Figure 7 is a partial cross section, partial exploded view of the low flow warning device;
Figure 8 is an exploded side view of the complete system as it is assembled;
Figure 9 is a perspective view of the foam baffle;
Figure 10 is an exploded view of the breathing hose connection to the hood of the protective suit;
Figure 11 is an exploded view of the breathing hose connection to an adapter for connection to the air flow control unit; and
Figure 12 is a view of the connector on the air flow control unit for connection with the breathing hose connection as shown in figure 11.

[0016] Figure 1 shows (in the form of a block diagram) an airflow system according to the prior art. The air supply comes from the source (e.g. a ring system or from a cylinder) and passes through a filter 1 and an orifice 2, both of which are contained in the pipe external of the protective clothing 3. The pipe 4 then passes through a seal 5 in the suit 3, through a safety device 6 (such as, for example, a whistle) to a distributor 7. The safety device is set up such that if the air flow drops below a predetermined minimum value, an alarm will sound.

[0017] At the distributor 7 the air flow is routed into at least two breathing air tubes 8, 9 which pass to the head region of the protective clothing to provide air for the user. Additionally there may be a further tube 10, which leads to a ventilation system for the arms and/or legs of the protective clothing. This air provides cooling, and the flow rate in this section does not have to be maintained at the same rate as that for the breathing tubes. However, there is no separate control of the flow rate in the ventilation system independent of that for the breathing tubes. The airflow to the whole system (both breathing and cooling) is controlled by the pressure of the air supply, and by the size of the orifice 2. This orifice is fixed for any given set of apparatus and cannot be quickly changed in response to a sudden change in the pressure of the air supply. As explained above, if there is a sudden decrease in the pressure of the air supply, the user will have to leave the area immediately and rectify the fault or adapt the equipment to compensate for the change.

[0018] Figure 2 shows (schematically) apparatus according to the present invention with the foam baffle removed. This baffle is added during assembly for the purpose of further noise reduction. Air passes from the air supply means to the air flow control apparatus 20 via a hose 21. The air passes through a filter (see figure 3) contained within the main portion of the control body 42. The air then passes both to the air flow control means 43 and to a cooling control body 24 which may or may not be operated depending upon the form of protective clothing being worn and the external environment in which it is worn. Within the air flow control means 43 the air passes through an annulus 52 in a channel 51 (see figure 5), the size of which is determined by the position of the piston 50. From channel 51 the air passes primarily to the air flow outlet 25, but also to a low flow warning device 26.

[0019] The air flows through the outlet 25, via a silencer 27 to the two outlet tubes 28 which are connected to breathing hoses which carry air to the head region. As indicated above, there is also a foam baffle 80, which is positioned in the air flow control apparatus which serves to further reduce the noise. The shape of the baffle is shown in figure 9, and in its assembled position extends from the cooling control body 24, over the outlet 25 filling the space up to the corner. It then extends round the ends of the air flow control means 43 and the whistle head 71 and is flush with the edge of the shell 22 in front of both outlets 28. Air can, of course, flow through this foam baffle to the outlets.

[0020] The low flow warning device comprises a whistle 70 (see figure 7) which is covered by a whistle head 71 to prevent the foam baffle 80 muffling the sound of the whistle. As is the case in traditional systems, the whistle is designed and arranged to sound if the air flow rate drops below a predetermined level.

[0021] The cooling means 24 receives filtered air from the control body 42 and passes it to a system which is similar to that in the main air flow control means 43. Again, there is an annulus 62 in a channel 61, the size of which is controlled by a piston 60 (see figure 6). Air passes out from the cooling means 24 to an outlet 29 which is connected to a hose which passes to the suit or hood being worn, where the cooling air is distributed to the arms and legs by tubes within the suit.

[0022] Figure 3 shows (in exploded view) the filter arrangement at the entry to the air flow control means 20. The filter unit 30 is easily removed from the air flow control apparatus in order that the filter element 34 can be replaced when necessary. In operation, the incoming air passes via a bore hose 31 (typically 10mm (3/8 inch) diameter) to the filter unit 30 from where it passes on to the air flow control unit 20. The unit 30 comprises a collar 32 which is sealed to the shell 22 of the control apparatus by means of three cap head screws (not shown). A centre spigot 33 to hold the filter element 34 is sealed by two o-rings 35, 36. The filter element 34 is sealed to the centre spigot 33 by two washers 37, 38 and a screw 39. The filter element 34 is preferably a 5-micron filter, although 25 or 50 micron filters could also be used.

[0023] In the event that the filter element 34 needs replacing for example if the air flow rate has dropped due to a suspected blocked filter, the user can remove the unit 30 from the air flow control apparatus 20 by unscrewing the three cap head screws (not shown) which pass through the collar 32. The filter element is then removed by unscrewing the screw 39 and lifting the filter element 34 (and the two washers 37, 38) off the centre spigot 33. The filter element may then be cleaned or replaced as appropriate. Once it is screwed back into position, the filter unit 30 can be tightly secured back to the air flow control unit 20 for use. After replacement of or cleaning of a filter element 34, the air flow rate should be tested using appropriate equipment (e.g. flow metres attached to the outlets 28) to ensure that the correct airflow is passing through the system. If the flow rate is correct, the apparatus can be used once again.

[0024] If further filtration is required, it is possible to include a suitable hepa filter in the bore hose 31 external of the air flow control unit 20. These filters are highly efficient and remove particulates with an efficiency of 99.5% or greater. Again a preferred size of filter is 5 microns.

[0025] Figure 4 shows (in exploded view) the air flow control body 42 and the air flow control means 43. The apparatus comprises a clamp collar 41 which sits outside the shell 22 of the air flow control unit 20. The air flow control body 42 sits inside the shell 22 and is held in place by means of cap head screws (not shown) passing through the collar 41 and the wall 22 into the body 42. From the body 42 there are three outlets. A first leads to the air flow outlet 25 onto which is attached a silencer 27. A second 44 leads to the low flow warning device 26 (see figure 7). The third 45 leads to the cooling control body 24. Before passing to any of these outlets the air has already passed through the filter 34 which, when fitted, sits inside the portion 46 of the main body 42. The filtered air passes directly to the outlet 45 to the cooling control body 24, and simultaneously on to the air flow control means 43. Further details of this can be seen in figure 5.

[0026] Figure 5 shows, in partial cross section, the air flow control means 43. A piston 50 is positioned within a chamber 51 through which air may flow. The size of the annulus 52 at the entrance to the chamber 51 is governed by the position of the piston 50. The piston 50 includes a through channel 53 through which air flows to a chamber 54 at the rear of the piston 50. The pressure of the air contained within this chamber 54 tends to push the piston 50 forwards, thus decreasing the size of the annulus 52. At the same time, springs 55 operate to push the piston 50 back towards the chamber 54. If the pressure of the air supply increases, the amount of air flowing through the channel 53 in the piston 50 increases thereby increasing the pressure in chamber 54. This increased pressure pushes the piston 50 forwards, decreasing the size of the annulus 52 through which air flows to the air flow outlet 25 and the low flow monitor device 26. The opposite effect occurs if the pressure of the air supply decreases, the pressure in the chamber 54 drops and the piston is pushed backwards by the springs 55 and the size of the annulus 52 increases. This allows more air to flow to the outlets 25 and 26.

[0027] This compensatory system maintains a regular flow rate to the air flow outlet 25 when the pressure of the air supply changes. In the system of the prior art, such a change in air pressure could not be controlled without changing the dimensions of the orifice 2 which could only be done when the system was shut down and the pipe to the suit dismantled.

[0028] At the top of figure 5 is shown one of the screw holes 56 by which the body 43 is attached to the shell 22 and the collar 41. The piston 50 has two o-rings at positions 57 and 58 to prevent any air reaching the chamber 54 by any means other than through the channel 53 in the piston 50.

[0029] The cooling control body operates on the same principles as the main air flow control means 43 as described above. The apparatus is shown in figure 6. The piston 60 controls the flow of air through the cooling control body by means of the flow of air through a channel 63 in the piston 60 to a chamber 64. Again the balance of air pressure from the chamber 64 on the base of the piston 60 against the springs 65 acting on the front of the piston affects the size of the annulus 62 through which the air flows to the outlet 29. The connection of the cooling tubing to the outlet 29 may be a conventional coupling collar.

[0030] The low flow warning device 26 is shown in more detail in figure 7. This is a conventional system in which the whistle 70 sounds when the air flow rate drops below a predetermined level. In normal operation, the flow of the air acts to hold the diaphragm 72 against the spring 73, blocking the air passage 74 through to the whistle 70. Air flows from the air flow control body 42 via outlet 44 to the warning whistle body 75 where is acts on the diaphragm 72. This pressure on the diaphragm 72 acts against the spring 73 which is housed in the warning whistle control cap 77. The consequent position of the diaphragm head 76 prevents air flowing to the whistle. However, when the air flowrate drops, the pressure against the spring 73 drops, the diaphragm 72 and associated head 76 consequently move forward and the airway 74 to the whistle 70 is opened and the whistle sounds. As stated previously, the whistle 70 is covered by a whistle head 71 to prevent the foam baffle 80 muffling the sound of the whistle.

[0031] Figure 8 shows an exploded side view of the complete system as it is assembled. The base section 20 containing all the elements described above (air flow control means 43, cooling control body 24 and low flow warning device 26) is padded out with a foam baffle 80 (of the shape shown in figure 9) to assist with noise reduction to below the required level. The lid 81 has a foam plate 82 laid inside (again for the purposes of noise reduction). The lid 81 is connected to the base section 20 by means of hexagonal screws 83 and dome nuts 84. An o-ring 85 is placed between the two sections to aid sealing. The assembled unit is then attached to an adjustable belt (which may be made of PVC or any other suitable material) and the unit is worn around the waist of the user, outside the chemical protective clothing.

[0032] The foam baffle 80 is formed in the shape shown in figure 9. This has been designed to ensure that the noise reduction is sufficient to take the level below the required standard, and also to provide equal air flow out through outlets 28 to the breathing tubes. The baffle 80 has a hole 90 in one of the sections. This hole is intended to be aligned with the silencer which is at the end of the flow outlet 25 from the air flow control means 43.

[0033] As stated above, the unit may be worn externally of the protective clothing which enables both disposable and reusable clothing to be used with this unit. The outlets 28 of the air flow control unit are connected via flexible PVC hoses to the hood of the clothing. The connections at each end of this hose are shown in figures 10 and 11 respectively. The mechanical connection shown has been designed to ensure an air tight connection around the entry to the hood, even when adhesive cannot be used.

[0034] Figure 10 shows the connection of the hose 100 to the hood. The hose 100 is clamped to a pair of clamp collars 101, 108 by means of a hose clamp collar 102; a collar retaining shaft 103 and a retaining collar 104. Two clamp collars are connected to the retaining shaft 103. The clamp collar 101 is slid onto the shaft 103 outside the protective hood and the shaft is then fed through an aperture in the hood to the external breathing tube clamp collar 108 which is screwed onto the shaft 103. To ensure a tight seal is maintained around the aperture in the hood two rubber washers 110 are added between the clamp collars on either side of the protective hood. The end of the hose 100 is then placed over the non screw end 105 of the retaining shaft 103. The clamp collar 102 is placed over the hose 100 such that the square troughs 106 in the collar 102 engage with the ridges 107 on the shaft 103. The clamp collar 102 folds shut over the hose 100 and is retained in place by means of the retaining collar 104 which is a snap fit onto the clamp collar 102. The hose is thus secured to the shaft 103, which feeds the breathing tube 108 in the hood. This secure connection is mechanically made without a need for adhesives or stitching.

[0035] A similar mechanical connection at the other end of hose 100 is shown in figure 11. The hose 100 is connected to a connecting collar 111 which screws onto the outlet connections 28 of the air flow control unit (see figure 12). A stem retaining collar 120 inside the shell 22 of the unit is attached to the shell 22 and this collar 120 supports a movable joining collar 122. The connecting collar 111 is then detachably secured to the air delivery stem by rotation of the joining collar 122 and movement in the direction of the arrow shown on figure 12.

[0036] The apparatus described above is manufactured principally of polypropylene which is chosen for its chemical resistance. The assembled unit has minimal protrusions/recessions which could be areas where chemical become entrained and are difficult to clean. The hoses used are made of PVC because of their flexibility and ease of manufacture, however any suitable material may be used, for example polythene. A number of the internal mouldings are made of acetyl, although again the invention is not limited to this material. It will be appreciated that this portable unit can be sealed at the respective outlets and inlets and thoroughly washed to decontaminate the unit, for example when used in an area of radioactivity. This enables the unit to be reused when the protective clothing may have been destroyed. This was not possible in the prior art systems where the airflow system was largely inside and connected to the protective clothing.

[0037] The units can also be worn internally of the protective clothing, but they are still independent and do not hinder the cleaning or disposal of the protective clothing after use. The unit is the same as that for external wear described above. When the unit is worn internally, the length of the bore hose 31 (see figure 3) is reduced to avoid problems with it getting tangled up with the limbs of the user. For internal use, the hoses 100 which leave the top of the unit pass inside the clothing to the hood region where they are held in place by material tubes in the hood. The outlets are thus held in a position similar to that when the hoses enter the hood from outside.

[0038] Apparatus as described above has been tested at a range of pressures, taking measurements of the flow rates in the breathing tubes both when the cooling system is connected and when it is not. When the cooling system is operated, the flowrates in that system are also recorded. Six different units were tested. The first three units (units A, B and C) were tested both without the cooling and with the cooling system running. The results are shown in table 1 below.

	Breathing tubes only			Breathing tubes with cooling connected			Cooling tubes		
Air line pressure (psi)	A	B	C	A	B	C	A	B	C
20	200	195	190	160	150	150	120	130	135
30	240	245	230	200	210	185	170	160	185
40	245	250	235	225	225	205	195	185	205
50	245	245	240	230	230	220	185	190	210
60	240	245	240	230	230	230	180	190	205
70	245	245	245	230	235	235	185	195	220
80	245	245	245	235	240	240	195	205	220
90	245	250	250						
100	250	250	255	240	240	240	210	200	235
110	250	250	255						
120	245	250	255						
130	245	255	260						

Table 1 - Flowrates of air in units A, B and C (in l/min)

[0039] As can be seen from the results for the breathing tubes only, acceptable flowrates are achieved over the range of pressures tested (1.4 - 8.9 bar (20-130 psi)). The flowrates are all within the range 180-260 l/min and are concentrated in the range 240-250 l/min. The lower limit of 180 l/min is set by the need to maintain a carbon dioxide level below 1% by volume in the hood. A flowrate lower than 180 l/min may result in the carbon dioxide level rising. With the cooling system attached, the flowrate in the breathing tubes drops below 180 l/min at 1.4 bar (20 psi), but is well above this value for the remaining pressures tested (2-6.9 bar (30-100 psi)). This would be expected because with the cooling system operating more air is required to be pumped round the system. However, at the relatively low pressure of 2 bar (30 psi) the flowrate in the breathing tubes is back up at a safe value.

[0040] The flowrate in the cooling system does not have to fulfil the same minimum requirement of 180 l/min since the air is being circulated round the suit for cooling purposes and not for breathing. In any event, the flowrate is generally in the region 185-220 l/min. You will note that the addition of the cooling system does not significantly reduce the flowrate in the breathing tubes - typically a drop of only 10-15 l/min - and that the flowrates in the breathing tubes still fall within the range of 180-250 l/min.

[0041] Results for a further three units (D, E and F) are listed in table 2 below. These results show flowrates with the cooling system in operation and the corresponding flowrates in the cooling system. Again at 1.4 bar (20 psi) the breathing flowrates are below the value of 180 l/min, but from 2.0-8.3 bar (30-120 psi) they generally fall within the range 200-250 l/min. The flowrate in the cooling system was lower, typically 145-175 l/min.

	Breathing tubes with cooling connected			Cooling tubes		
Air line pressure (psi)	D	E	F	D	E	F
20	165	160	165	105	110	115
30	210	215	200	135	130	145
40	225	225	220	145	140	150
50	225	230	225	145	145	155
60	230	235	235	155	150	155
70	235	240	240	155	155	165
80	235	240	245	160	165	170
90	235	240	245	160	160	170
100	240	240	250	160	155	170
110	240	245	255	165	160	175
120	240	245	255	165	165	175

Table 2 - Flowrates of air in units D, E and F (in l/min)

[0042] As can be seen from the above results, a flowrate within the range 180-250 l/min is obtained over a wide range of pressures using the current apparatus. It is clear that a sudden change in pressure can be easily accommodated by the apparatus of the present invention without the need to leave the working area to change the pipe to the suit. For example, if the pressure in the air supply was initially running at 4.1 bar (60 psi) and it suddenly dropped to half that value, the flowrate in the breathing tubes would generally drop from approximately 230 l/min to 210 l/min, still well above the limit of 180 l/min.

[0043] The present invention therefore provides a safer, more flexible system than that of the prior art. The unit can be used for a range of air line pressures without changing any of the components (for example orifice plates). Since the units are worn externally of the chemical protective clothing, they can be used by a number of people working in different environments which may have different pressures in the air supply line.

[0044] The silencer and the foam sections present in the assembled unit maintain the noise level below 80db as required by EN270 and prEN943-1. The noise level in the units used for the tests described above ranged from 63 to 65 dB. At the same time, the noise level of the whistle was maintained to be greater than 90 dB by the presence of the whistle head. This is important, to ensure the user is aware of an air flow problem as soon as possible to give maximum time to solve the problem or to clear the area. As indicated above, the air supply pressure will have to drop to a very low value for the air flow rate to drop below the level of 180 l/min.

[0045] It will be apparent to a person skilled in the art that the results from the experiments described above are not dependent upon the exact configuration of the elements in the unit. Therefore it is clear that the key features of the above apparatus as set out in the accompanying claims are applicable to any suitable units.

Claims

1. Air flow control apparatus (20) comprising an air inlet (21), a pressure responsive air flow control means, and an air outlet (28), in which air flow in the outlet is maintained above a critical value across a range of pressures by means of the air flow control means.

2. Air flow control apparatus as claimed in Claim 1, in which the air flow control means includes a pressure balance feature.

3. Air flow control apparatus as claimed in Claim 1 or Claim 2, in which the air flow control means comprises piston means (50) and associated channel means (51), the position of said piston means controlling the flow of air through the channel.

4. Air flow control apparatus as claimed in Claim 3, in which the piston means incorporate a channel (53) through the piston (50), air preferably flowing through the channel to a chamber (54) at the rear of the piston (50), the position

of the piston being controlled by the air pressure in said chamber.

5. Air flow control apparatus as claimed in Claim 3 or Claim 4, in which the piston is acted on by biasing means, said biasing means preferably being a spring (55).

6. Air flow control means as claimed in any preceding Claim, in which the apparatus additionally comprises a low flow monitor (26).

7. Air flow control apparatus as claimed in Claim 6, in which the low flow monitor includes a whistle (70), arranged to sound if the flow rate drops below a predetermined value, preferably 180 l/min.

8. Air flow control means as claimed in any preceding Claim, in which the apparatus additionally comprises a cooling system (24), the flowrate in which preferably being controlled by piston means (60) and associated channel means (61), the position of said piston means controlling the flow of air through the channel.

9. Air flow control means as claimed in any preceding Claim, in which the apparatus additionally includes a filter (34) before the pressure responsive air flow control means.

10. Air flow control apparatus as claimed in any preceding Claim, in which the apparatus further includes silencing means, preferably including a foam baffle (80).

11. Air flow control means as claimed in Claim 10, in which the silencing means includes a silencer (27) attached to the outlet of the pressure responsive air flow control means.

12. Air flow control means as claimed in any preceding Claim, in which the critical value is 180 l/min.

13. Air flow control means as claimed in any preceding Claim, in which the air flow rate in the outlet is in the range 180 to 250 l/min, the range of pressure over which the flow is maintained is 2-10 bar and the noise level is less than 80dB.

14. Air flow control apparatus as claimed in any preceding Claim, in which the apparatus is enclosed within a unit which can be worn externally of protective clothing.

15. A breathing tube for use in association with air flow control apparatus as claimed in any preceding Claim, in which the breathing tube is passed through a protective hood and sealed without the need for adhesives or stitching.

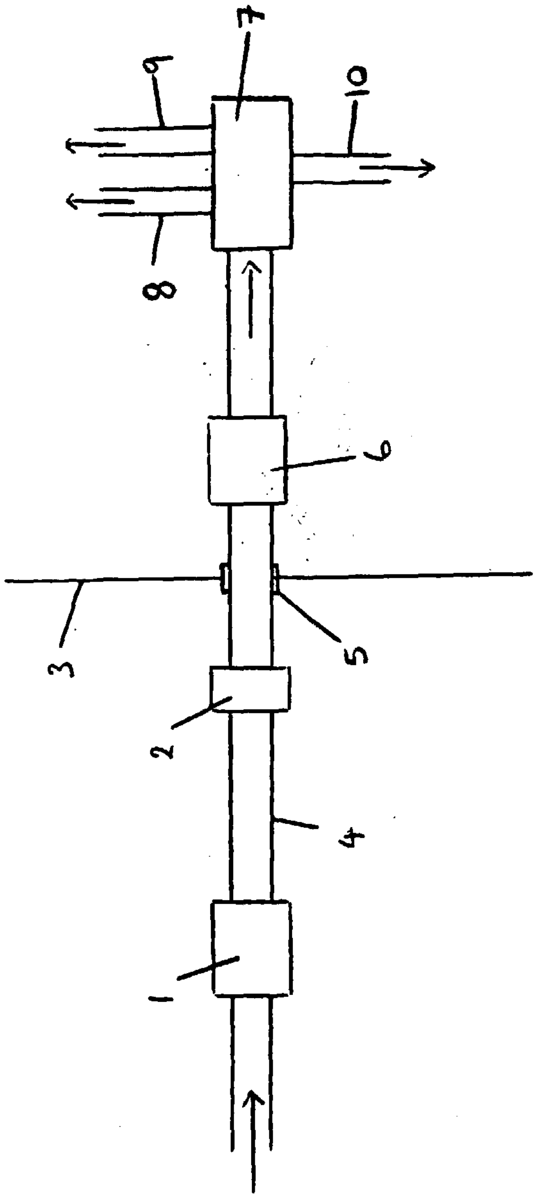

FIG 1

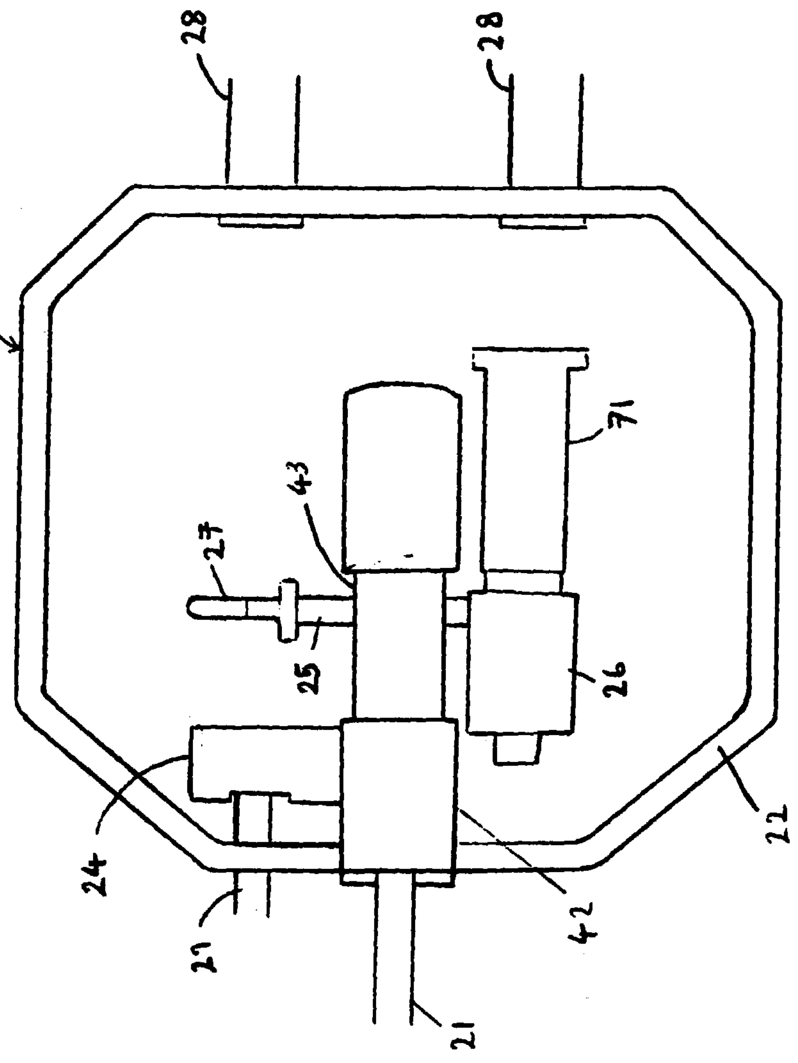

FIG. 2

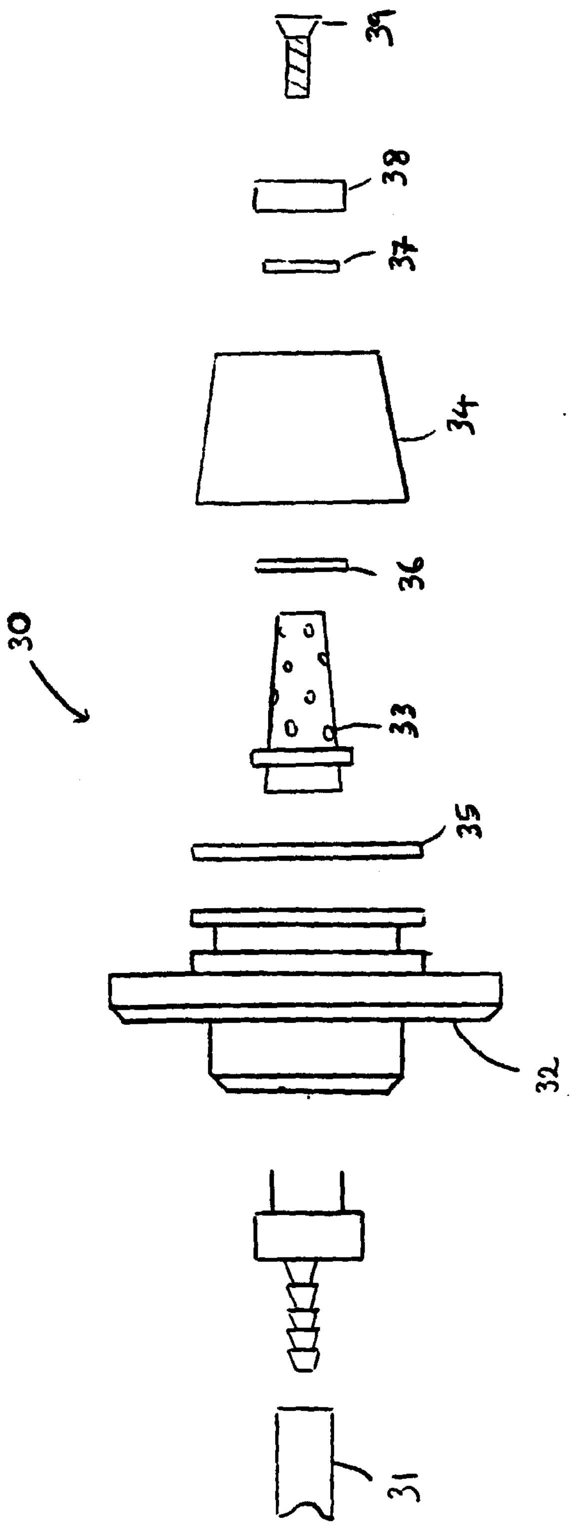

FIG. 3

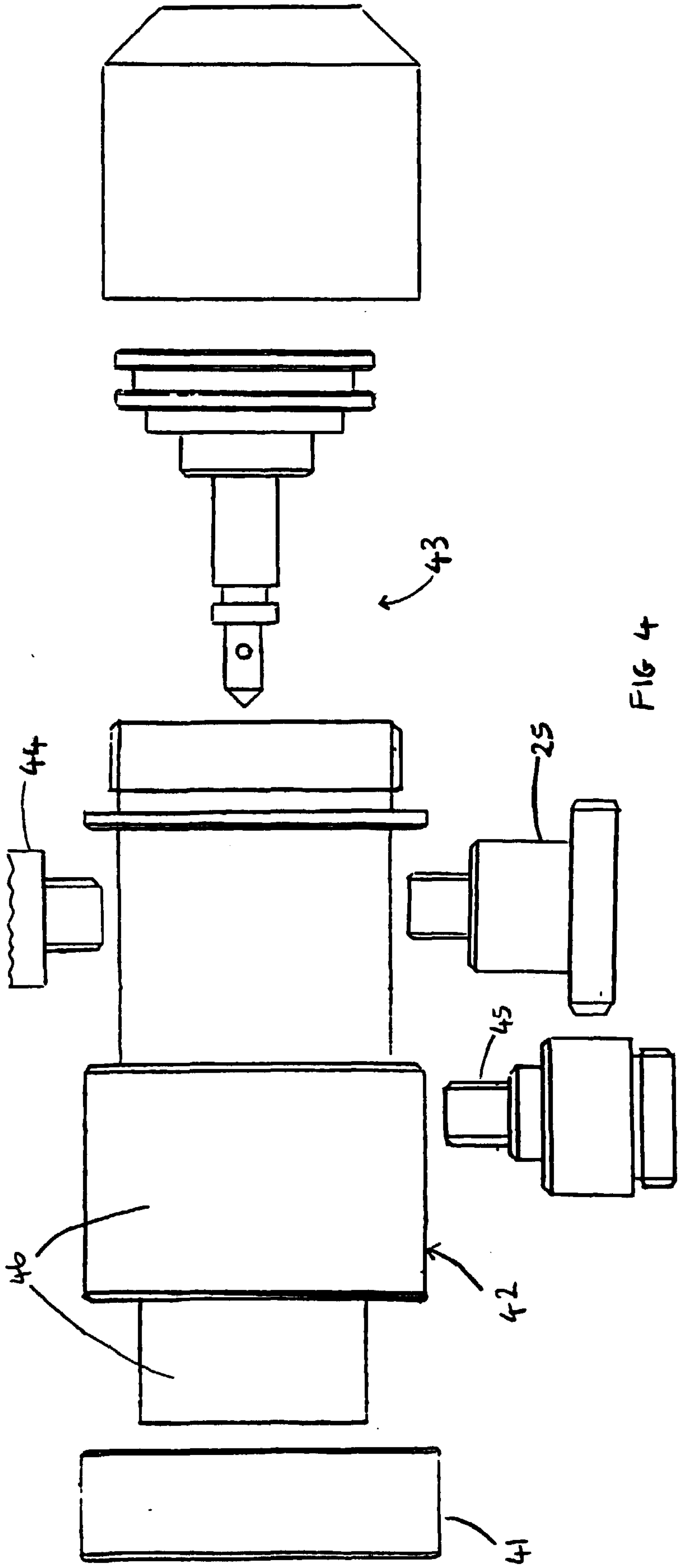

FIG 4

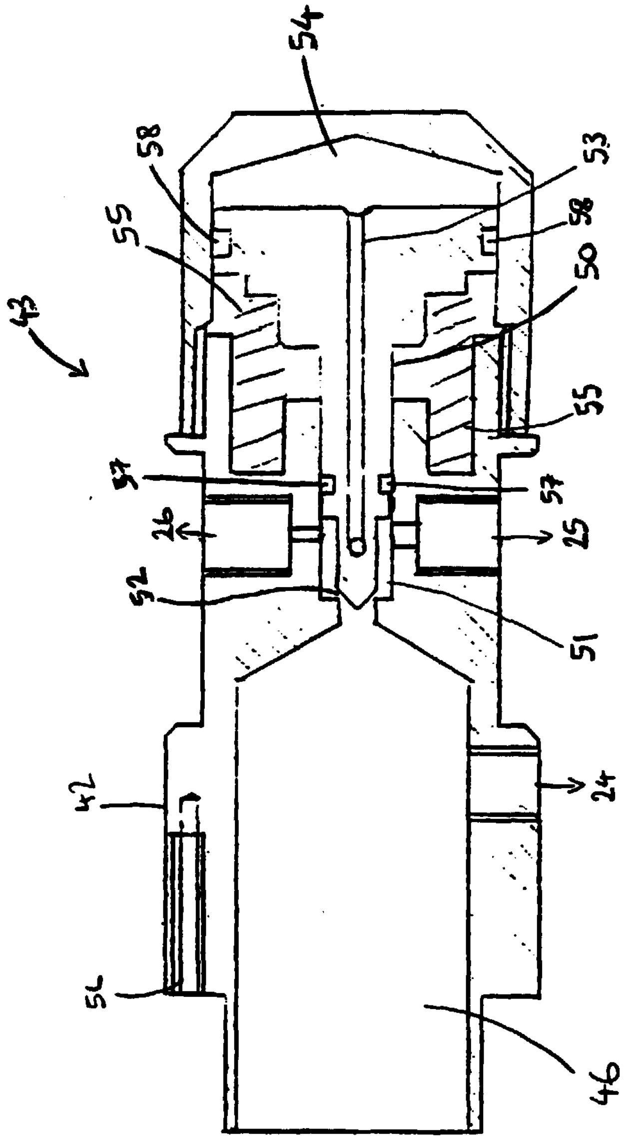

FIG. 5.

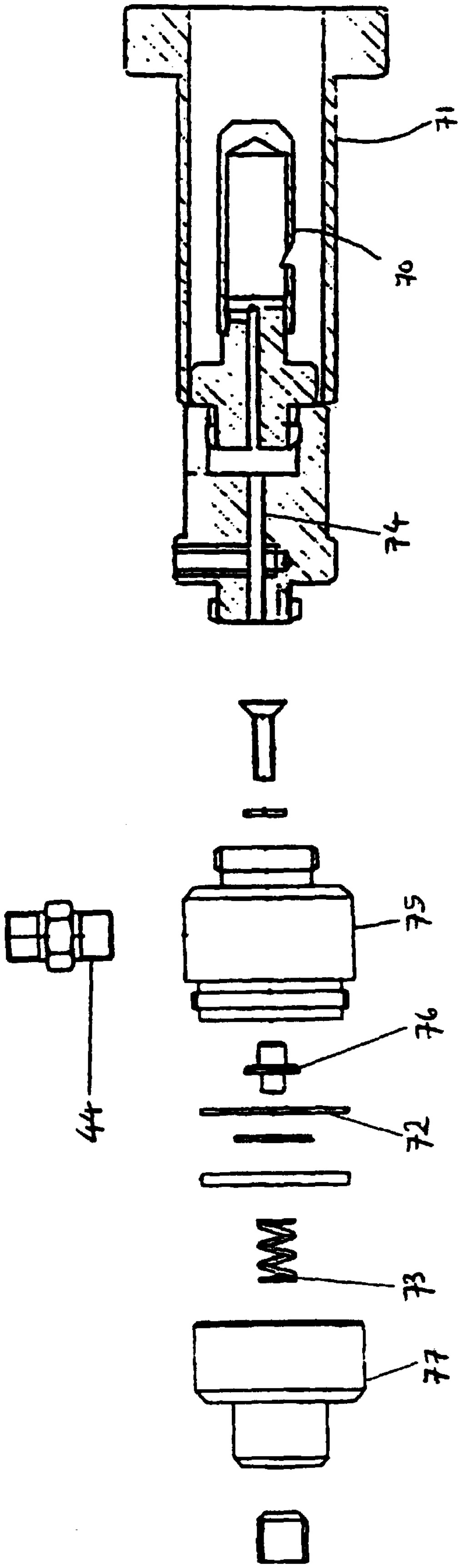

FIG. 7

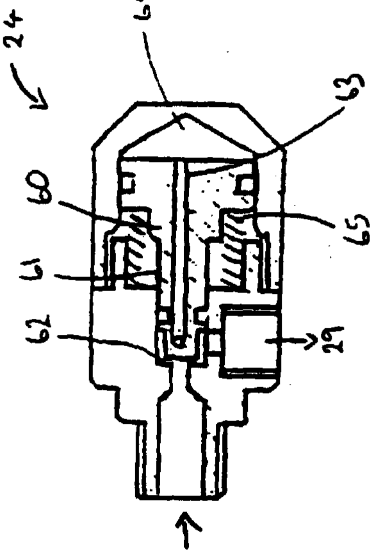

FIG. 6

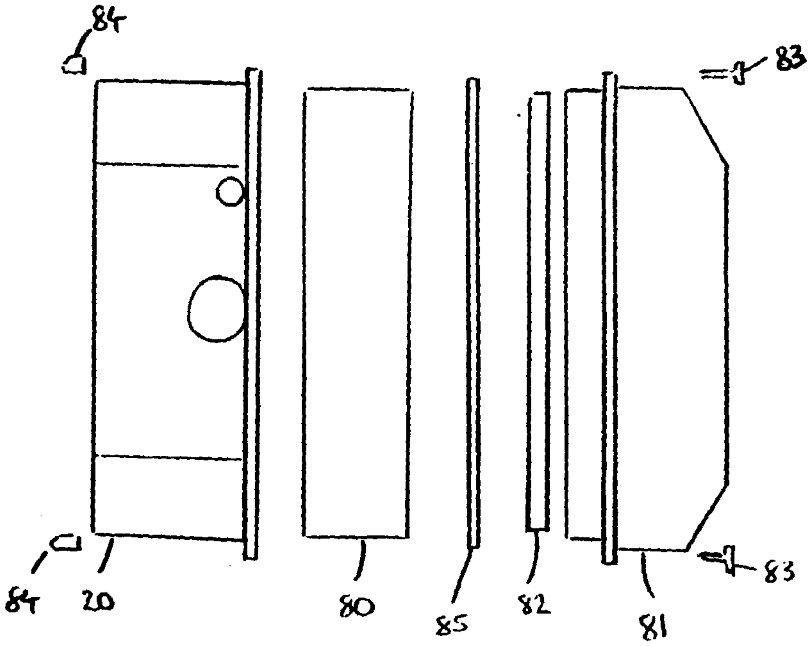

FIG. 8

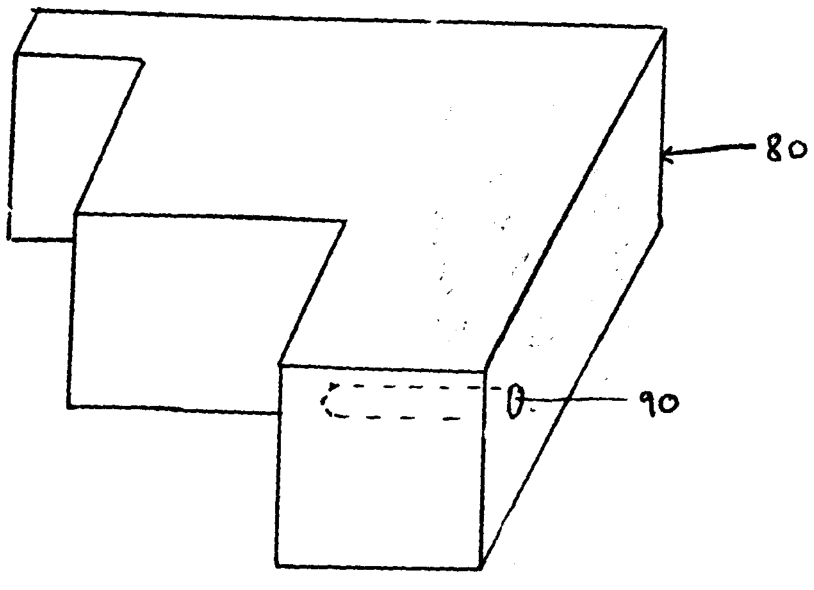

FIG. 9

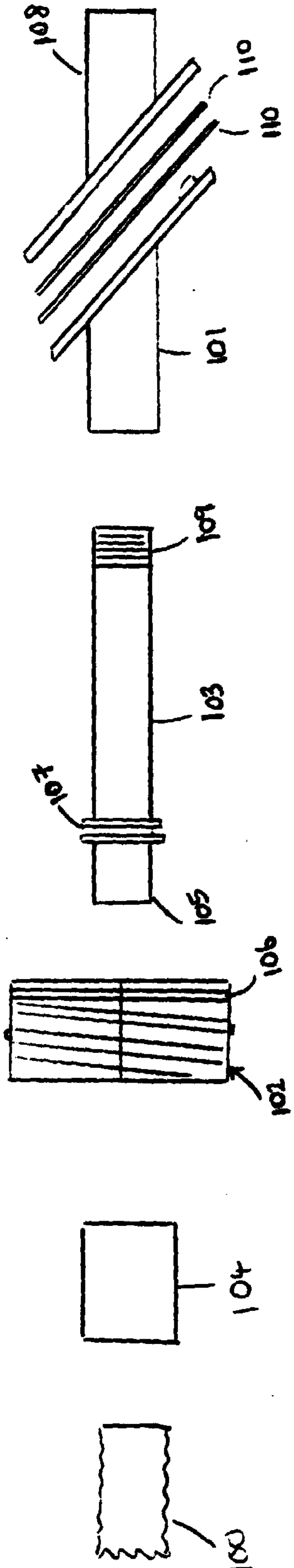

FIG 10

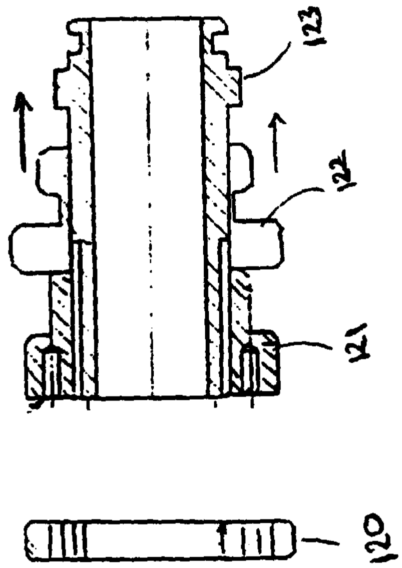

FIG. 12

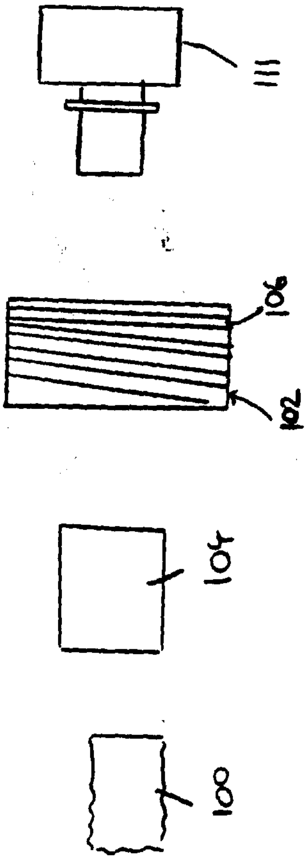

FIG 11

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 30 9115

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 February 2001	van Bilderbeek, H.

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