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Some Aspects of Ventilation and Filtration

D.H. Wheeler, R. Pratt et al.

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SOME ASPECTS OF VENTILATION AND FILTRATION

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SUMMARY

The general principles for ventilation systems are now well established but increased interest in safety and reliability and the constant need to reduce exposure has led to more detailed examination of a number of elements of ventilation systems.

This paper considers four such elements, namely:

1) Back diffusion through slots
2) Fire dampers and spark arrestors
3) Circular HEPA filters
4) In-situ testing of filters

SOME ASPECTS OF VENTILATION AND FILTRATION

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1 BACK DIFFUSION THROUGH NARROW GAPS

1.1 Introduction

In a number of concrete cells there are large plug doors which are removed to provide access into the cell. These doors are not usually sealed and the inward velocity of air through the narrow gap provides the containment and prevents the egress of contamination from the cell.

It has been shown experimentally that for larger openings such as fume cupboards a mean velocity of air of 1.0 m/s is adequate to prevent induced flow outwards but a literature search failed to reveal any published evidence that such a figure can be used to prevent back diffusion through narrow slots such as those round cell doors which are typically only a few mm wide.

1.2 Flow through openings

This problem was considered by Andrew Metcalfe at AERE Harwell(1) and by using the flow equation for streamlined flow he produced the graph which is shown at Fig 1.

The graph plots pressure differences against slot width for different flow velocities and it is clearly seen that as slot width reduces a very much greater pressure difference is required to maintain air velocity through the slot.

Although this is a result one would expect it also shows that for slot widths of less than 2 mm it becomes impossible with normally accepted pressure differences to induce an air velocity of 1 m/sec through the opening. The question must then be asked whether the inability to maintain such a velocity is of any consequence or is the slot so narrow that adequate and acceptable containment is provided.

1.3 Back diffusion through slots

A. Metcalfe has developed his case and arrived at a formula giving the concentration at the operating face of the opening.

$$Co = 0.371 \frac{D^2 \ Cmax}{L^2 \ V^2}$$

where Co = concentration outside slot (μCi/cm^3)

D = coefficient of diffusion (cm^2/s)

Cmax = concentration inside slot (μCi/cm^3)

L = length of crack (cm)

V = velocity in crack (cm/s)

The result from this equation can be compared with the Derived Air Concentration (DAC) for the material under consideration.

Example 1

Consider the case of pure tritium within the cell and a flow rate through the crack of 5.08 cm/s (10 ft/min).

The concentration within the cell obtained from the decay curve of tritium is 1.31 Ci/cm^3.

$D = 0.611$ cm^2/s

$L = 167.6$ cm

$t = 1.8$ cm

$$\therefore \ Co = \frac{0.371 \times 0.611^2 \times 1.31 \times 10^6}{167.6^2 \times 5.08^2}$$

$$= 0.251 \ \mu\text{Ci/cm}^3$$

as the DAC is 2×10^{-5} (Ref 2) then for a concentration less than the allowable, the concentration must be less than

$$1 \text{ part per } \frac{0.251}{2 \times 10^{-5}}$$

1 part per 12,550

Example 2

If we consider an aerosol of plutonium with a maximum concentration of $140 \times 10^{-8}\,\mu\text{Ci/cm}^3$ (Ref 3) in the cell assuming an aerosol size of 2 microns then

$D = 1.4 \times 10^{-7}\ \text{cm}^2/\text{s}$ (ref 4)

$L = 167.6$ cm

$t = 1.8$ cm

$V = 5.08$ cm/s

then

$$\text{Co} = \frac{0.371 \times (1.4 \times 10^{-7})^2 \times 140 \times 10^{-8}}{167.6^2 \times 5.08^2}$$

$$= 1.40 \times 10^{-26}\,\mu\text{Ci/cm}^3$$

as the allowable is $2 \times 10^{-12}\,\mu\text{Ci/cm}^3$ (Ref 2), this is satisfactory.

It is therefore possible to specify a maximum concentration within a cell so that the concentration in air at the crack opening is less than the DAC.

2 FIRE PROTECTION

2.1 Introduction

The design and operation of ventilation systems plays an important role in maintaining the safety of a facility in the event of fire.

It has become apparent that a number of facilities built some years ago do not meet the requirements of the latest Building Regulations which specify fire compartments, fire resistance of structures and escape routes.

When these areas are refurbished due account must be taken of the latest regulations and the ventilation system must satisfy these requirements by careful positioning of fire dampers and removal of smoke as far as it is compatible with proper radiological protection. Any conflict must be resolved by consideration of the relative hazards.

It is not the intention of this paper to discuss the hazard analysis but rather to consider some practical aspects of equipment such as fire dampers and spark arrestors.

2.2 Fire dampers

Where the ventilation ductwork penetrates fire barriers it is necessary that fire dampers should be fitted with the same fire resistance as the barriers but where hot labs are concerned it is not acceptable for them to shut automatically in the event of fire. It may be preferable to maintain ventilation to clear smoke or contamination and it is therefore necessary for the fire and incident officers to have the capability of opening and closing fire dampers from a remote location.

If operation is from a remote location it is highly desirable that the damper position should also be indicated at the same remote location so that the incident officers can tell at a glance the state of the dampers.

Although remote operation is specified there is also the need to provide means of operation local to the damper as a last resort if the remote operation fails for some reason.

It is also undesirable for fire dampers to be actuated under fault conditions such as supply failure and any such faults should not cause the damper to move.

In practical terms the above requirements lead one to specify either an electric motor drive or pneumatic activator but whichever is used it is essential that they satisfy the above requirements of

no automatic operation
damper position unchanged under fault conditions
local and remote operation
damper position indicated
dampers can be closed individually

In addition to these operational requirements the construction of the damper must also

resist corrosion

have the same gas tightness as the duct

allow dampers to close even after they have expanded

maintain same fire resistance as barrier in which they are fitted

Although we have said above that the damper is fitted in the fire barrier this is not possible when the damper operating gear is external to the ductwork and should be readily accessible. In these circumstances the fire damper is located away from the fire barrier as shown on Fig 2 and the section of duct between damper and wall is properly insulated to the same resistance as the barrier.

Fire dampers are not necessary in ducts which are as fire resistant over their whole length as the structure through which they pass.

2.3 Spark Arrestors

It is also apparent that the older installations do not always provide proper protection to the filters in the case of the ventilation duct carrying glowing particles to the filter.

Many installations have long lengths of ductwork between the potential source of fire and the filter which would allow incandescent debris to cool before reaching the filter but where attempts have been made to provide added protection in the form of spark arrestors these have frequently been positioned too close to the filter to be effective.

This state of affairs has not been helped by the diagram in UKAEA Code of Practice AECP 1054 which shows a spark arrestor immediately preceding a HEPA filter nor by the UKAEA specification AESS 30/93700 which allows the spark arrestor frame to be clamped directly to the main filter and states that "the specification covers a non-combustible panel which, when placed upstream of an absolute filter prevents glowing embers and large particles of containment from reaching the filter insert".

Amendments to these documents will emphasise the need for cooling lengths between the spark arrestor and filter and will indicate that the preferred form of spark arrestor is a simple BS 40 mesh which is sited at least 6.4 m upstream of the HEPA filter to allow time for penetrating sparks to burn out. This distance is related to an air velocity of 4 m/s and would need to be greater at higher velocities.

NB The aperture size of BS 40 mesh is 0.35 mm and the screening area is about 35 to 40%.

Spark arrestors are now installed either in a separate chamber some distance upstream from the HEPA filters, or immediately downstream of a preceding filter or at the entry to the extract ductwork, as shown on fig 3.

These spark arrestors are constructed to have a very low filter efficiency in order to avoid the need for periodic replacement and the associated disposal problems and whereas filters are arranged for a downward flow to maximise retention of particles the flow through the spark arrestor should have no downward component to help make it self-cleaning.

3 CIRCULAR FILTERS

3.1 Introduction

An assessment of the problems associated with the installation, removal and ultimate disposal of standard deep-pleat rectangular filters has highlighted the need for alternative designs of filter inserts for remote change filter systems where high levels of alpha, beta, gamma activity can be expected. The main disadvantages of the standard filter insert result from its physical shape.

The rectangular filter is difficult to handle and position remotely, requires a high degree of flatness for the sealing face of the housing, is difficult to post into and out of a containment and produces severe problems in terms of its ultimate disposal into the standard 200 litre drum currently used by the UK nuclear industry.

An examination of alternative filter geometries highlighted several advantages for filters of circular geometry. These are:-

1. Circular filters would be compatible with developed double-lid posting and containment systems.
2. Circular filters would be compatible with existing waste treatment facilities and disposal routes based on 200 litre drums without breakdown or physical manipulation.
3. Circular filters could be sealed into the housings with circular seal rings onto cylindrical sealing surfaces which would be easy to generate to the required tolerances and surface finishes. They could be designed such as to require no mechanical clamping systems to effect a seal between filter and housing.
4. Circular filters would be easier to handle and move remotely.

5. Appropriate design considerations would lead to cylindrical filters significantly weaker in strength than conventional rectangular filters with subsequent ease of volume reduction by crushing prior to ultimate disposal should this be required.

Examination of current filter manufacturing technology and expertise suggested that production of radial flow cartridge filters of HEPA standard was entirely feasible. Some companies had been producing high integrity filters of this type with ratings up to 200 m^3/h for some time, and with the wider introduction of manufacturing capability for pleated panels as used in high-capacity filters no difficulties were anticipated in scaling up to 1700 m^3/h and beyond. A typical filter is shown in Fig 4.

3.2 Development of Filter Inserts

It was anticipated that a range of filter sizes would be required with a maximum physical size being limited by the need to dispose of the filters into the standard 200 litre waste drum. The air flow rate associated with that filter was seen as being 1700 m^3/h. These criteria were met with a filter insert measuring 500 mm by 620 mm long, the differential pressure at 1700 m^3/h being 250 Pascals. However, during the development programme considerable interest was expressed by plant designers in a high capacity filter with a rated flow of 3000 m^3/h or 3400 m^3/h in line with the high capacity mini pleat filters of rectangular geometry.

To date, this lower value of 3000 m^3/h at a pressure drop of 230 Pascals has been achieved with a filter size of 530 mm diameter by

620 mm long. Development of the full 3400 m^3/h filter is progressing, but relies on the development of machinery to produce a full 100 mm deep-pleated filter panel from which the cartridge is made.

Preliminary work has been carried out to assess the viability of volume reduction of the filter prior to disposal. It has been shown that the filter can be reduced to approximately one quarter of its initial length, and hence volume with modest crushing loads of some 2-3 tonnes (Fig 5).

3.3 High Level Active Cell Primary Filters

Many Active Facilities were designed to accommodate standard rectangular filters as primary extract filters mounted in the work benches or floor-mounted. The filters were not designed to be clamped into position as ease of remote handling and changing of the filters was the prime consideration, and the filters were assumed to effect a seal onto the housing through a combination of their weight and generated differential pressure. These arrangements are seldom satisfactory.

The situation on one cell facility at Harwell was worsened by the combination of high activity levels on the filters demanding shielded transfer from the cell and the installed transfer system being based on the 7" diameter "block pot". It was necessary to dismantle the old filters and package them within the 7" pots prior to disposal, a lengthy operation generating many flasking operations.

The primary filters have now been replaced with a cluster of 10 radial flow cartridge filters, measuring 165 mm x 200 mm long rated at 85 m^3/h each. The filters are sealed into a counter bored hole in the top plate of a fabricated open box structure which is itself sealed into the well in the cell floor (Fig 6) in place of the deep pleat filter. Each filter is sealed into the plate with a lip seal which is integral with the end of the filter, and the seal is effected without clamping through positioning only.

Each filter can be easily replaced using master-slave manipulators and transferred from the cell for disposal in the existing 7" diameter transfer system without dismantling.

The new design overcomes the basic sealing and remote handling problems associated with rectangular deep pleat filters and removes the requirement for costly in cell operations in preparation for disposal.

Design work is now in hand to develop a 450 m^3/h filter measuring 280 mm x 280 long, so that the standard 1700 m^3/h filters can be replaced with clusters of 4 such filters where appropriate.

3.4 Circular Filters for Large Volume Installations

Because of the relative ease of sealing without clamping and ease of disposal, the use of circular filters for large volume facilities should be of benefit compared to the use of conventional rectangular filters. The principles outlined in Section 3.3 can easily be applied to provide a low volume installation for high air throughputs.

A filter for such applications has been developed and found to meet all the requirements of the Atomic Energy Specification AESS 30/93402. The filter insert is illustrated in Fig 7. The seal is fabricated from

'U' section extruded silicon rubber held in place in the groove in the top flange of the filter with a silicon rubber 'o' ring. Thus a double lip seal is provided to seal the filter into a counter-bored hole in a plate, which can be designed to provide the floor of a cell dedicated to remote filter operations.Filter changing can be effected simply with an overhead grab device mounted on a x-y carriage above the filter bank with no clamping mechanism required to seal the filters.

If required filters could be volume reduced within the cell so that several filters can be transferred together at each flask movement.

The limiting unit filter size for such systems would be the dimensions of the inter-cell transfer systems and flasks, and the need to remain compatible with existing disposal routes and waste treatment facilities. The 3000 m^3/h or 3400 m^3/h filters would appear to be entirely suitable for such applications.

3.5 Bag Change Canisters

Reported difficulties with the sealing of standard filters in bag change canisters, combined with the ease of sealing circular filters has resulted in the development of a bag change canister incorporating a large circular filter.

The filter insert design is based on the 3000 m^3/h filter, but the top flange is modified to carry a silicone rubber seal on the inside of the throat of the filter (Fig 8). The silicone disc forms a flap seal against a tapered spigot feature built into the filter housing. Thus no clamping is required, the seal being effected purely through positioning the filter in the housing.

The canister itself is easy to manufacture. Air enters through the back of the canister directly into the filter insert. The outer case of the housing provides a plenum in which filtered air is collected before exhausting downwards through a port in the outer casing. High Integrity Shut-off dampers are available to suit the inlet and outlet ports.

Work is also in hand to produce an in-line version of the canister, (Fig 9) where the inlet and outlet ports are in the top and bottom of the canister, in the conventional way as such a design is favoured by some plant design teams.

With the present design, the pressure drops associated with air flow through the housing and filter results in an air throughput of 2200 m^3/h at 250 Pascals. Work is in hand to increase this air flow to 3000 m^3/h through design to eliminate unnecessary flow resistances.

The canister design has the added advantage of providing a circular bagging ring to ease bagging operations.

3.6 Push Through Filter Change System

A filter change system has been developed for small cells and boxes, in which filter changing is effected by loading filters from the cold side and ejecting contaminated filters into the hot side. The system is shown diagramatically in Fig 10.

The filter insert is of radial flow design, and carries seals in its end flanges.

The filter housing, constructed in stainless steel, is mounted on the inner containment wall of the cell. Air flows from the cell, into the filter, and is ducted away through ductwork connected to the collection plenum downstream of the filter element.

To effect a filter change a clean filter is positioned into the end of the main housing tube and is pushed into the housing by a distance equivalent to one filter length; in doing so it replaces the used filter which is ejected into the cell. As long as the filter is sized physically to be compatible with installed cell transfer facilities it can then be disposed of in the same way as other cell waste arisings.

Early designs of housing were fabricated in stainless steel, to form the collection plenum and other housing details. However, a simpler, cheaper design has evolved in which the housing is now a simple stainless steel tube with a "pulled tee" to facilitate connection of the extract ductwork. (Fig 11). The collection plenum for filtered air is formed between the end flanges of the filter and the housing tube.

The seal between the filter and housing is effected by a simple flat seal ring cut from silicon rubber sheet. In operation the seal is folded back over a feature on the filter end pieces to form a flap seal, which has the benefits of a large contact area, low friction, and minimum compression of the seal material.

Where shielding is required, the filter loading tube penetrates the biological shielding and is fitted with a steel shield plug. Several filters are placed in the tube and changes effected by "rodding" through the shield plug.

A range of systems covering air flow rates from 50 m^3/h to 600 m^3/h have been developed. Flow/pressure drop characteristics for the range are given in Fig 12.

3.7 Conclusions

The development and test work carried out to date has demonstrated that high integrity filters of equal performance to conventional deep-pleat designs can be produced in radial flow cartridge form in sizes up to 3000 m^3/h. The application of these filters to nuclear off-gas cleaning facilities should provide better systems in terms of filter seal performance, reduced handling problems and ease of disposal of contaminated filters via existing disposal routes. Filter systems incorporating these filters are being developed for high contamination level applications, whilst their use for low contamination applications is being studied.

4 IN SITU FILTER TESTING

4.1 Introduction

When high efficiency filtration is specified as the result of a hazard analysis the degree of filtration demanded is usually expressed as a decontamination factor. This factor is the reciprocal of the penetration and a DF of 2000 (equivalent to a penetration of 0.05%) is frequently used for the modern HEPA filter.

By using one of the standard bench tests such as the sodium flame filter test (BS 3928 - 1969) it is comparatively easy to confirm the efficiency of the filter medium itself but damage may be caused to the filter during installation, leaks may occur if the gaskets are not properly seated and compressed and filters or seals may deteriorate with time or during operation.

It was recognised in AECP 1054 - 1979 that testing of filters in-situ was necessary to ensure that the filters as installed met the desired DF and that this was maintained during its useful life. This code of practice recommended the use of dioctylphlalate (DOP) with a mixing length between injection point and sampling point upstream of filter of 10 duct diameters and a similar length between filter and sampling point downstream of filter.

As such lengths cause severe restrictions on the design of the ducting it was decided to investigate the need for such mixing lengths and B Green at Harwell embarked on a series of experiments. Her early findings (5) were that for single point injection, single point sampling and an edge leak on the filter the specified lengths of 10 duct diameters were completely inadequate for proper mixing and accurate measurements.

There was therefore, on the one hand the desire to reduce duct lengths to improve design flexibility but on the other hand it had been shown experimentally that duct lengths should be increased if hazard analysis criteria were to be achieved.

A limited programme of work was initiated to investigate mixing devices with the aim of reducing the length of ducting necessary on extract systems to accommodate the requirements of in-situ filter testing.

4.2 Mixing Devices

The experimental work on mixing devices is reported by B Green in her paper "Development of in-situ aerosol injection methods" - March 1983 (5). The purpose of this programme was to compare the mixing efficiences of stairmand disc, ring and doughnut and Komax mixer with various injection positions; the injection positions being centre injection, single point edge injection and four point edge injection.

The work was carried out in a purpose made flow rig (Fig 13) with a duct size of 600 x 600 mm and designed for air flows between about 1000 m^3/h and 9000 m^3/h although the tests were carried out at a constant flow of 5000 ft^3/h equivalent to a duct velocity of 3.9 m/s.

The aerosol used was cold DOP detected by light scattering equipment - the maximum and minimum record of DOP concentration being measured by scanning the probe across the duct at the sampling points provided.

The volume flow rates were measured by hot wire anemometer and pressure readings were taken with inclined gauge manometers.

The tests on each mixing device involved initially adjusting the flow to 5000 m^3/h and then injecting the aerosol either to the middle of the ducting on to one edge or to all four edges. By scanning the probe at each sampling point the maximum and minimum concentration readings could be identified and recorded.

To avoid erroneous pressure measurements caused by swirls and eddies close to the mixing device the pressure drop measurements were taken at intervals along the ducting to establish a representative pressure drop figure.

An extract from the test results is shown below. For the purposes of these tests the flow was assumed to be mixed when the difference of maximum and minimum about the mean is ± 10%. This figure was based on a report by Dorman in 1981 (6) and an American Standard ANSI N510 1975 (7).

These test results show that shorter mixing lengths are possible but only at the expense of increased pressure differential. The comparison shows:

Komax mixer	Mixed at 4½ D	prssure drop 25 mm H_2O
Ring and doughnut (150 mm separation)	5½D	11
Stairmand disc	10¾D	3

Investigation of the injection methods show the desirability of injecting in the centre of the duct or, for marginal improvement in mixing, injecting at the four edges. The simulation of a gasket leak by single edge injection showed the difficulty of its detection. This is shown on Fig 14.

4.3 Sampling Probes

An investigation into multipoint sampling probes (8) was undertaken to allow in-situ filter testing to be achieved for the first stage of a two stage filter system when the distance between the filter and sampling point is too short for proper mixing. The duct size for the application under consideration was 350 mm and the test rig used for the mixing devices was modified by inserting a length of 350 mm duct as shown at Fig 15.

A Komax mixer was employed upstream to ensure a uniform challenge across the filter face, probe 1 is used to measure upstream challenge concentration while probe 2 is used to measure downstream challenge concentration after filtration but without mixing. Probe 3 is used to measure the downstream challenge concentration after filtration and after mixing. The difference between readings from probe 2 and 3 gives an indication of suitability of each probe for use in close proximity to a filter where the flow is unmixed.

The filters used were standard HEPA filters which had been subjected to conventional DOP measurements. Higher penetrations had been achieved by piercing small holes in the filter media along the edge to simulate a seal leak.

Filter A	Standard	DOP penetration 0.005%
Filter B		DOP penetration 0.05%
Filter C		DOP penetration 1.30%

A number of different probe configurations were used and a sample is shown at Fig 16.

The tests involved setting the rig to the required flow rate and then injecting the aerosol. The upstream measurements of challenge concentration were obtained by probe 1. Downstream measurements were obtained at probe positions 2 and 3 for each sampling probe and for each filter. The results are shown at Fig 17.

The results show clearly that the probe of type A is the most suitable as a static multipoint sampler in close proximity to a filter face, and accurate readings were obtained in a duct length of less than 4 diameters.

4.4 Plant Considerations

From the previous paragraphs of mixing length and use of frame samplers a picture emerges of the requirements for a plant design. After injection of the challenge aerosol a distance of 10 duct diameters is needed before the sampling point just upstream of the filter if a stairmand disc is used for mixing. A minimum distance of 4 diameters is then required downstream of the filter if a frame sampler is used. This configuration is shown at Fig 18.

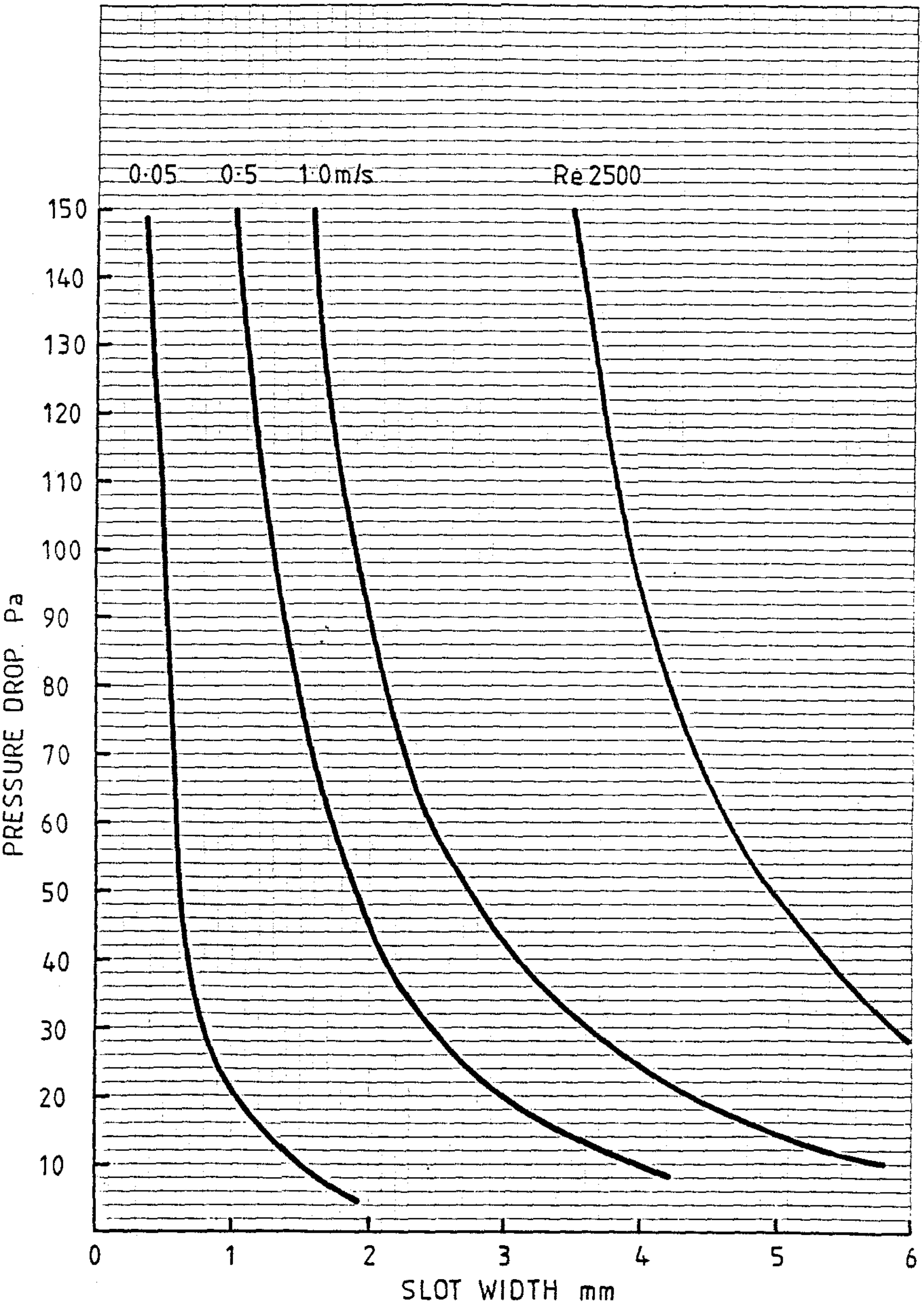
The requirements for different configurations are shown at Fig 19 and 20.

Further consideration of test methods is provided in AERE publication R11255 (9).

BIBLIOGRAPHY

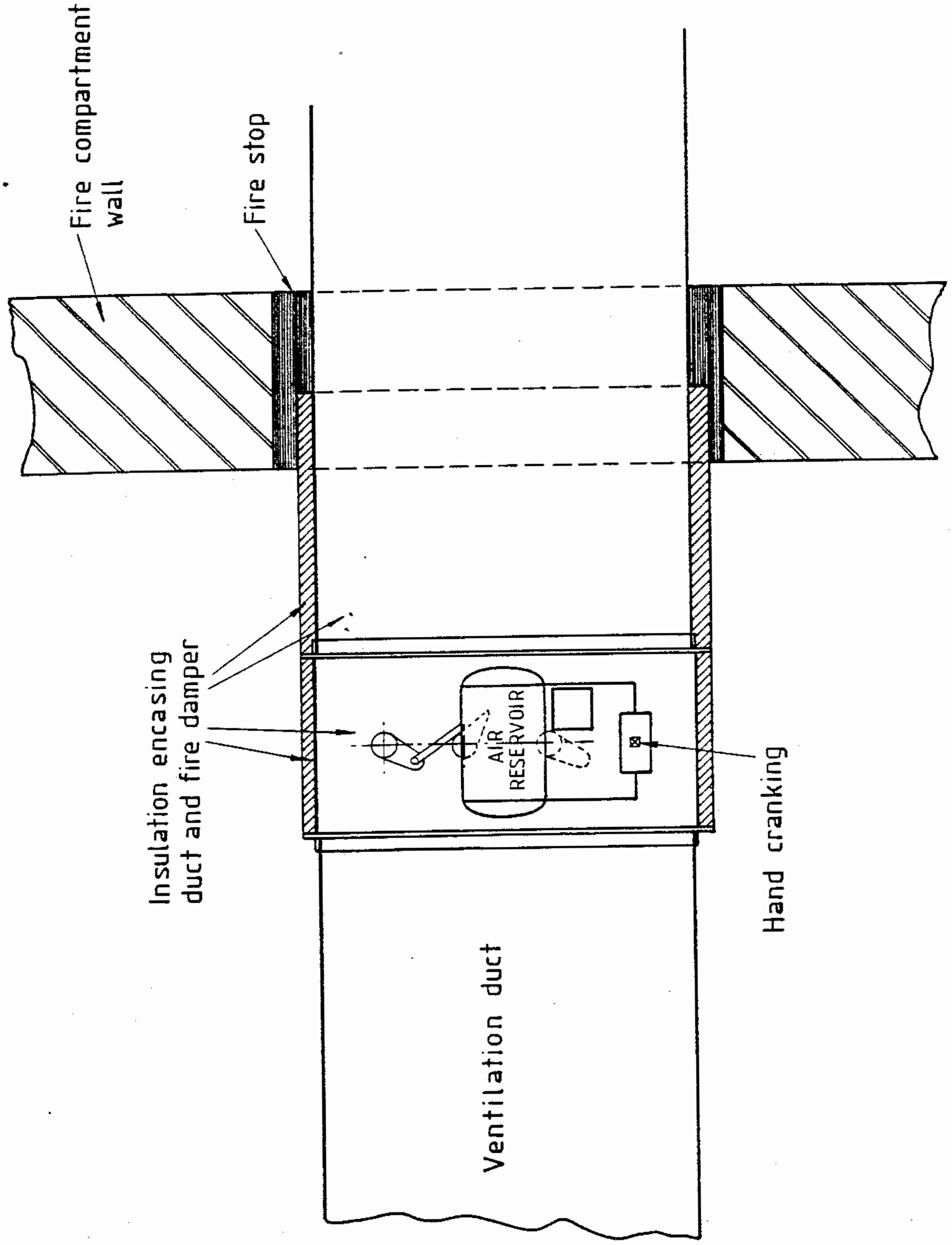
1	A Metcalfe	Unpublished paper PEN(83)28
2	UKAEA Harwell	Radiological Protection Training The basis and practice of radiological protection at AERE Harwell (Extension notes for professional staff) AERE - EMS Gen 18 (1982)
3	Robotham F P J et al	Release of contamination from glove boxes and fume hoods, paper 38 Int.Symp. on Radiological protection of the worker (1966)
4	Stamford Research Institute Journal	Vol 5 p95
5	B L Green	Unpublished paper FDSWP (83) P9
6	Dorman R G	A comparison of the methods used in the Nuclear Industry to test High Efficiency Filters - Commission of the European Communities June 1981
7	ANSI N510 - 1975	Testing of Nuclear air-cleaning systems
8	B L Green, B L Smith	Unpublished paper CVTWP (83) P25
9	D C Stevens, B L Green	In-situ filter testing using DOP aerosol and photometric detection. AERE - R11255

FIG.1

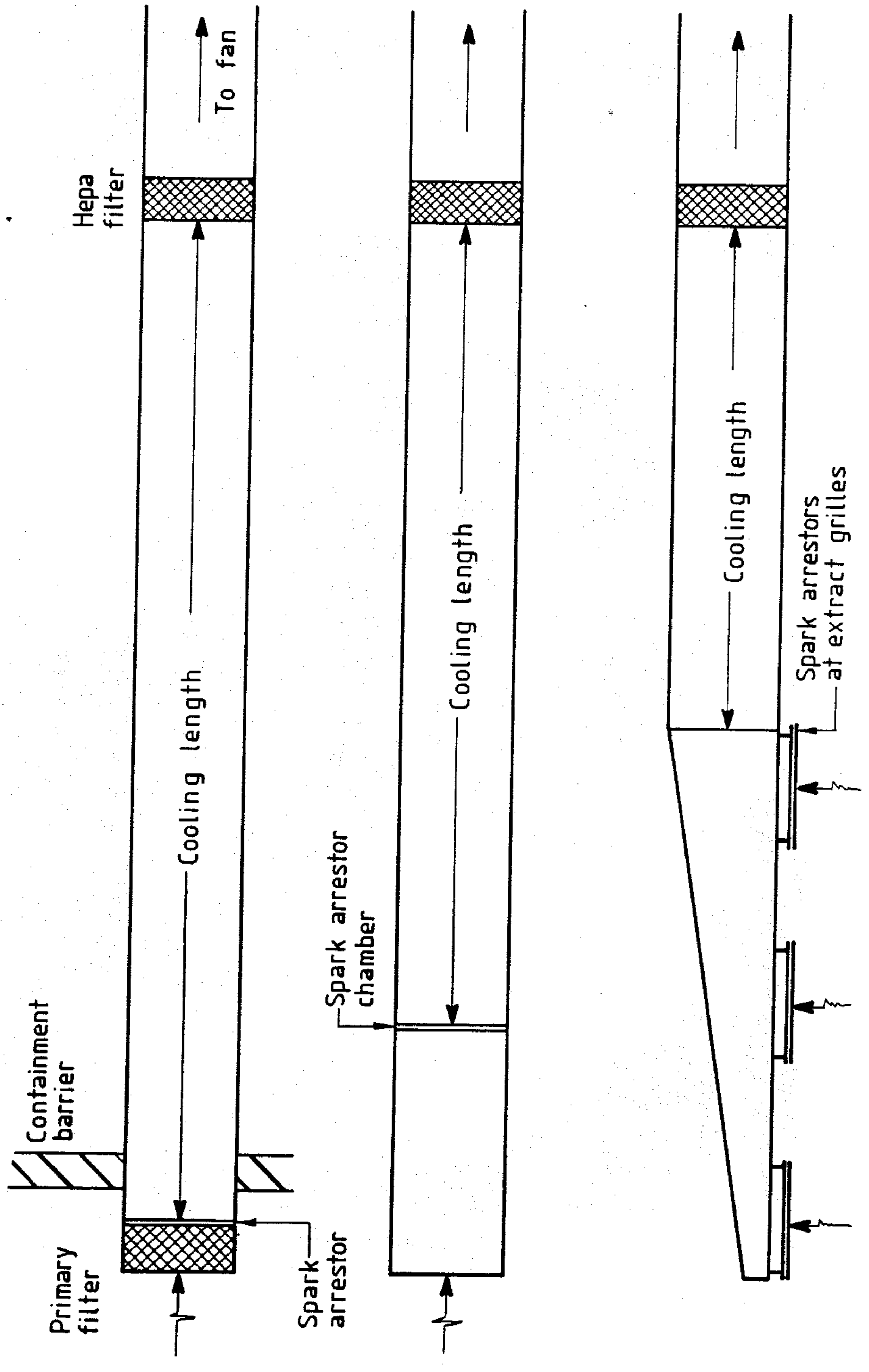


VARIATION OF PRESSURE DROP WITH SLOT WIDTH

FIG.2



FIRE DAMPER



SPARK ARRESTORS

FIG.4

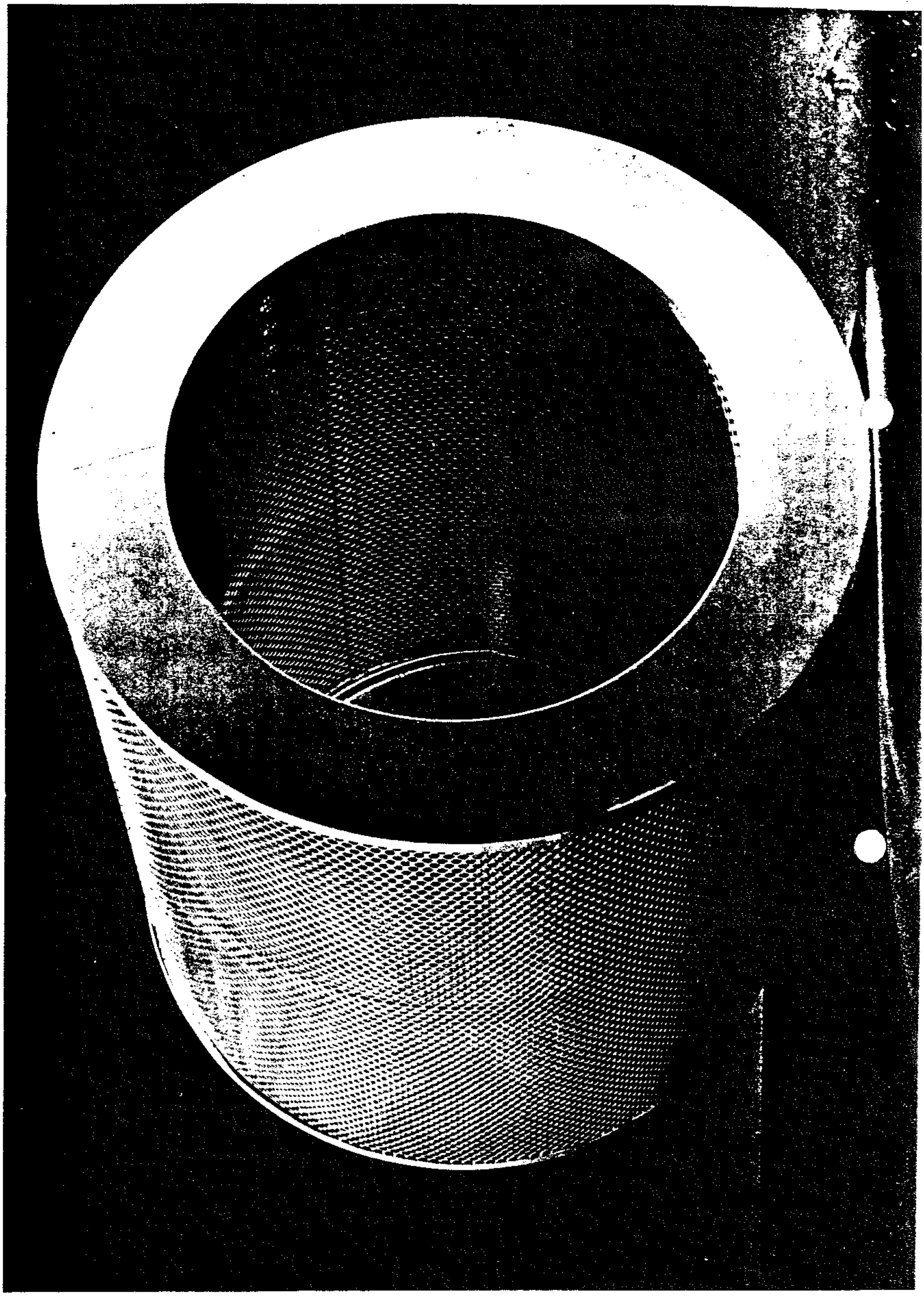


FIG.5

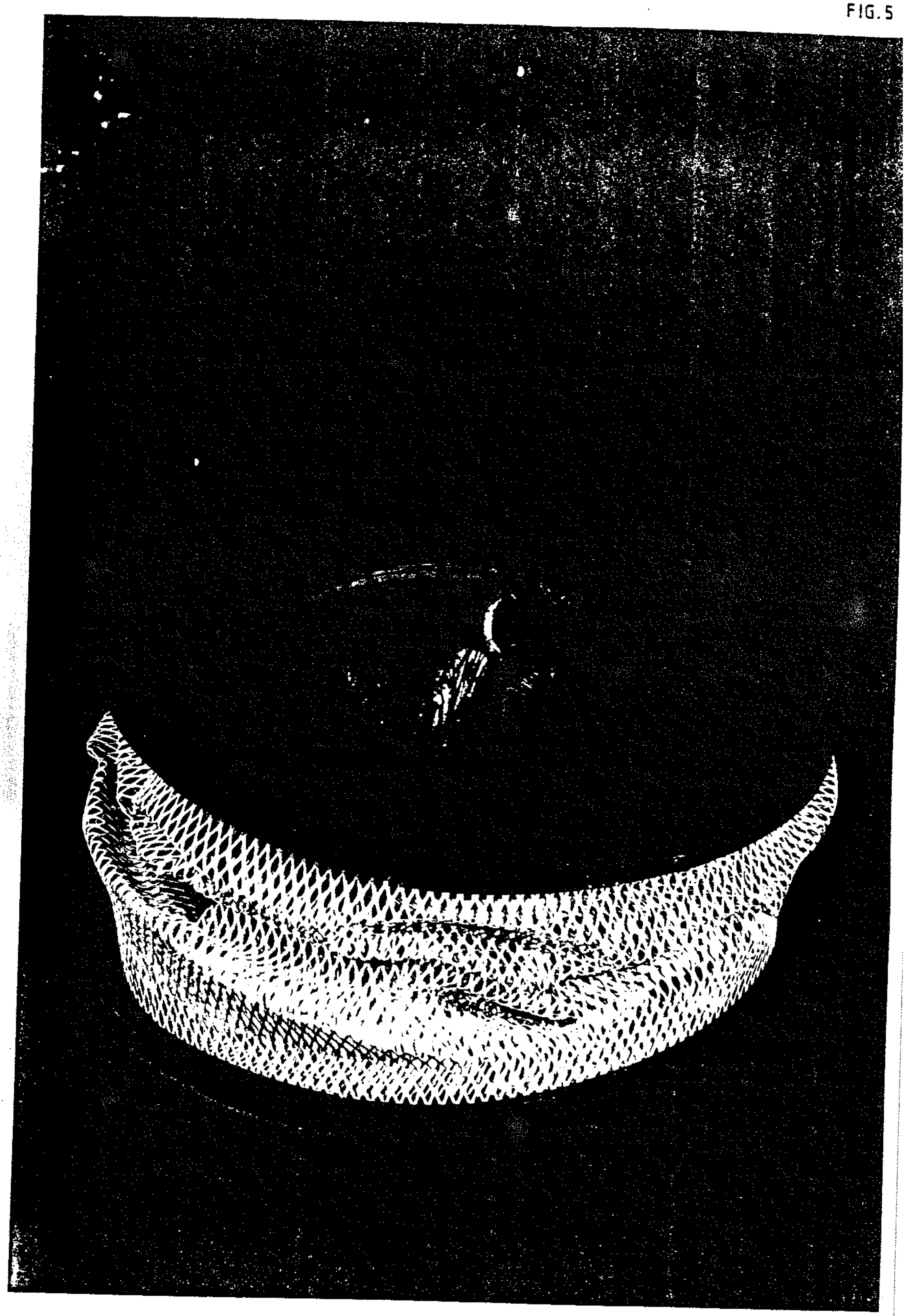


FIG. 6

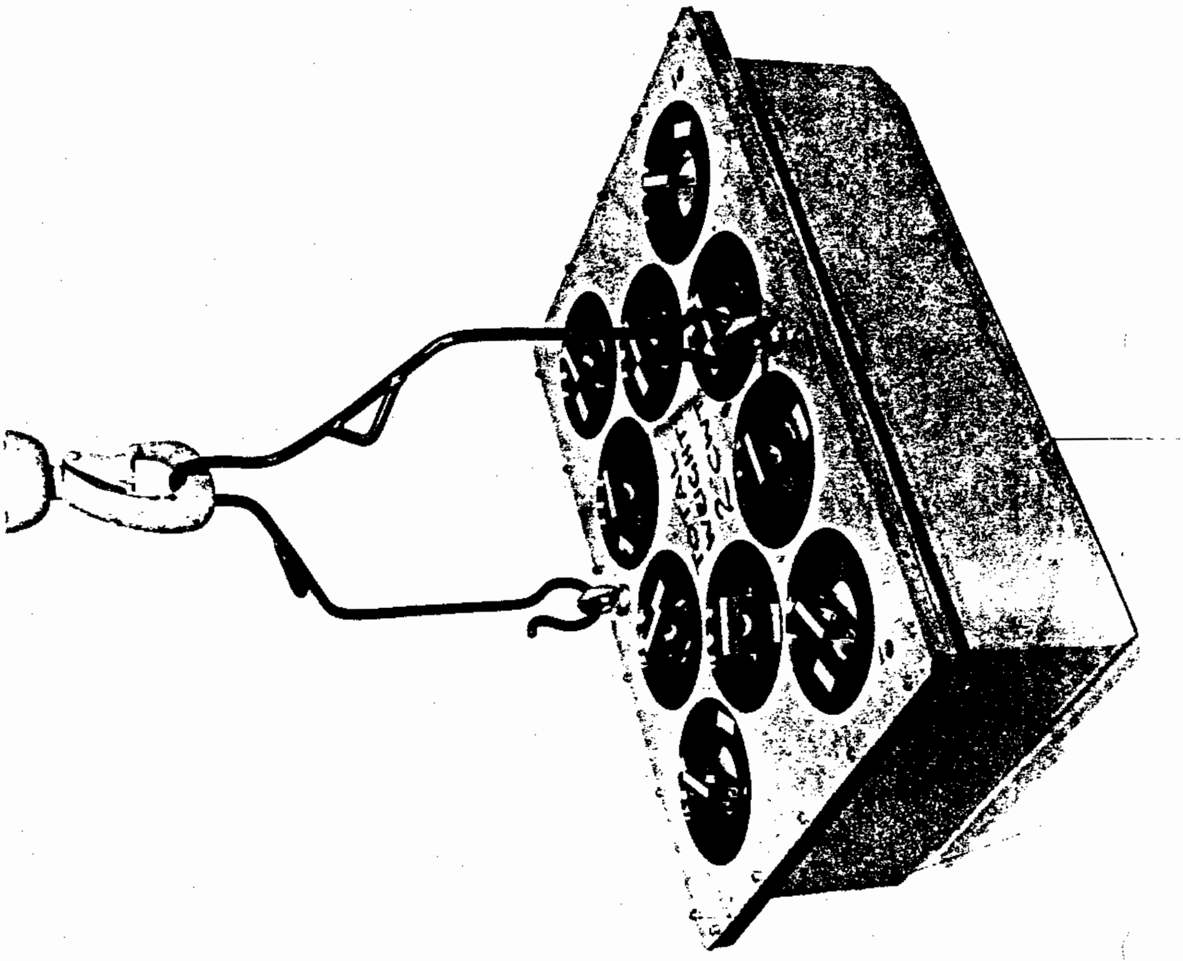


FIG. 7

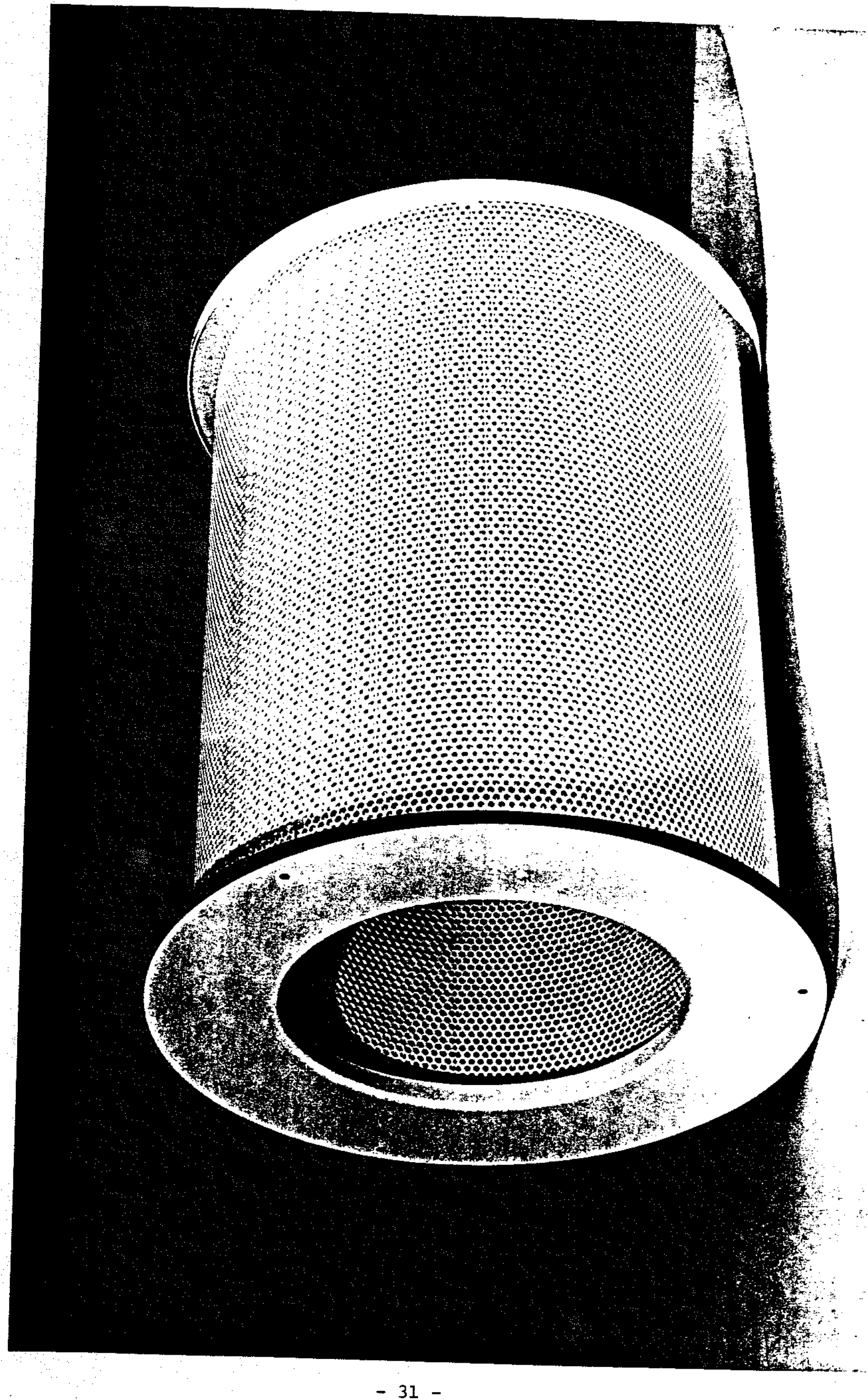


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FIG.8

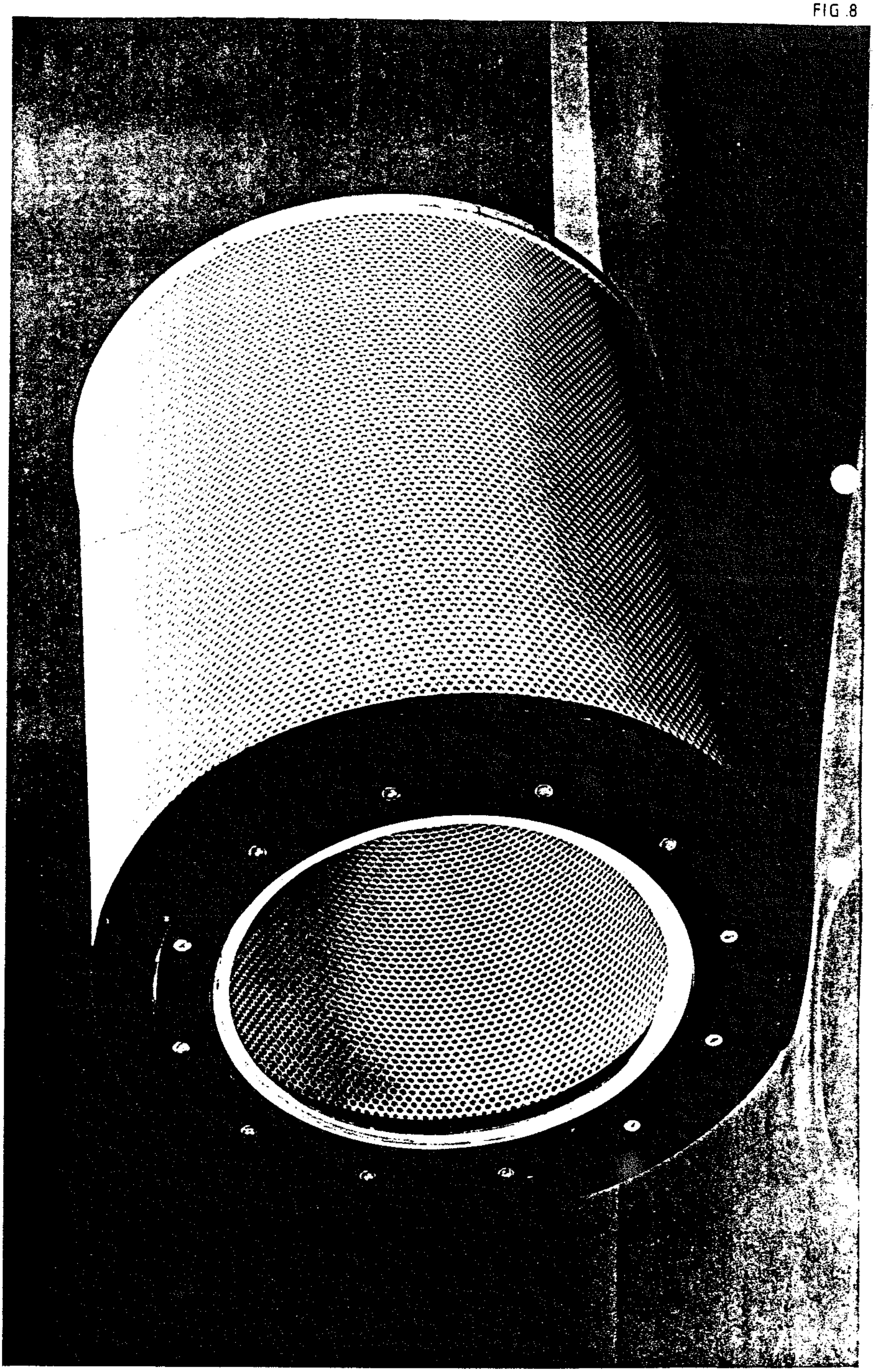
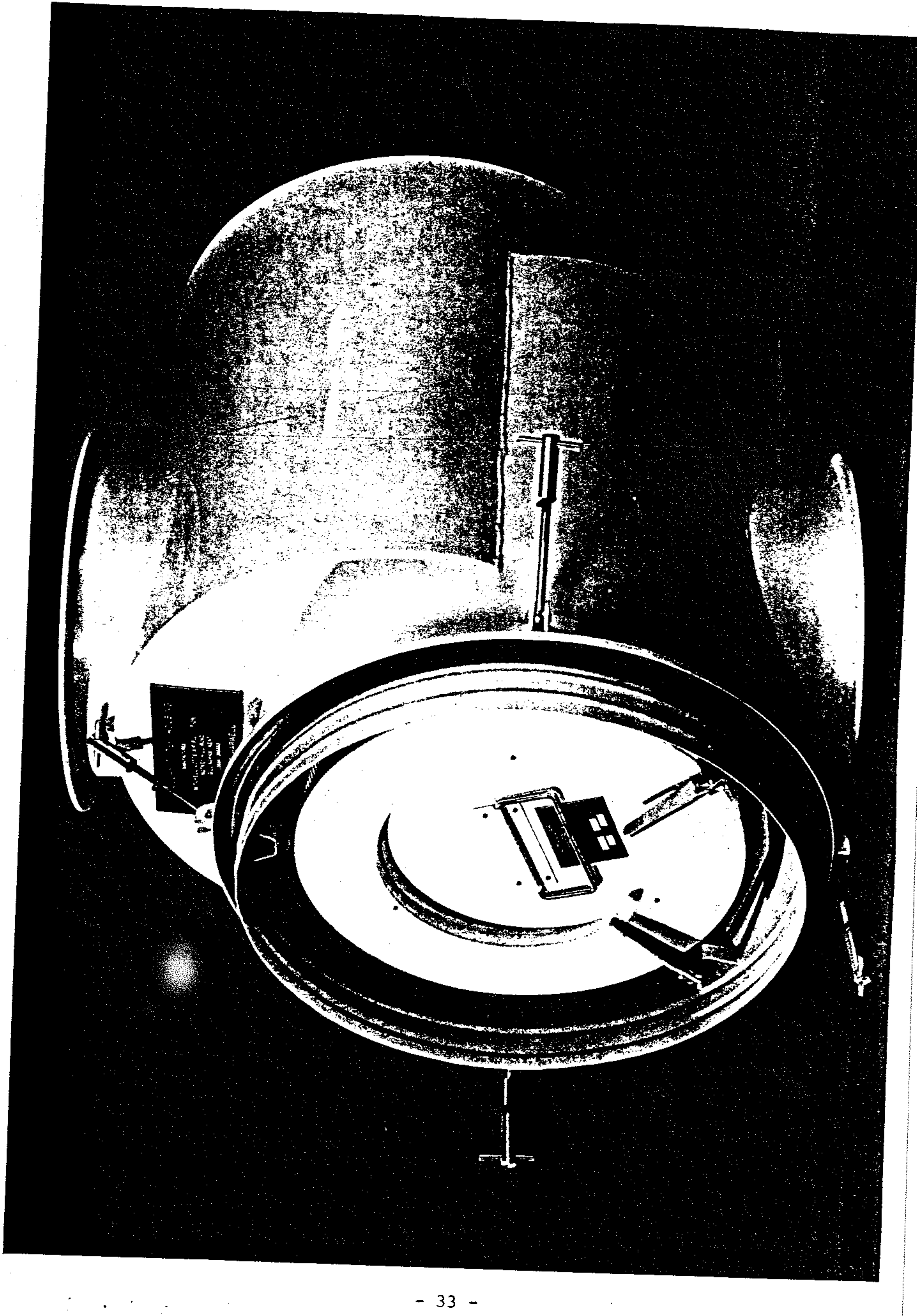
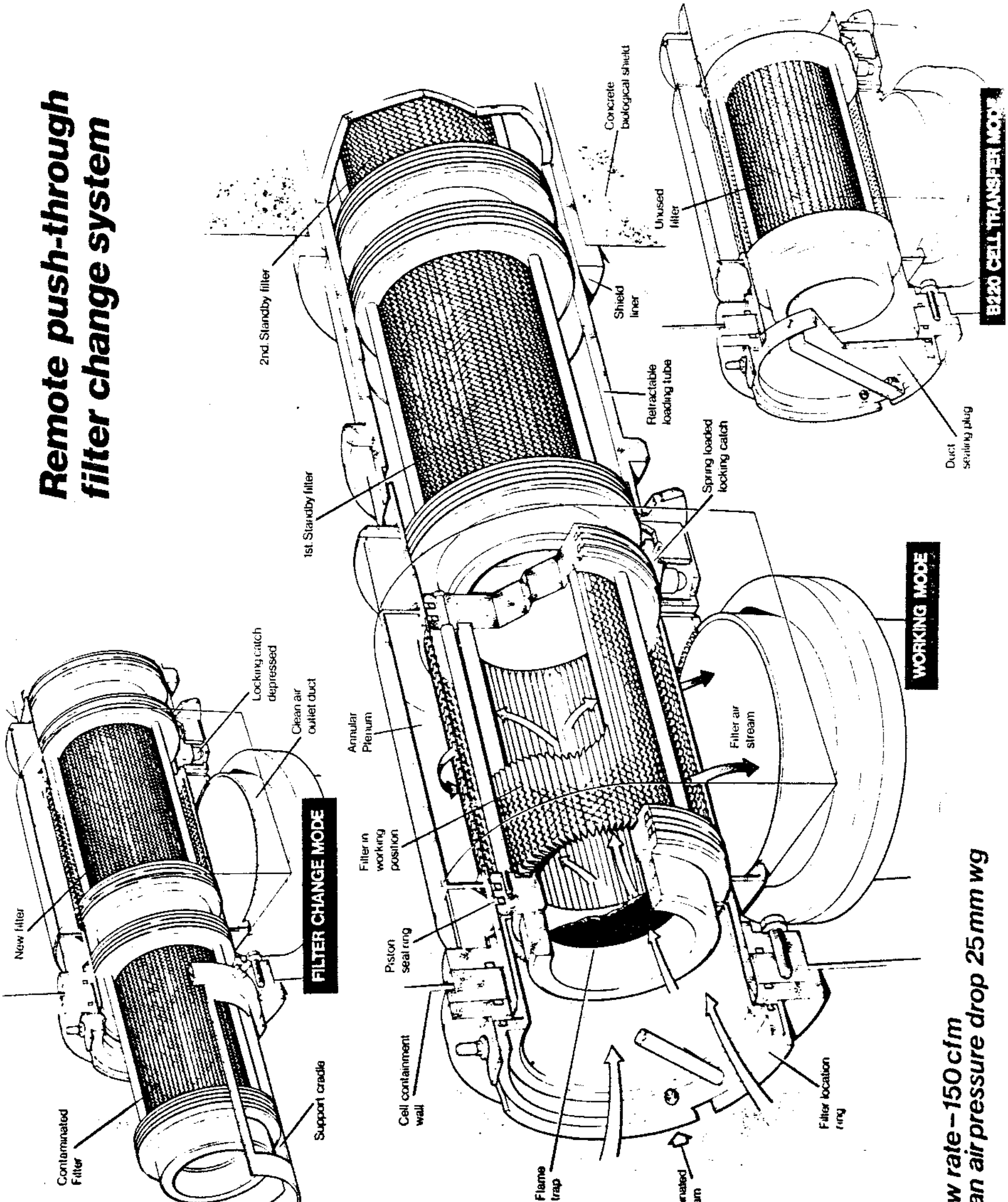


FIG.9

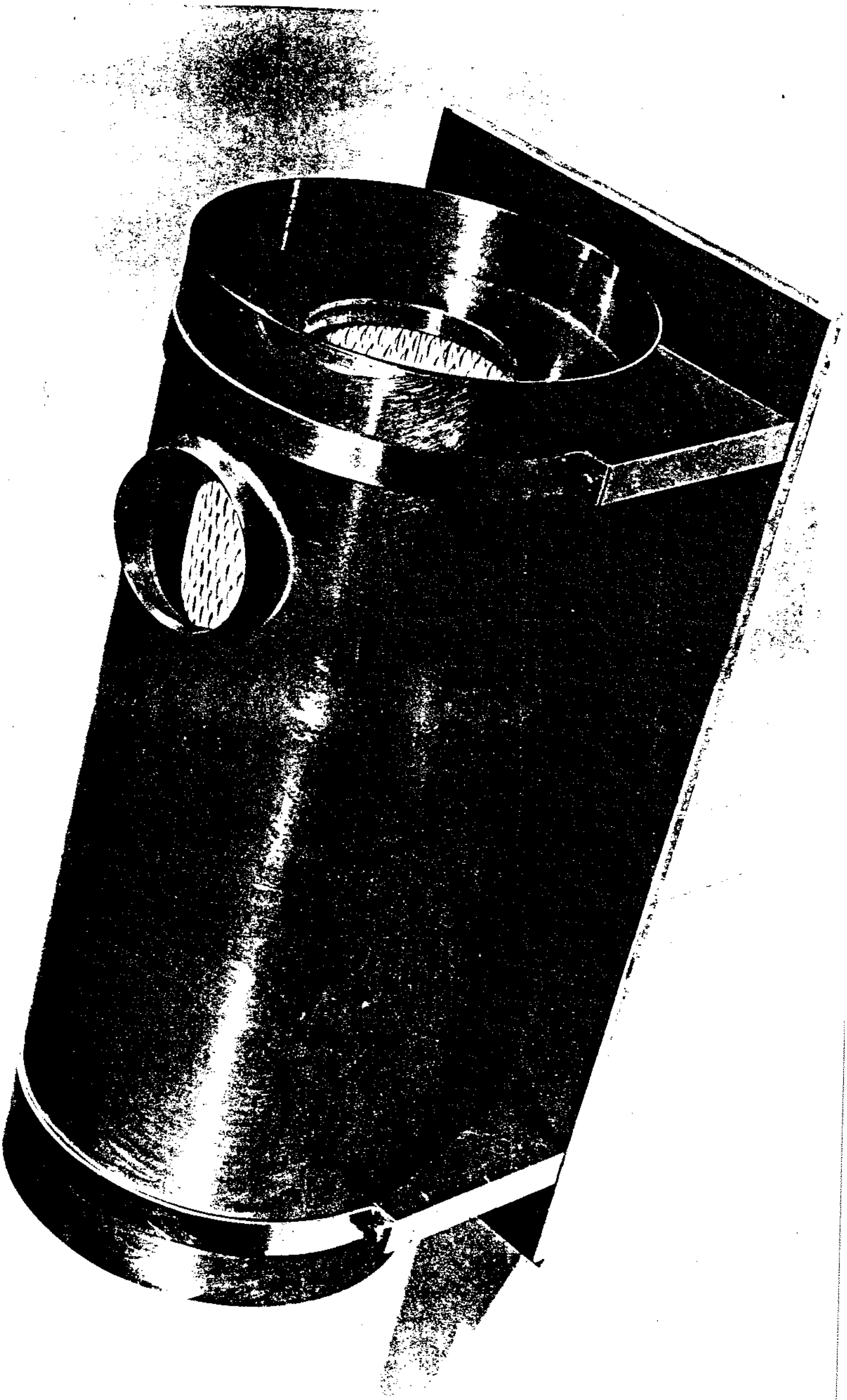


Remote push-through filter change system



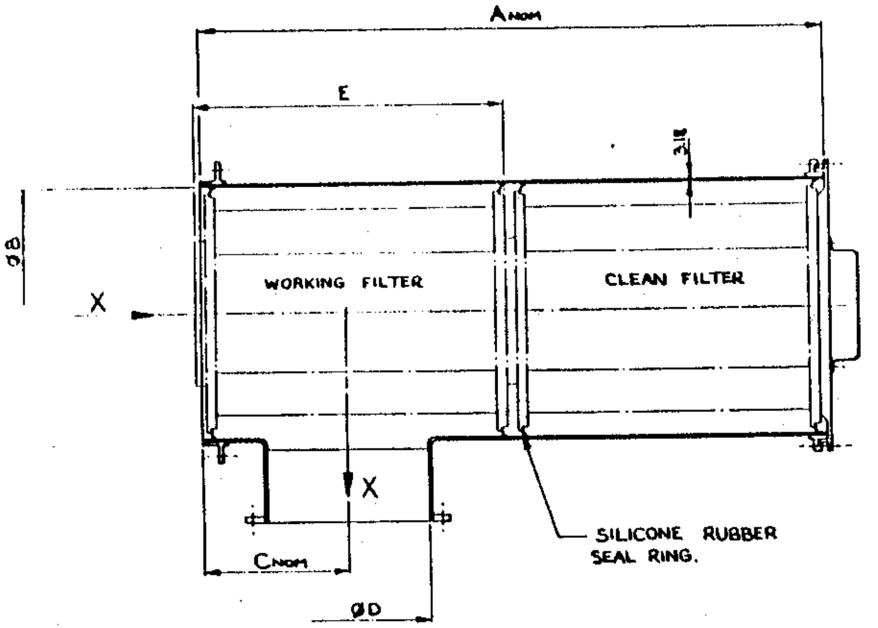
Flow rate–150 cfm
clean air pressure drop 25 mm wg

FIG.11



DRG NO CH11050

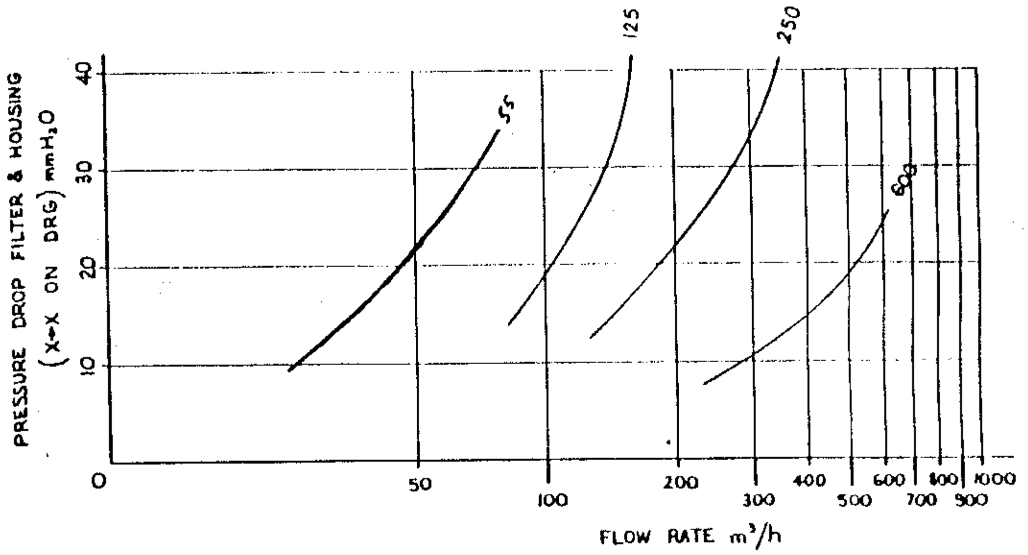
THIRD ANGLE PROJECTION



NOTES

1. STAINLESS STEEL HOUSING. FLANGES CAN BE SUPPLIED TO SUIT SPECIFIC APPLICATIONS.

MASTER DRAWING NUMBER	SYSTEM NOM FLOW RATE m³/h	A	ØB	C	ØD	E
CH11051	55	330	135	70	55	150
CH11052	125	604	210	150	82	300
CH11053						
CH11054	250	754	250	190	135	375
CH11055	600	804	330	200	212	400



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DATE 12 10 84
MOD NO

TOLERANCES — UNLESS STATED

SURFACE TEXTURE IN μM 1.6 UNLESS STATED

REMOVE BURRS & SHARP EDGES

DIMENSIONS IN mm.

ORIGINAL SCALE 1:5

UKAEA LABORATORY –

TITLE OUTLINE DRG O. PUSH THROUGH HEPA FILTER SYSTEM

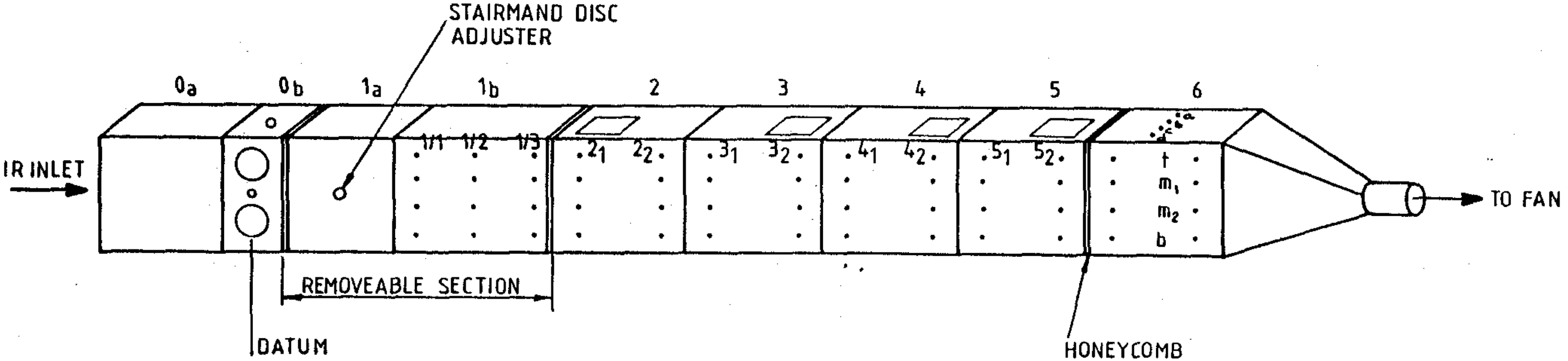
QUALITY ASSURANCE APPLIES
QA SCHEDULE [illegible]

DRG NO CH11050

WORK STUDY REF

CONTRACTOR CONTR'S DRG

FIG.12



Distances Datum to Sample Points

1_1 = 750mm
1_2 = 1260
1_3 = 1755
2_1 = 2180
2_2 = 2680
3_1 = 3120
3_2 = 3702
4_1 = 4165
4_2 = 4670
5_1 = 5115
5_2 = 5715
6 = 6225

In Section 2, 3, 4, 5 there is a perspex viewing window in the top of the duct

In Section 0_b the aerosol is injected into the centre of the tube from the top

Distance injection point to the disc is 400mm

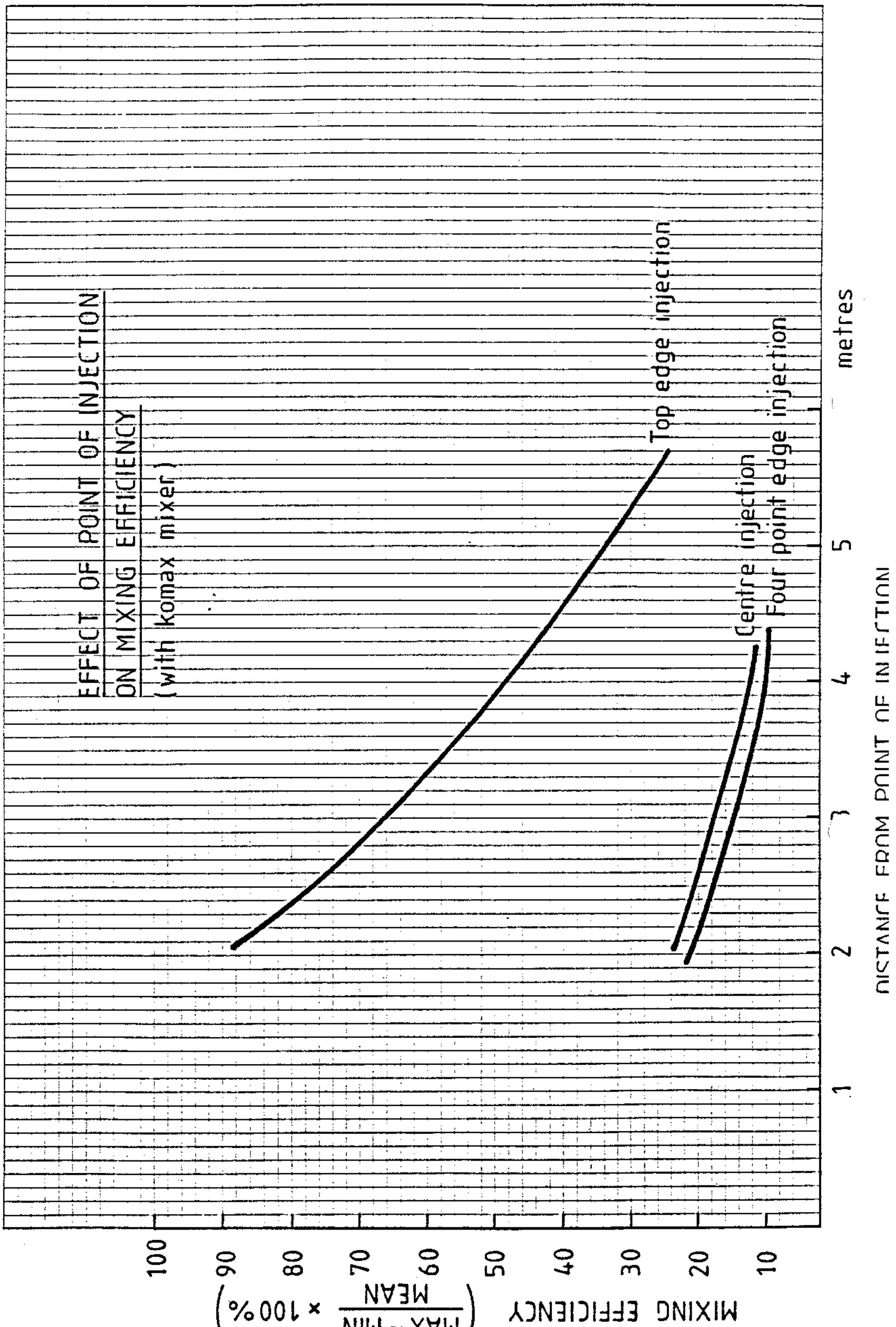
Distance injection point to the removeable section is 150mm

Bend inserted between injection section and the removeable section (0_b, 1_a) centre line length 900mm

LAYOUT OF AEROSOL INJECTION TEST RIG

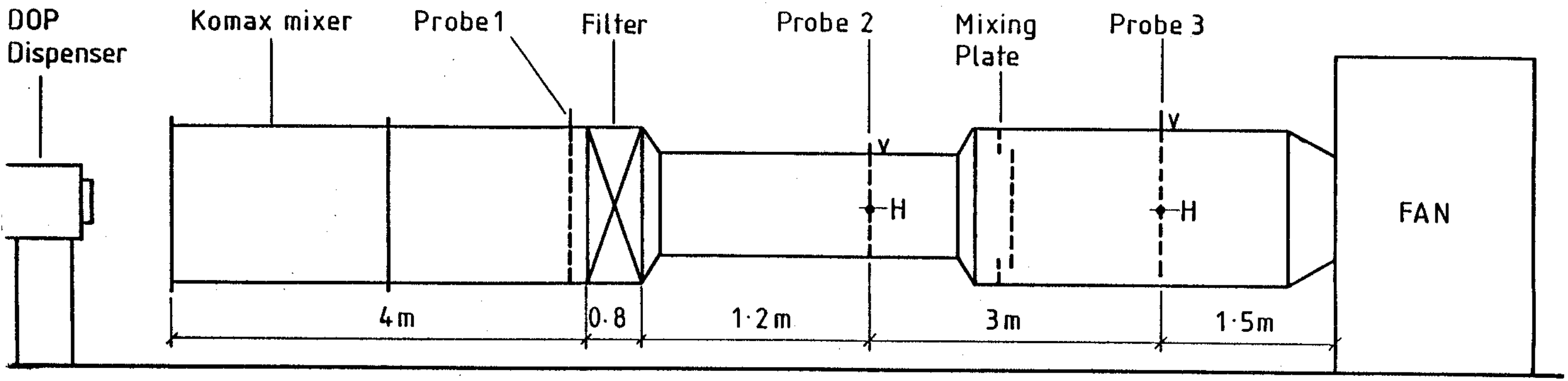
FIG.13

FIG.14


EFFECT OF POINT OF INJECTION
ON MIXING EFFICIENCY
(with komax mixer)
Top edge injection
Centre injection
Four point edge injection
MIXING EFFICIENCY $\left(\frac{MAX - MIN}{MEAN} \times 100\%\right)$
100
90
80
70
60
50
40
30
20
10
1
2
3
4
5
metres
DISTANCE FROM POINT OF INJECTION

Probe position	1	Upstream challenge mixed
	2	Downstream penetration unmixed
	3	Downstream penetration mixed
	v	Vertically placed
	H	Horizontally placed

NOTE: Dimensions of trunking (a) Large sections 610mm x 610mm
(b) . Reduced sections 350 mm Ø



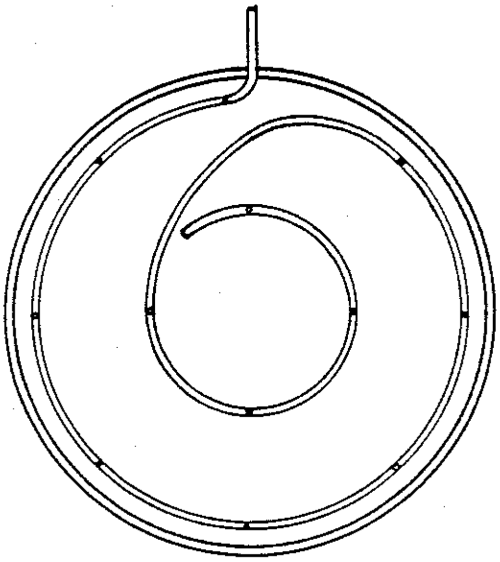
RIG CONFIGURATION

FIG.15

MULTIPOINT SAMPLING PROBES

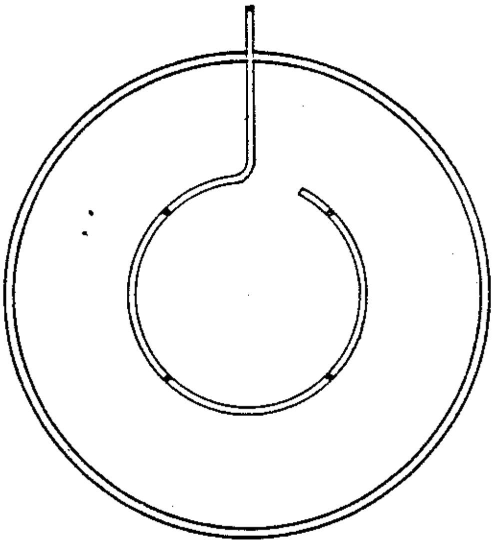
FIG.16

A



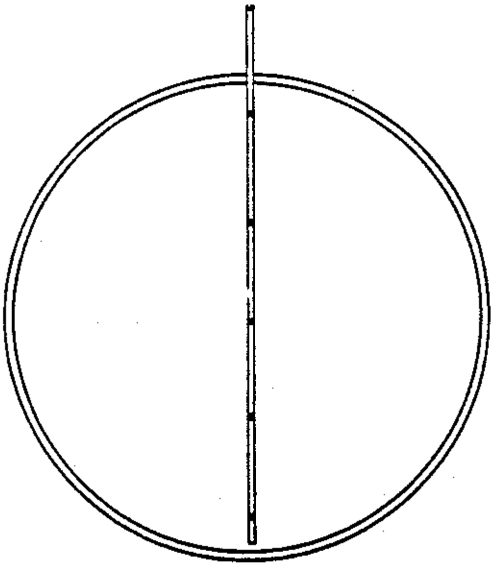
6mm or 8mm dia. tube
0·7 or 1·2mm dia. holes
6 or 12 holes

B



6mm tube
1·5mm dia. holes
4 holes

C



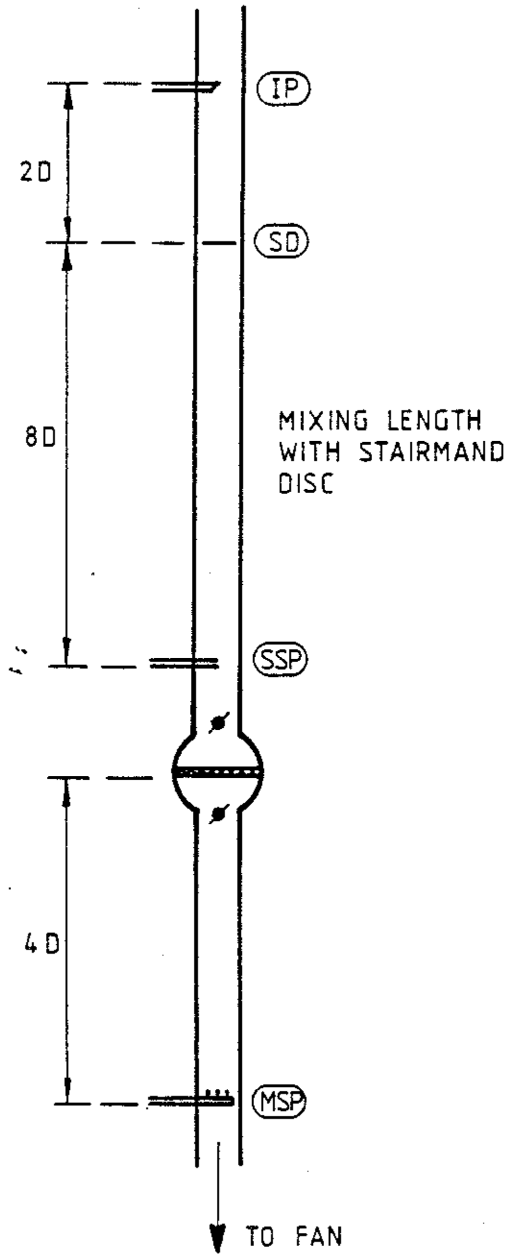
6mm or 8mm tube
0·7 or 1·5mm dia. holes
5 or 11 holes
Probe vertical or horizontal

FIG.17

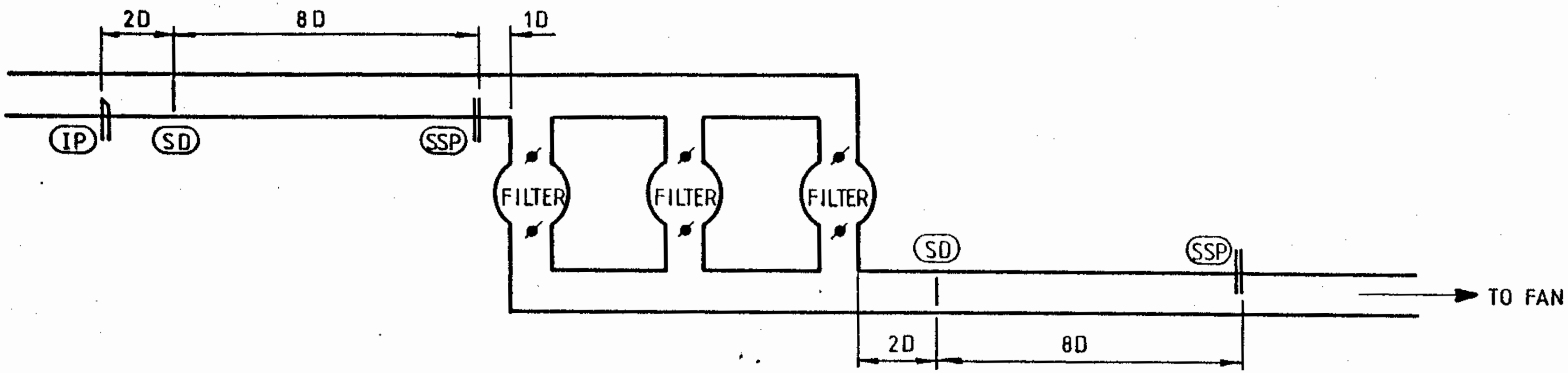
PROBE TYPE	TUBE DIA mm	HOLES Number and size	FILTER A PROBE POSITION		FILTER B PROBE POSITION		FILTER C PROBE POSITION	
			1	2	1	2	1	2
A	8	12 x 0.7	0.005	0.005	0.040	0.045	1.30	1.25
B	6	4 x 1.5	0.007	0.007	0.020	0.055	1.10	1.3
C (Vertical)	8	5 x 0.7	0.001	0.002	0.050	0.035	0.40	0.50

Filter A = 0.005% penetration; conventional DOP
Filter B = 0.05% penetration; conventional DOP
Filter C = 1.30% penetration; conventional DOP

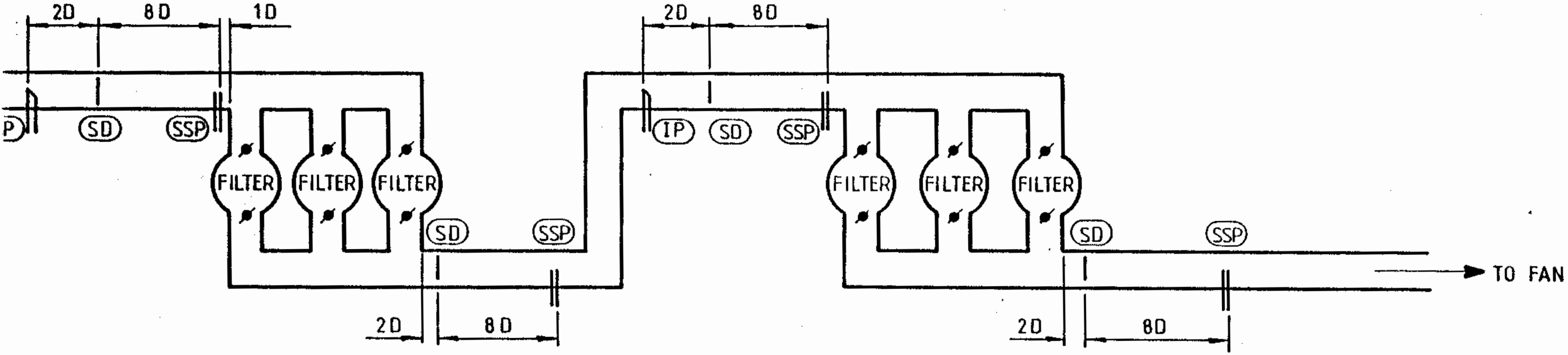
FRAME SAMPLER TEST RESULTS



IN-SITU FILTER TESTING REQUIREMENTS



Single Stage

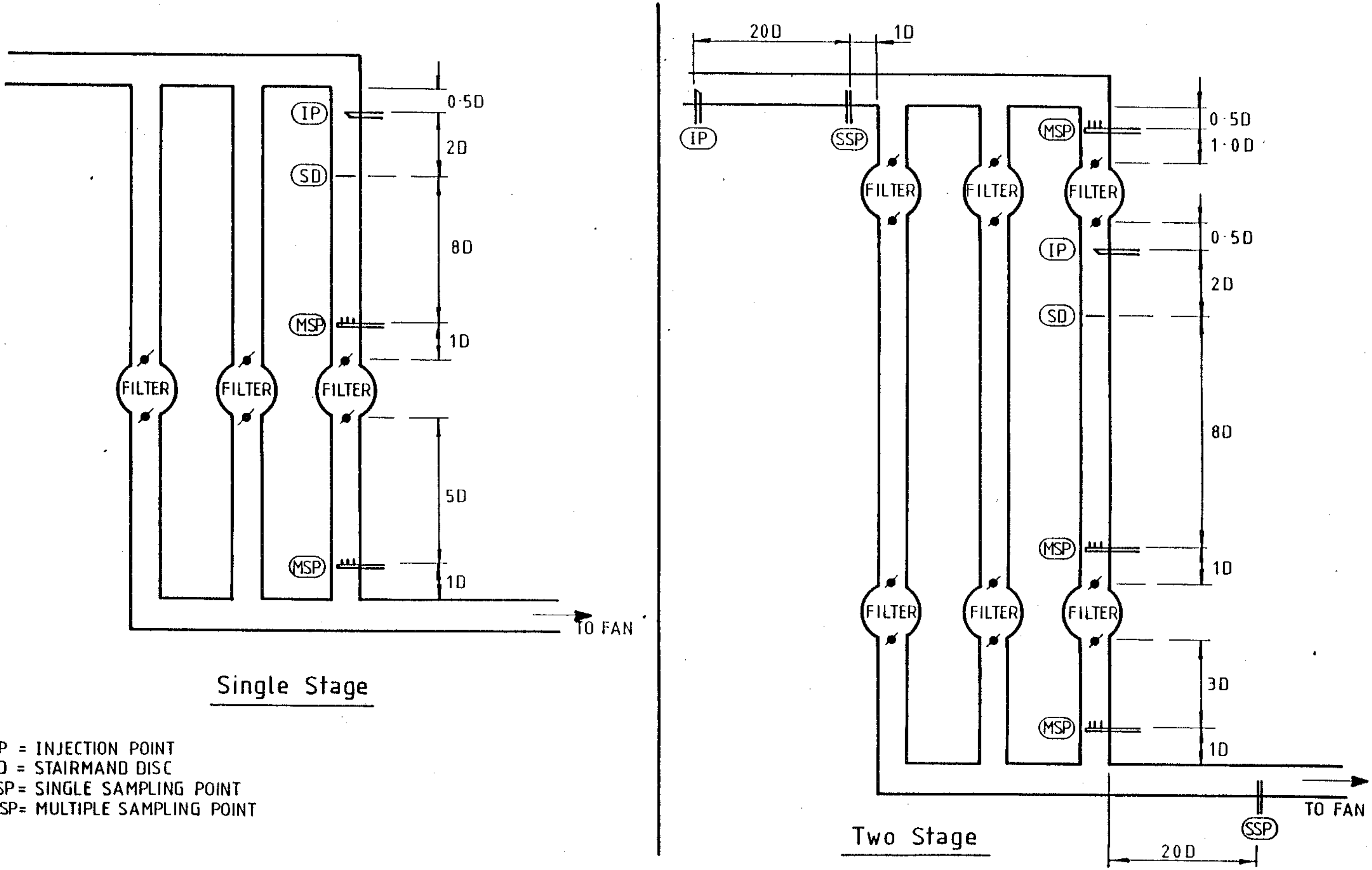


Two Stage

IP = INJECTION POINT
SD = STAIRMAND DISC
SSP = SINGLE SAMPLE POINT

IN-SITU FILTER TESTING ARRANGEMENT
(TESTING FILTER BANK)

FIG.19



Single Stage

Two Stage

IP = INJECTION POINT
SD = STAIRMAND DISC
SSP = SINGLE SAMPLING POINT
MSP = MULTIPLE SAMPLING POINT

IN-SITU FILTER TESTING ARRANGEMENT
(TESTING INDIVIDUAL FILTERS)

FIG.20