BRITISH STANDARD

BS 3928:1969

Method for

Sodium flame test for air filters —

(Other than for air supply to I.C. engines and compressors)

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Co-operating organizations

The Mechanical Engineering Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

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British Compressed Air Society*
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Technical Section of the British Paper and Board Makers Association
United Kingdom Atomic Energy Authority
Individual filter manufacturers

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Contents

Foreword

This standard makes reference to the following British Standards:

BS 249, *Leaded brass (58 per cent copper, 3 per cent lead) rods and sections (other than forging stock).*

BS 267, *Cold rolled brass sheet, strip and foil, 70/30 brass.*

BS 409, *Naval brass sheet, strip and plate (excluding naval brass condenser plate).*

BS 885, *Brass tubes for general purposes, 70/30 arsenical brass, aluminium brass.*

BS 970, *Wrought steels. En series.*

BS 1042, *Code for flow measurement.*

BS 1400, *Schedule of copper alloy ingots and copper and copper alloy castings.*

BS 1407, *High carbon bright steel (silver steel).*

BS 1408, *Patented cold drawn steel spring wire.*

BS 1806, *Dimensions of toroidal sealing rings ("O" seals and their housings).*

BS 1845, *Filler metals for brazing.*

BS 2831, *Methods of test for air-filters used in air-conditioning and general ventilation.*

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The test cloud, composed of sodium chloride particles mainly within the size range 0.02 μm to 2 μm equivalent diameter, has a mass median size of about 0.6 μm and provides a searching test of a filter. Estimation of the amount of particulate matter penetrating the filter is by flame photometry and, as the apparatus is almost instantaneous in action, it has a considerable advantage for high efficiency filters over the methylene blue test (BS 2831[1)]) which requires a time of test sufficient to collect a visible quantity of dye on the test paper, and furthermore it has little effect on the filter. This test is therefore intended as a replacement for the methylene blue test for filters of less than 0.01 % penetration and as an alternative for filters of 0.01 % to 100 % methylene blue penetration. Although the particle size distribution is similar to that of the methylene blue cloud, experience has shown that measurement of penetrations under 0.01 % by the method described in this standard may not be in agreement with the methylene blue test because the duration of the methylene blue test can cause clogging of some types of filter and the esparto test paper is of low efficiency towards the highly penetrating particles which have passed through the filter under test. For filters of penetration above 0.1 % the two methods of test should give almost identical results.

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1) BS 2831, "*Methods of test for air-filters used in air-conditioning and general ventilation*".

Another design of sodium flame equipment is available to cover the same range of penetration as that measurable by the equipment described in this standard.[2)]

NOTE Where metric equivalents are stated the figures in imperial units are to be regarded as the standard. The metric conversions are approximate. More accurate conversions should be based on the tables in BS 350, "*Conversion factors and tables*".

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 44 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

[2)] If another design of equipment is used, it must give the same penetration results as the standard equipment. In the event of disagreement between test rigs, the value given by the standard equipment will be accepted as the true value. Full particulars of one alternative design may be obtained from the Industrial Collaboration Office, A.E.R.E. Harwell.

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1 Scope

This British Standard specifies a method of test for low-penetration air-filters (other than for air supply to I.C. engines and compressors) using the sodium flame method.

2 General principle

The test cloud of common salt is generated by the evaporation of water from a spray of droplets formed by atomizing a solution of salt in a spray box. Most of the larger droplets are removed by baffles placed axially around the nozzles and the remainder of the cloud is blown down the ducting by the main air flow.

The remaining large droplets fall out in the entrance to the ducting and are removed by draining into a detachable sump. Thorough mixing of the cloud is ensured by a circular baffle situated centrally in the ducting down-stream from the spray box. The relative humidity of the air and the dimensions of the ducting are such that all the water has evaporated by the time the aerosol reaches the filter under test, leaving a test cloud of small particles of salt. After passing through the filter under test the air flows down the effluent ducting, mixing being carried out by means of a baffle and orifice plate, the latter also serving, with its associated manometer, to meter the air flow. Within the effluent ducting is an elbow bend sampling tube which is connected to a flame photometer. The flame photometer consists of a flame tube assembly through which a proportion of the effluent air passes. Any entrained salt particles produce the characteristic emission of sodium yellow light from the hydrogen burner. After passing through suitable optical filters, the light from the flame falls on the cathode of a photomultiplier cell and the resulting photo-current is measured by means of a sensitive galvanometer. By prior calibration of the instrument, readings given by the effluent cloud from the filter can be converted into percentage penetration figures.

3 Test rig

The test rig shall be assembled as follows (See Figure 1):

3.1 Fan. A fan shall be provided capable of delivering the maximum required flow of air against the resistance of the complete equipment and filter under test.

3.2 Humidity and contamination control. The air delivered by the fan shall be dried sufficiently so that the relative humidity (r.h.) of the salt-laden air at the filter face shall be less than 60 %, and it shall also be filtered in order to prevent contamination of the salt solution by dust and lint.

3.3 The test cloud generator

3.3.1 The test cloud generator shall normally consist of up to four atomizers and baffles (Figure 2) contained in a suitably sized box (Figure 3) of polyvinyl chloride (PVC) (or other non-corrodible material) designed for insertion between the fan and main ducting.

3.3.2 Each of the atomizers A shall be constructed of stainless steel and conform to Figure 2. The baffle, positioned symmetrically around the atomizer, may be constructed from a rigid polythene[3] bottle and held in position by drilling the screw cap and sliding it over the atomizer feed tube, a tight fit being obtained by packing the cap with a polythene sleeve before screwing it on to the bottle.

Three slots 5 in (127 mm) long and 1 in (25 mm) wide, with the long sides turned inwards for $^3/_{16}$ in (5 mm) shall be cut in the side of the bottle, the remaining portions of the bottle acting as baffles for the spray which strikes the centre of each of these baffles and escapes to the spray box through the slots. The liquid feed tube shall project through the bottom of the bottle into the salt solution and drain holes shall be made in the bottom so that excess liquid will run back into the spray box.

3.3.3 The spray box shall consist of a non-corrodible container of suitable size and shape to accommodate 4 atomizers (Figure 3). The box shall have a short length of 12 in (305 mm) diameter inlet and outlet ducting with suitable flanges for connection to the fan and main ducting. The lid of the box shall be made of clear material[4] reinforced at the edges by light alloy angle bar. The lid shall be held in position by quick release clips and a thick sponge rubber gasket shall be included to make the box airtight. The bottom of the box shall be made to slope slightly from each side towards the centre, at which a 1 in (25 mm) drain tap shall be installed to drain away used salt solution. In order to reduce solution agitation an inverted transparent plastics[4] tray shall be placed on the bottom of the spray box, 4 holes to be drilled through the tray at the appropriate places to accommodate the polythene[3] bottles which serve as baffles.

[3] It should be noted that the name polythene is equivalent to the name polyethylene.
[4] A material such as perspex is suitable.

3.3.4 The atomizer shall be connected by individual feed pipes and a manifold (Figure 3) to a supply of compressed air capable of delivering up to 4 ft^3/min (113 l/min) of free air for each atomizer, at a constant pressure of 100 lbf/in^2 gauge (7 bar)[5]. The air shall be delivered clean and free from oil and water. The feed pipes shall pass into the spray box through close-fitting bushes near the top of one side. Each shall carry, outside the box, an isolating valve and a flow-meter, so that the number of atomizers in use can be controlled and the flow to each checked (to guard against blockage or leakage). For testing high-efficiency filters at flows exceeding 500 ft^3/min (850 m^3/h) 4 atomizers are needed; between 200 ft^3/min (340 m^3/h) and 500 ft^3/min (850 m^3/h) 2 atomizers; between 50 ft^3/min (85 m^3/h) and 200 ft^3/min (340 m^3/h) 1 atomizer, and below 50 ft^3/min (85 m^3/h) preferably a one hole atomizer. Each compressed air flowmeter shall be capable of measuring 3.3 ft^3/min to 3.5 ft^3/min (95 l/min to 100 l/min) of free air at a pressure of 100 lbf/in^2 (7 bar [6]). Alternatively, a single flowmeter capable of measuring the same total flow may be incorporated in the manifold (e.g. 2 ft^3/min to 20 ft^3/min (50 l/min to 500 l/min) range flowmeter for 4 atomizers), together with an isolating valve on each feed pipe. The constant pressure of 100 lbf/in^2 (7 bar[6]) may be obtained by the use of either a bleed-off valve or a regulating valve in the manifold. The valve shall be mounted near the flame tube to facilitate operation of the rig, together with a pressure gauge and the flowmeter (if a single one is used). The pressure gauge shall be of the Bourdon type with a dial of not less than 6 inches (150 mm) diameter, reading accurately to 100 lbf/in^2 (7 bar [6]).

3.4 Ducting. The ducting B shall be of such diameter, *D*, that the linear speed of air shall not exceed 30 ft/s (9 m/s) and of such length that at least 2 seconds shall elapse for the passage of air between the atomizers and the filter under test, so that complete evaporation of water from the spray takes place before arrival at the filter. It shall be made of, or treated with, salt-resistant material such as polyvinyl chloride. A sump shall be provided on the underneath of the duct, placed at a distance *D* from the spray box, to drain liquid carried over from the atomizers. The circular mixing baffle of diameter $D/\sqrt{2}$ situated at least 10 *D* from the spray box shall be supported centrally on wires or thin strips offering little resistance to flow. One axial sampling point E facing up-stream, at least 5 *D* from the baffle shall be provided in the inlet ducting, near the front face of the filter unit, for calibration purposes and r.h. measurements of the salt-laden air. The sampling orifice E shall have a sharp leading edge, and be of such a diameter that the sampling velocity is between ¼ and 4 times the duct velocity at a sampling flow rate of between 1 ft^3/min and 2 ft^3/min (28 l/min and 56 l/min). Within these limits, errors due to anisokinetic sampling are negligible.

For a test rig handling 1 000 ft^3/min (1 700 m^3/h) ducting diameter *D* of 12 in (305 mm) is suitable.

3.5 The filter housing. This shall consist of expanding sections from circular inlet to rectangular section, the cross-sectional area of the large end being not more than 50 % greater than that of the filter under test. Between the expanding sections there shall be a parallel section, of the same cross section as the rectangular ends, having a length between 10 % and 20 % greater than the depth of the filter under test, and within which the complete filter unit (including support and retaining frame) is to be mounted on a suitable supporting plate in accordance with the filter manufacturer's normal method of installation.

Static pressure taps shall be provided as near as practicable to the front and back faces of the filter. A suitable differential manometer capable of being read to an accuracy of 0.05 in (0.1 mm) water gauge (w.g.) shall be connected to the pressure taps.

NOTE When the maximum face dimension of the filter exceeds say, 3 ft (915 mm) the expander section on the upstream side becomes inconveniently long. Shorter expanders (but not less than 1½X) may be used if it is demonstrated that the dust distribution remains uniform over the face of the filter.

[5] 1 bar = 10^5 N/m^2.
[6] 1 bar = 10^5 N/m^2.

3.6 Effluent ducting. The ducting C shall be of suitable length and of diameter *d* to accommodate a circular mixing baffle, orifice plate O with tappings, sampling tube E_1 and a flap or other suitable valve.

For a test rig handling 1 000 ft^3/min (1 700 m^3/h) a ducting diameter *d* of 8 in (200 mm) is suitable.

The circular mixing baffle of diameter $d/\sqrt{2}$ shall be supported centrally on wires or thin strips offering little resistance to flow and situated 3 *d* from the end of the transformation piece.

An orifice plate constructed and installed in accordance with BS 1042[7)] shall be inserted in the outlet section 10 *d* from the baffle. A suitable differential manometer shall be connected to pressure taps situated distances *d* upstream and *d*/2 downstream of the orifice.

The thin walled sampling tube E_1, with the open end cut square and of such area that the sampling velocity is within ¼ to 4 times duct velocity, shall be inserted centrally into the duct facing the air flow at a distance of 5 *d* from the orifice plate.

A flap or other suitable valve shall be inserted in the ducting 5 *d* from the sampling tube.

3.7 Flame photometer. Inside the flame tube of the photometer assembly, Figure 4, a burner (Item 20) produces an ovoidal flame symmetrical about the vertical axis. It fits closely over the flow restricter (Item 21) which fits into the hydrogen feed pipe (item 10). The burner shall be of copper as the rate of returning to clean flame conditions, after contamination, depends upon the thermal conductivity of the burner. The photomultiplier views the flame through tube K, the window in the flame tube (Item 4), and the glass chimney (Item 5) which fits closely inside the flame tube. Alignment is maintained by the bracket (Item 6) which can be adjusted relative to the flame tube. The burner height, which affects calibration, shall be fixed relative to the flame tube and bracket, by means of a supporting collar of suitable height (Item 22) and the grub screw (Item 24) so that the tip of the burner is 2 mm below the line of sight of the photomultiplier, i.e. 2 mm below the flame tube window.

The photomultiplier with its associated dynode chain resistors, rotating optical shutter and filter box shall be contained in a light-tight housing. The filter box M, just in front of the photomultiplier, contains an optical interference filter, permanently installed, to isolate the sodium yellow lines, and space for neutral density light filters to reduce the light level to a convenient value. A power unit consisting of a half-wave rectifier with corona discharge stabilizer N shall be used to provide a negative voltage of about 1 000 V for the photomultiplier, the output from which shall be led to a galvanometer, P[8)] (see Appendix **A.4**). An electrostatic voltmeter may be placed across the E.H.T. output to serve as an indication of voltage output. When the photometer control cock (Y, Figure 1 and detail Figure 7) is in the TEST position the flow of air down the sampling tube shall be controlled, normally between 1 ft^3/min and 2 ft^3/min (28 l/min and 57 l/min) by the flap valve in conjunction with the fan damper and a bleed in parallel with tube H, the effluent being allowed to pass to the horizontal tube H and atmosphere.

Some of the air flowing down the tube H is drawn into the vertical flame tube T, which contains the hydrogen burner, Q, this convective flow being almost independent of the flow in H, the flame burning quite freely. The tube H shall be connected to a supply of filtered air from a small blower G when the cock is in the STAND-BY position thus preventing short-term contamination of the burner by dirty air from the room when tests are not in progress.

The hydrogen supply to the burner shall be regulated to secure the correct flame size and shall be indicated either by a flowmeter or by a manometer[9)]. Pressure hosing shall be used to supply gas from a cylinder fitted with a pressure regulating valve to reduce pressure to a maximum of 7 lbf/in^2 (0.5 bar [10)]).

[7)] BS 1042, "*Code for flow meausrement*".
[8)] A suitable instrument may be obtained from Pye of Cambridge Ltd., and is known as the Pye Scalamp Galvanometer Type 7904/S.
[9)] If a manometer is employed the hydrogen pressure should be regulated to 10 cm w.g. Pressure variations of ± 10 % may be tolerated in order to maintain the 5 cm clean flame deflection.
[10)] 1 bar = 10^5 N/m^2.

4 Assembly of Apparatus

The apparatus shall be installed in a reasonably clean room, free from dust producing equipment and preferably with provision for heating during cold weather. Overall length of the apparatus may be reduced by semi-circular bends in the duct, such bends being of at least 2 ft (0.6 m) radius. The flame tube shall be positioned so that direct sunlight and draughts are avoided and instruments shall be mounted to avoid vibration. There shall be no serious constriction in tubes by screw clips or by the use of flowmeters with needle valves, as such devices will cause impaction of particles. Instruments may be mounted on panels or tables or by combination of both of these methods. The whole apparatus shall be assembled so that it is free from dust, special care being taken with the flame tube. Rubber hosing shall be washed to remove all traces of French chalk. The photomultiplier shall be placed in its housing in darkness or under faint red light and shall not be exposed to bright light. Approximately 1½ gallons (7 litres) of 2 % salt solution (see Appendix **B.2**) are required for each charging of the spray box.

5 Calibration

5.1 Clean flame background. With a good quality filter in circuit (0.005 %) the clean flame background value shall be determined as follows:

1) Insert the interference filter and neutral density filter to a value of at least 3 in the optical filter box.

2) Switch on the galvanometer and set at zero on most sensitive range.

3) Switch on the mains supply to the power unit with the photomultiplier masked and allow at least five minutes for the dark current to stabilize. This should be not more than a deflection of 2 mm.

4) Turn the cock to TEST position.

5) Switch on the impeller fan and adjust to correct air flow.

6) Switch on the ancillary fan or blower, G.

7) When the dark current is steady back off on the galvanometer by adjusting zero.

8) Light the hydrogen burner and adjust to correct flow.

9) Adjust the flow of air to the horizontal tube H to between 1 ft^3/min and 2 ft^3/min (28 l/min and 56 l/min) measured by inclined gauge or by flowmeter [the apparatus will function well on flows of 0.5 ft^3/min to 2 ft^3/min (14 l/min to 57 l/min)].

10) Switch the galvanometer to the least sensitive range and unmask the photomultiplier.

11) Switch the galvanometer to more sensitive ranges noting the galvanometer deflection at each step.

12) Gradually remove the neutral density filters until the galvanometer deflection is about 50 mm.

13) When the deflection appears to be steady, check that the hydrogen flow is 500 ml/min and insert appropriate neutral density filters to give a deflection of 50 mm on Range 1 of the galvanometer. Allow the apparatus to stabilize for at least half an hour, checking deflections at 5 minute intervals. To maintain a 50 mm deflection it may be necessary to adjust the hydrogen flow within the range 500 ± 50 ml/min.

It is necessary to follow these instructions carefully to check on clean flame deflection as this deflection provides an indication of the stability of the whole apparatus. A small amount of contaminant will be readily detected by removing the cowling and inspecting the flame for yellow coloration. If clean, the flame should be scarcely visible and slightly blue. A large deflection will also be obtained if there are light leaks in the photomultiplier housing. Such leaks may usually be detected by wrapping black cloth round the housing.

When the background deflection is steady the neutral density values shall be noted. In future work these neutral density values shall be employed for obtaining the clean flame deflection of 50 mm and hydrogen flow shall be within ± 10 % of 500 ml/min. The meter reading should be fairly steady, varying by less than 1 mm although occasional flicks may occur if dust or fibres are blown into the flame. A roughing filter F (Figure 1) shall be inserted, if necessary, to remove such particles from the system, and may be left in circuit when low penetration filters are being tested, but it shall have a penetration large enough to exert no appreciable effect on removal of particles smaller than 1 μm which have penetrated the filter under test. It shall be removed for testing filters with a measured penetration higher than 10 %. (A suitable roughing filter may be constructed of approximately 1⁄9 ft^2 (0.01 m^2) area, from 1 or 2 sheets of glass-fibre battery separator material and shall have a penetration of about 90 %. The roughing filter shall be renewed after every 20 filter tests.)

5.2 Main calibration. The dilution circuit for the main calibration shall be built in as a permanent part of the test rig (Figure 1) and the relationship between salt concentration and deflection shall be obtained as follows:

1) Check that the clean flame background is correct.

2) Insert neutral density filters to the value of at least 3.0.

3) Remove the roughing filter F as it may cause loss of some of the larger particles from the unfiltered cloud.

4) Switch on the impeller fan and adjust to correct air flow.

5) Turn on compressed air to atomizer(s) and check that the air flow at 100 lbf/in^2 (7 bar [11)]) is equivalent to 95 l/min to 100 l/min free air delivery.

6) Check the relative humidity and control the heat input, if necessary, to reduce relative humidity to a maximum of 60 % at the filter face.

7) Bleed off a small metered proportion of the unfiltered test cloud by the sampling orifice E. The rate of flow through the orifice is the sum of the flows through meters A_1 and G_1, Figure 1.

8) Mix part of the sample which is being bled off (of between 1 l/min and 10 l/min) with a measured air flow of between 20 l/min and 200 l/min. This diluting air shall be of less than 60 % relative humidity and shall have been filtered through high efficiency filters.

9) Bleed off a flow of a few l/min of this mixture (measured by the flowmeter C_1) and mix thoroughly with a larger measured flow of dry filtered air metered by flowmeter D_1.

10) Pass between 1 ft^3/min and 2 ft^3/min (28 l/min and 56 l/min) of the final mixture in **5.2** 9) to the control cock Y and thence to the horizontal flame tube.

11) When all flows are steady adjust neutral density filters in the optical filter box to obtain a suitable galvanometer deflection.

By varying the proportions of clean filtered and salt-laden air, concentrations of from 0.005 % to 100 % of the original cloud may be obtained, for each of which concentrations the galvanometer deflection shall be read and the total value of neutral density filters noted. Only one dilution stage is required for concentration of 5 % to 100 %.

A plot of equivalent deflection against percentage concentration leads to a straight line up to about 10 % concentration with curvature between 10 % and 100 %. The equivalent deflection/concentration graph, as plotted on log – log paper, is shown in Figure 5. It has been found that the deflection is directly proportional to the mass of salt over a wide range of concentrations and is independent of particle size in the range employed in this test. Calibration shall be carried out at each main flow rate to be employed and for each calibration calculations shall be set out as shown in Appendix C.

NOTE 1 The galvanometer deflection should not be read until a few minutes after each flow adjustment has been made in order to ensure that the correct concentrations have been reached. Good mixing of the salt laden and clean air is essential in the mixing chambers, which should be of about 10 litres capacity, or fluctuations of the flame will occur. Small pulses in the flow through the low volume flowmeters may cause fluctuations in readings and excursions of ± 10 % in both galvanometer and flowmeter readings may be encountered. With care, however, by estimation of mean readings of galvanometers and flow meters, good linearity of deflection versus concentration will be obtained.

NOTE 2 It is essential that the flowmeters and tubes be free from serious constrictions as described in Clause **4**.

NOTE 3 The power unit voltage is fixed by the corona discharge stabilizer and this voltage, together with the degree of sensitivity of the photomultiplier and attenuation by the interference filter, controls the galvanometer deflection. Each of these three factors varies from component to component and therefore changing any one causes a change in calibration.

NOTE 4 Recalibration should be carried out when any of the above factors has been changed (Note 3).

NOTE 5 Spot checks on calibration should be made daily. At least five points should cover the range 0.01 % to 100 % concentration.

6 Testing Procedure

The following testing procedure shall be carried out:

1) Switch on the galvanometer and zero with sensitivity switch on the most sensitive range.

2) Switch on the E.H.T. and allow 5 minutes warming up period.

3) Check the dark current and if within the standard limits re-set the galvanometer to zero.

4) Light the hydrogen burner and immediately turn on the ancillary blower or fan with the cock on STAND-BY. Adjust the hydrogen flow to the requisite level and check the clean flame background.

5) Connect the filter unit to be tested into the circuit.

6) Switch on the main fan, adjust the flow to correct value and read the pressure drop across the filter.

[11)] 1 bar = 10^5 N/m^2.

7) With the cock turned to TEST position adjust the flow to flame tube to between 1 ft^3/min and 2 ft^3/min (28 l/min and 57 l/min) and again check the clean flame background. If the clean flame deflection is 50 mm when the hydrogen flow or pressure is within the stipulated limits the apparatus is performing satisfactorily. The particle generation is checked by passing the 100 % cloud through the flame system (after inserting the appropriate neutral density filters).

8) Insert neutral density optical filters appropriate to the value of the expected penetration.

9) Gradually apply pressure to the atomizers whilst noting the galvanometer reading.

10) If no gross faults are apparent adjust the pressure to 100 lbf/in^2 (7 bar [12)]) and the neutral density optical filter to such a value as to obtain suitable deflection on the galvanometer checking that the air flow to each atomizer is equivalent to 95 l/min to 100 l/min free air delivery.

11) When the deflection is steady note its value.

12) Switch the cock to STAND-BY, turn off the spray and finally turn off the main air flow.

NOTE A slight difference may be found between the clean flame background readings on TEST and STAND-BY if the air from each part of the circuit is not quite of the same standard of cleanliness. This difference should be less than 5 % if the apparatus is clean and the reading when the cock is on TEST is the one which is to be used in calculation.

Specimen calculations for determining percentage penetration are shown in Appendix D.

7 Effect of humidity on the flame

As the humidity in the flame tube is increased the galvanometer deflection decreases. This depressive effect is approximately 2 % of clean flame background for a 10 % increase in relative humidity. The spray from four atomizers increases relative humidity in the trunking by some 5 % at 1 000 ft^3/min (1 700 m^3/h) so that, whilst the salt penetrating causes an increase in galvanometer deflection, this increase is smaller than would be found if there were no humidity changes. The error involved in measuring penetrations of 0.002 % at 1 000 ft^3min (1 700 m^3/h) is thus about 10 % and may be neglected, but allowance has to be made for humidity if filters of the measured value of 0.001 % penetration and less are being tested. It is indeed possible when testing very high efficiency filters for the deflection to decrease when the spray is turned on, the decrease being attributable to increased relative humidity.

[12)] 1 bar = 10^5 N/m^2.

Appendix A Ancillary Apparatus

A.1 Relative humidity control. To obtain accurate results it is essential that the particulate matter at the filter face consists of dry salt particles and for this the relative humidity in the main ducting at the entry to the filter unit under test must be below 60 %. When the atomizers are in operation water from the spray will increase the relative humidity and any apparatus for controlling the relative humidity to the above figure shall be connected on the inlet side of the spray box.

Suitable air drying apparatus is available commercially and, where regular testing is necessary, justifies its cost. The relative humidity of the air can be reduced by heating and this may be satisfactory when intermittent testing is practicable.

The relative humidity shall be measured by wet and dry bulb thermometers, or other device of similar accuracy and response, salt laden air being bled off from the main ducting immediately before the filter unit (sampling point E). There is unlikely to be any serious error due to salt deposition on the wet bulb thermometer so long as the wick is cleaned at frequent intervals.

A.2 Photomultiplier. The photomultiplier shall be of high sensitivity (approximately 200 ampere/lumen sensitivity at 1 000 V), and have a dark current of less than 0.003 μA[13)]. Special attention shall be paid to the photomultiplier housing in order to prevent the ingress of stray light.

A.3 E.H.T. unit. The E.H.T. unit circuit for the photomultiplier is shown in Figure 6. It consists of a half-wave rectifier with resistance-capacity smoothing followed by a corona discharge stabilizer[14)].

A.4 Galvanometer. The signal shall be measured on a suitable galvanometer and in order to damp it and reduce the effects of occasional flicks when dust or fibre are blown through the flame a 250 μF electrolytic condenser and a 25 kΩ resistor shall be connected across the galvanometer terminals. The galvanometer shall always be read in the sensitive range (Range 1), deflection being reduced to scale by the use of neutral density filters, and it shall be mounted so that it is not subjected to vibration.

A.5 Interference filter. The sodium light interference filter[15)] is employed to reduce the amount of unwanted radiation falling on the photomultiplier cathode and hence to increase the signal/background ratio.

A.6 Neutral density filters. Neutral density filters 2 in (51 mm) square are employed to reduce the light value to a convenient intensity[16)]. A neutral density filter will reduce by the same amount the intensity of light of all wavelengths in the visible spectrum. The amount of reduction is given by the antilogarithm of the neutral density value. Thus a filter of neutral density 0.4 (antilog $\approx$ 2.5) reduces the intensity by a factor of 2.5, that is to 40 % of the original value, whilst a neutral density filter of value 2.0 reduces the intensity by 100, that is to 1 %. Suitable values of neutral density filters may be 0.1, 0.3, 0.4, 0.7, 1.0, 2.0, 3.0 and 4.0, giving transmission of 80 %, 50 %, 40 %, 20 %, 10 %, 1%, 0.1% and 0.01 % of the incident light. Neutral density values must be accurately known, or a smooth calibration curve may not be obtained. The main function of the neutral density filters is to attenuate sodium light as wavelengths other than those around 5890 Å (sodium yellow) are greatly attenuated by the interference filter. It is therefore more important that the value stated on the neutral density filters should hold for light of 5890 Å than for the whole range of visible wavelengths. The stated value should be within ± 2 % of the true value at 5890 Å.

A.7 Calibration of neutral density filters. The neutral density filters may be accurately calibrated by means of a transmission densitometer. However, the interference filter to be used in the apparatus shall be fitted to the instrument so that attenuations are measured for the particular band of radiations which will normally reach the photomultiplier.

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13) A suitable photo-multiplier is an "end-window" type manufactured by Electrical & Musical Industries Ltd., Hayes, Middx. Type 9524A should be ordered, quoting the above data.

14) A suitable stabilizer is manufactured by the General Electric English Electric Companies Ltd., London, W.1, Reference No. SC1/1000.

15) A suitable sodium interference filter of 2 in diameter and having a band width of 90 A at half peak is manufactured by Barr & Stroud Ltd., Anniesland, Glasgow, W.3.

16) Suitable "all glass" filters may be obtained from Chance Bros. Ltd., Smethwick, Warley, Worcs., or their agents.

If no transmission densitometer is available the calibration of neutral density filters may be made using the flame photometer as follows. With the apparatus ready for use the calibration equipment is employed to provide a diluted test cloud. A concentration sufficiently low to produce a galvanometer reading approaching full scale deflection with no additional neutral density filter is used. To achieve this it may be necessary to reduce the atomizer pressure and employ a poor quality particulate filter before diluting the aerosol. The low value neutral density filters, marked 0.1, 0.3 and 0.4, should then be inserted, in turn, in the filter box and the corresponding galvanometer deflections noted. The clean flame background should then be checked and a measurement made using each neutral density filter. The reduction factor of each neutral density filter should then be found by calculating the ratio of the deflections of the galvanometer above background. That is, by dividing the reference deflection by the deflection obtained with the unknown neutral density filter. Having checked the reduction factors to ensure reproducible results, the neutral density values are then found as the logarithum of the reduction factors. Higher neutral density values are calibrated by employing, as references, previously calibrated neutral density filters which have a total value approximately equal to the neutral density filter under test. The reference deflection is obtained by increasing the salt concentration until the galvanometer reading approaches full scale. The apparent reduction factor of the unknown neutral density filter is found as described above, then multiplied by the reduction factors of each calibrated neutral density reference filter used. The result obtained is the absolute reduction factor. This, in turn, is converted to neutral density value. Neutral density filters of increasing attenuation may be calibrated in this way, but attention shall be paid to the accuracy with which the lower values are calibrated, as these determine the accuracy of the figure found for low transmission filters.

A.8 Experimental data. Typical data as in Columns 1 to 6 are obtained using the method given in **A.7**, as follows:

1	2	3	4	5	6	7	8	9
Neutral density (reference values)	**Reference deflection with salt**	**Clean flame background**	**Neutral density (marked value)**	**Deflection with salt**	**Clean flame background**	**Apparent reduction factor**	**Absolute reduction factor**	**True neutral density value**
	cm	cm		cm	cm			
—	14.4	5.0	0.1	11.6	4.0	1.236	1.236	0.09
—	14.4	5.0	0.3	7.2	2.5	2.00	2.00	0.30
—	14.4	5.0	0.4	5.5	1.9	2.61	2.61	0.42
0.3, 0.42	14.2	1.0	0.7	13.9	1.0	1.02	5.34	0.73
0.3, 0.73	10.4	0.5	1.0	11.0	0.5	0.94	10.06	1.00
0.3, 0.73, 1.00	13.7	Nil	2.0	15.4	Nil	0.89	95.62	1.98
0.3, 0.73, 1.98	12.3	Nil	3.0	11.2	Nil	1.10	1 121	3.05

A.9 Typical calculation of reduction factor:

(Column 7, line 3) $= \frac{14.4 - 5.0}{5.5 - 1.9}$

$= \frac{9.4}{3.6}$

$= 2.61$

(Column 8, line 5)

Apparent reduction factor $= \frac{10.4 - 0.5}{11.0 - 0.5}$

$= \frac{9.9}{10.5}$

$= 0.94$

Absolute reduction factor $= 0.94 \times 2.00 \times 5.34$

$= 10.06$

Appendix B Maintenance

B.1 The flame photometer. Errors are likely to be caused by a dirty burner, but, if the flame is allowed to burn in the clean air stream for about two minutes, the contaminant should disappear. If, after a reasonable interval, the burner still appears to be dirty it must be removed and rubbed with a cloth. It is possible that, after working for long periods at high salt concentrations, the rubber hosing and flame tubes may become contaminated and require cleaning.

It is necessary to ensure that the optical filters are kept clean and free from moisture which sometimes condenses on them, especially after the first half-hour after lighting the hydrogen flame. The glass chimney should occasionally be washed, both inside and out. If the apparatus is left unused in a dusty atmosphere, the open end of the flame tube shall be covered.

B.2 Salt solution. Sodium chloride in 2 % w/v (e.g. 2 g in 100 ml of water) solution in distilled water, in quantity, shall be filtered through a coarse filter paper or good cloth filter.

B.3 Atomizers. Regular inspection of the spray nozzles is essential to ensure that all orifices are functioning properly. Any blockage in the orifices will be indicated by a fall in the reading on the high pressure flowmeter and the atomizers shall then be removed and the blockage cleared, by tapping vigorously or, as a last resort, clearing the orifices carefully, with a blue steel wire, until the correct flowmeter reading is obtained. The salt solution should be replaced daily, or more frequently if necessary. When the test rig is to be closed down for any length of time the remaining salt solution shall be drained off, clean water put into the spray box and the atomizers given a short burst of compressed air to clear them of residual salt solution. Finally the water shall be drained off and the spray box left empty of liquid until the rig is required for further use.

Four atomizers shall be the maximum number in any one spray box, but should a more sensitive test be required two spray boxes in parallel may be employed.

B.4 General equipment. Fans, blowers and motors should be maintained in accordance with manufacturers' instructions.

Appendix C Main Calibration

Specimen calculations (1 000 ft^3/min) (1 700 m^3/h).

Calibration curves similar to Figure 5 shall be prepared as detailed below for each rated air flow.

C.1 Test cloud. 2 % salt solution atomized at 100 lbf/in^2 (7 bar [17]) from 4 atomizers and mixed with partially dried filtered air to a total flow of 1 000 ft^3/min (1 700 m^3/h).

C.2 Clean flame background deflection (see **5.1**). Interference filter + 0.9 neutral density (ND) filter = 5.0 cm on Range 1.

[17] 1 bar = 10^5 N/m^2

C.3 Experimental data. The data in Columns 1 to 7 are obtained employing dilution circuit as shown in Figure 1. For high concentrations (above about 5 %) only one dilution is required and the second mixing vessel may be removed from the circuit.

1	2	3	4	5	6	7	8	9
Flowmeter readings l/min				Total value of neutral density (ND)	Clean flame background (BG)	Deflection with salt	Corrected deflection (see C.4)	Per cent of original concentration
A_1	B_1	C_1	D_1					
					cm	cm	cm	%
2.2	74	1.0	120	1.32	2.0	6.4	11.6	0.024
1.9	74	2.5	120	1.7	0.8	5.2	27.8	0.05
4.9	74	2.1	120	2.0	0.4	4.8	56.5	0.11
9.1	74	3.0	120	2.42	0.2	4.8	152.0	0.27
9.0	74	6.0	120	2.7	Nil	4.5	285.0	0.51
8.7	52	9.0	71	3.2	Nil	4.4	880	1.6
—	—	6.3	120	3.6	Nil	6.8	3 400	5.0
—	—	9.2	71	3.9	Nil	6.7	6 700	11.5
—	—	8.7	25	4.3	Nil	4.5	11 300	25.8
—	—	9.1	13	4.6	Nil	3.0	15 000	41.2
—	—	—	—	4.6	Nil	4.0	20 000	100

C.4 Calculation of corrected deflection

(Column 8, line 1) = (6.4 – 2.0) × antilog (1.32 – 0.9) cm
= 11.6 cm

C.5 Calculation of percentage of original concentration

$$\text{(Column 9, line 1)} = \frac{A_1}{A_1 + B_1} \times \frac{C_1}{C_1 + D_1} \times 100$$

$$= \frac{2.2}{2.2 + 74} \times \frac{1.0}{1.0 + 120} \times 100$$

$$= 0.024\ \%$$

C.6 Plot a graph showing deflection (Column 8) versus concentration (Column 9) as shown in Figure 5.

NOTE 17 Deflection should always be measured on the most sensitive range of the galvanometer by insertion of suitable neutral density filters.

NOTE 2 Flow in tube H is maintained at about 1 ft^3/min (28 l/min).

NOTE 3 Similar calibration curves may be prepared for other air flows using the appropriate numbers of atomizers (see **3.3.4**).

Appendix D Specimen calculations for obtaining sodium flame penetrations

D.1 Testing at 1 000 ft^3/min (1 700 m^3/h). Let the clean flame background be 5.0 cm, with a neutral density optical filter of 0.9 and sodium interference filter in the box, and the deflection versus percentage of test cloud at 1 000 ft^3/min (1 700 m^3/h) (test and calibration carried out employing 4 atomizers) be as shown in Figure 5 (Curve 1).

The deflection obtained when filter is tested = 8.9 cm. The extra deflection caused by the salt penetrating is then

8.9 – 5.0 = 3.9 cm.

A deflection of 39 cm on the calibration Curve 1 (Figure 5) is equivalent to a penetration of 0.08 % so that 3.9 cm is equivalent to 0.008 %.

D.2 Testing at 200 ft^3/min (340 m^3/h). Let it be assumed that the test is carried out at 200 ft^3/min (340 m^3/h) the clean flame background being 5.0 cm with a neutral density optical filter of 0.9 and sodium interference filter in the box and the deflection versus percentage of test cloud at 200 ft^3/min (340 m^3/h) (test and calibration carried out employing 2 atomizers) be as shown in Figure 5 (Curve 2).

The deflection obtained when the filter is tested is 6.3 cm with a neutral density optical filter of 1.6 in the optical filter box and the clean flame reading with a neutral density filter of 1.6 is 1.0 cm.

The extra deflection due to the salt penetrating is thus

$6.3 – 1.0 = 5.3$ cm

The deflection with a neutral density filter of 0.9 would therefore have been

$5.3 \times \text{antilog } (1.6 – 0.9)$, i.e. $5.3 \times 5 = 26.5$ cm

The percentage penetration read from the calibration Curve 2, Figure 5 is therefore 0.02.

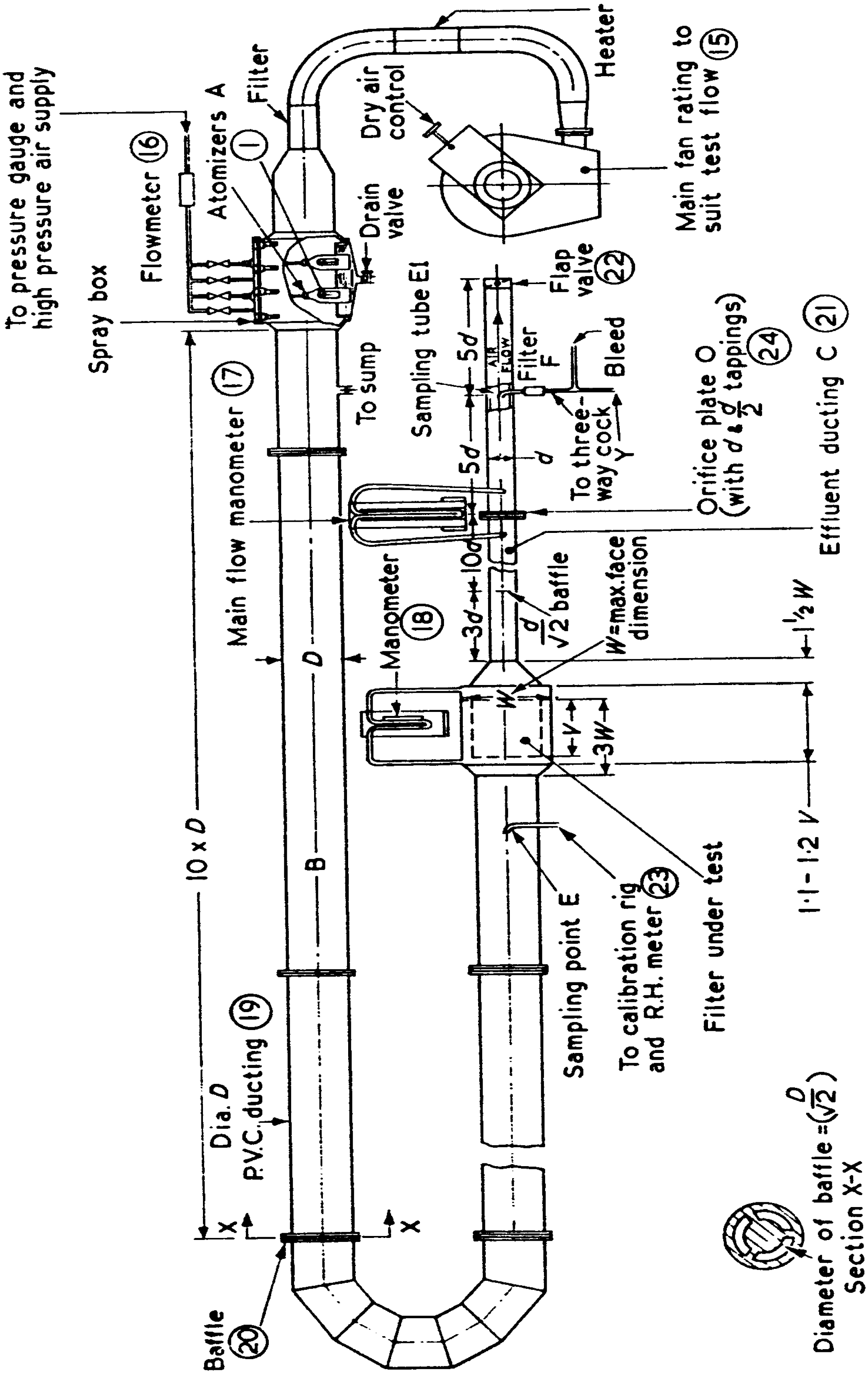
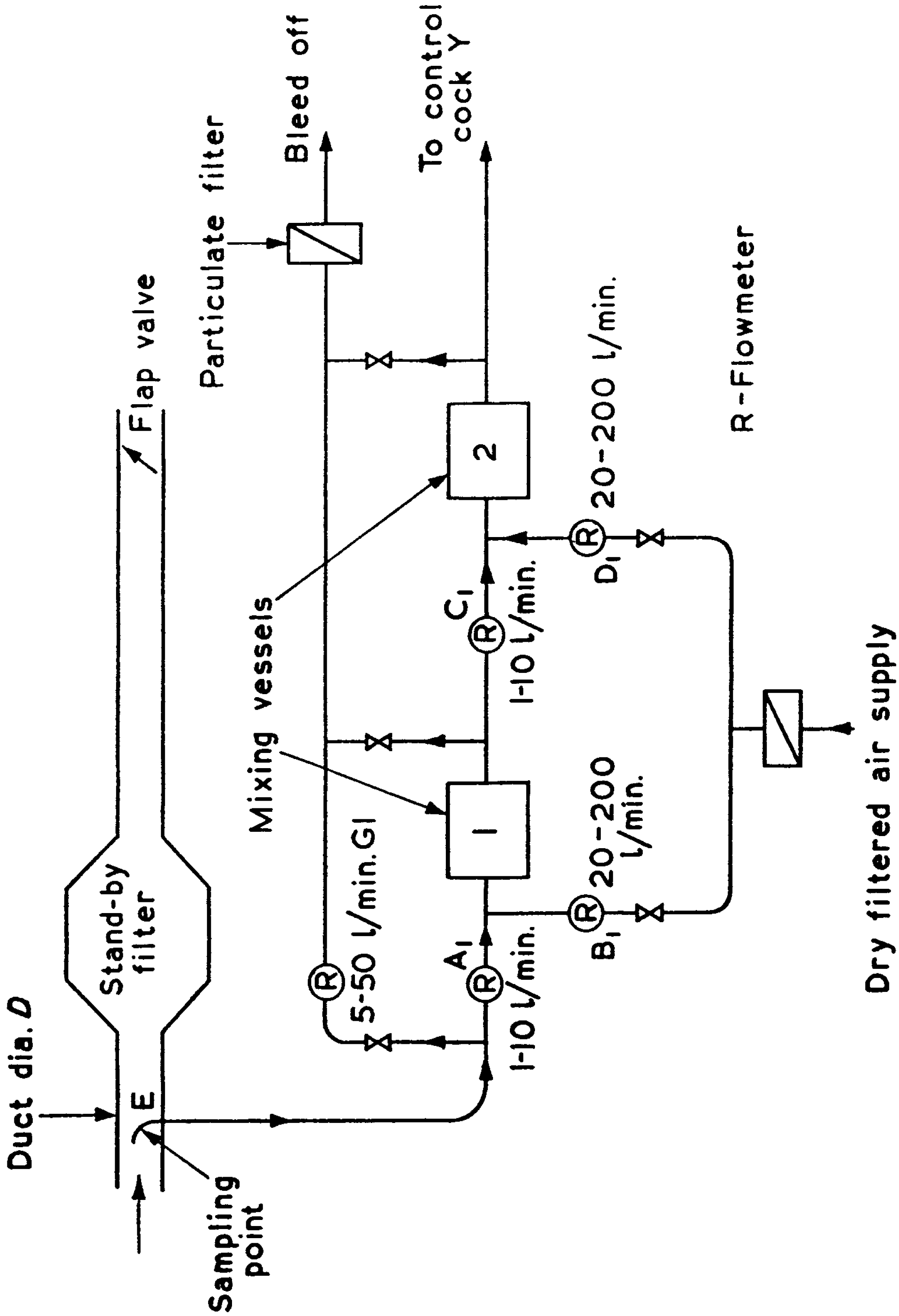


Figure 1 — General layout of test rig

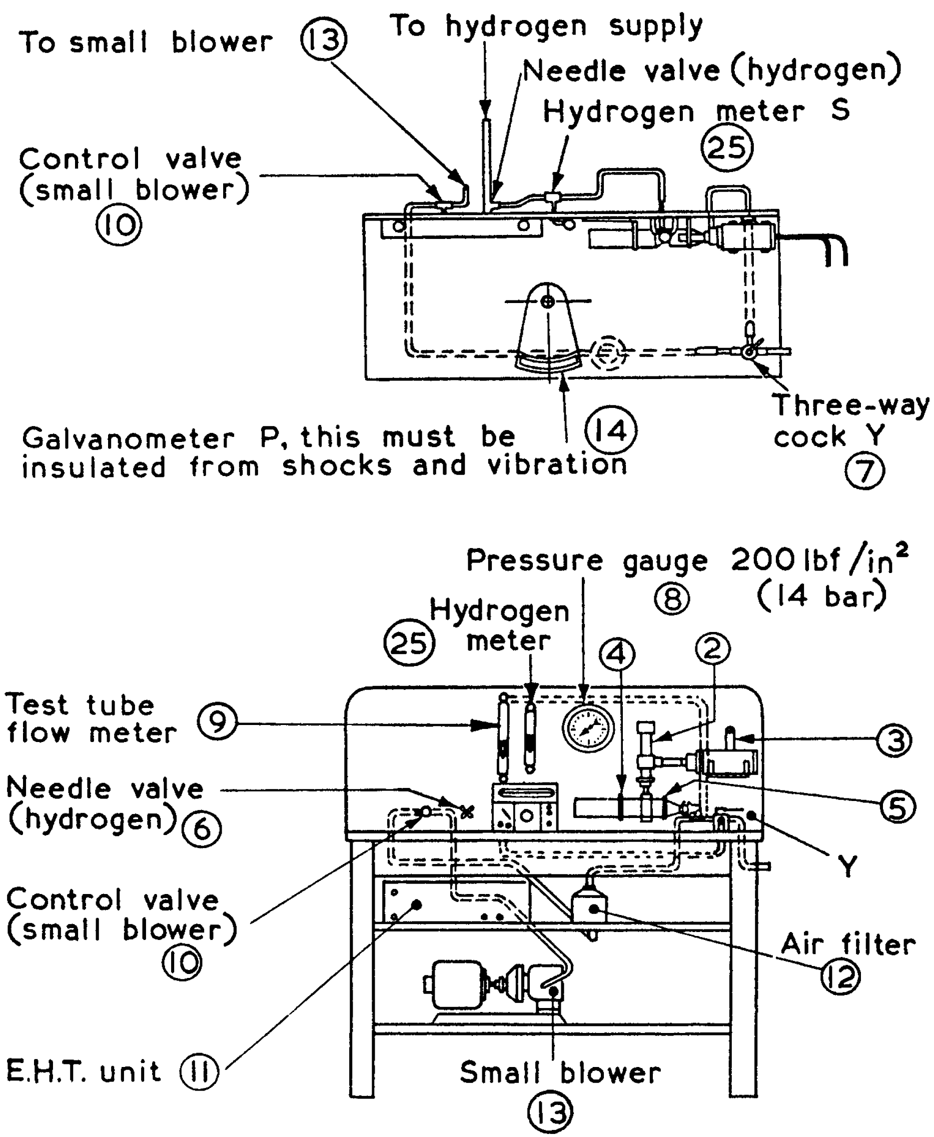
For item list see page 14



Dilution circuit for calibration

Figure 1 — General layout of test rig *(continued)*

For item list see page 14

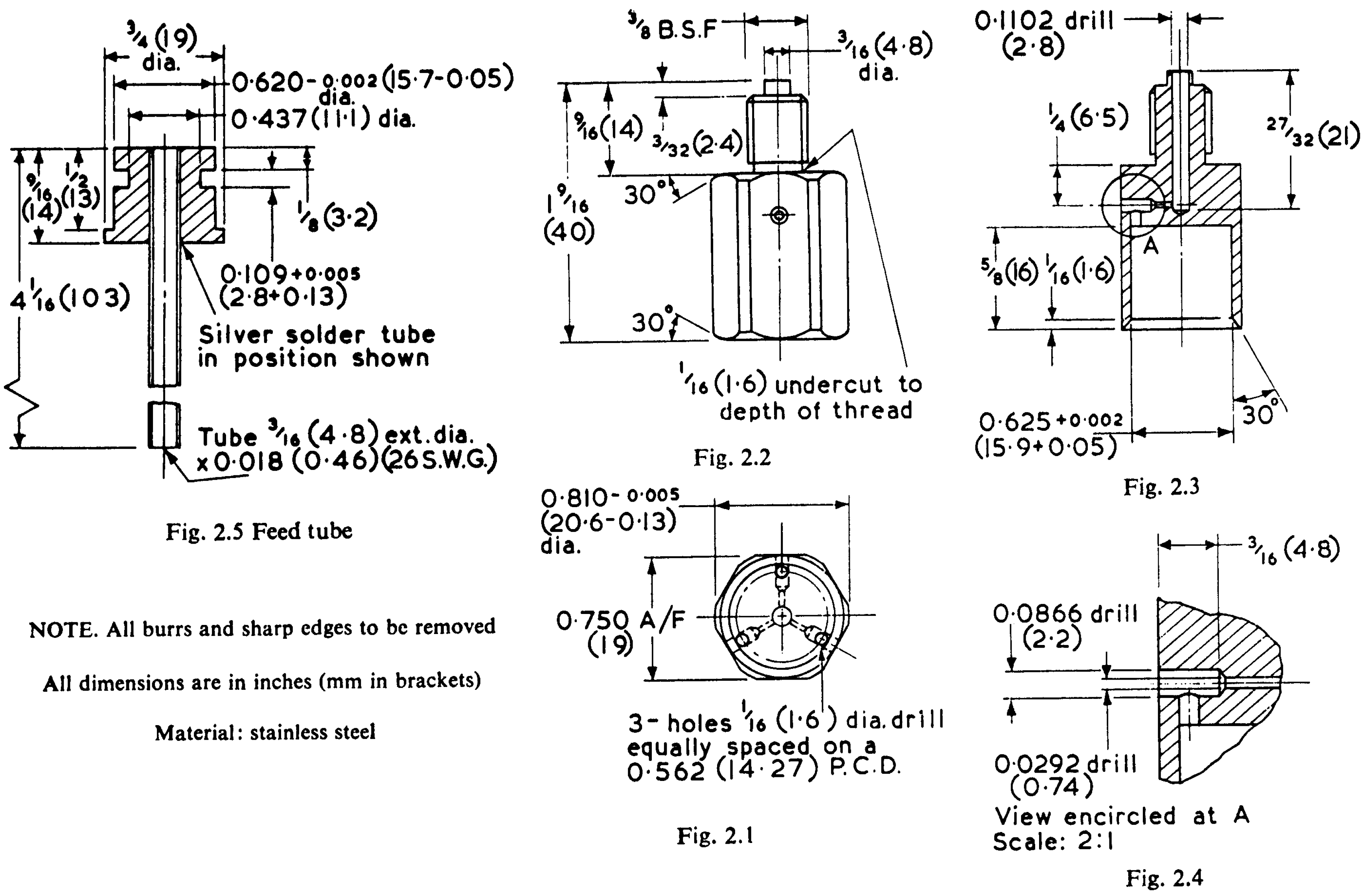


ITEM LIST FOR FIG. 1

Item	Fig. No.	Name	No. off	Remarks
1	2	Atomizer assembly	4	
2	4	Test tube and flame tube assembly	1	
3	N.D.	Support bracket	1	
4	N.D.	Top bracket, flame tube	1	
5	N.D.	Test tube bracket	2	
6	N.D.	Needle valve	1	
7	N.D.	Control cock	1	
8	N.D.	Pressure gauge 0–200 lbf/in² (0–14 bar)	1	
9	N.D.	Test tube flowmeter	1	
10	N.D.	Control valve	1	
11	N.D.	E.H.T. unit	1	
12	N.D.	Air filter, high quality	1	
13	N.D.	Small blower with ¼ hp motor. 1420 rev/min	1	
14	N.D.	Galvanometer	1	
15	N.D.	Main fan	1	
16	N.D.	Flowmeter	1	
17	N.D.	Main flow manometer	1	
18	N.D.	Manometer	1	
19	N.D.	‘ *D* ’ dia. ducting	As reqd.	
20	N.D.	Baffle	1	$\left(\text{dia.} = \frac{D}{\sqrt{2}}\right)$
21	N.D.	‘ *d* ’ dia. ducting	As reqd.	
22	N.D.	Flap valve	1	
23	N.D.	R.H. meter	1 comp.	
24	N.D.	Orifice plate (with d and $\frac{d}{2}$ tappings)	1	To BS 1042
25	N.D.	Hydrogen flowmeter	1	

N.D. = no drawing.

Figure 1 — General layout of test rig *(continued)*



NOTE. All burrs and sharp edges to be removed

All dimensions are in inches (mm in brackets)

Material: stainless steel

For item list see page 16

Figure 2 — Assembly of atomizer (items 1 and 2)

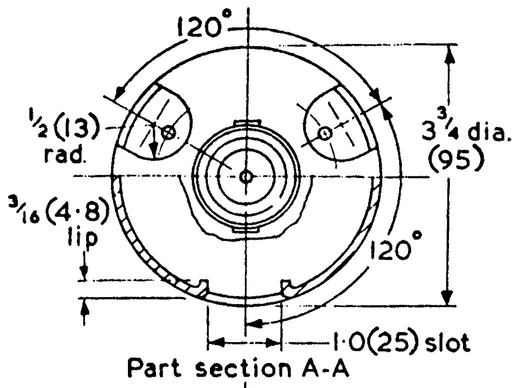


Fig. 2.7

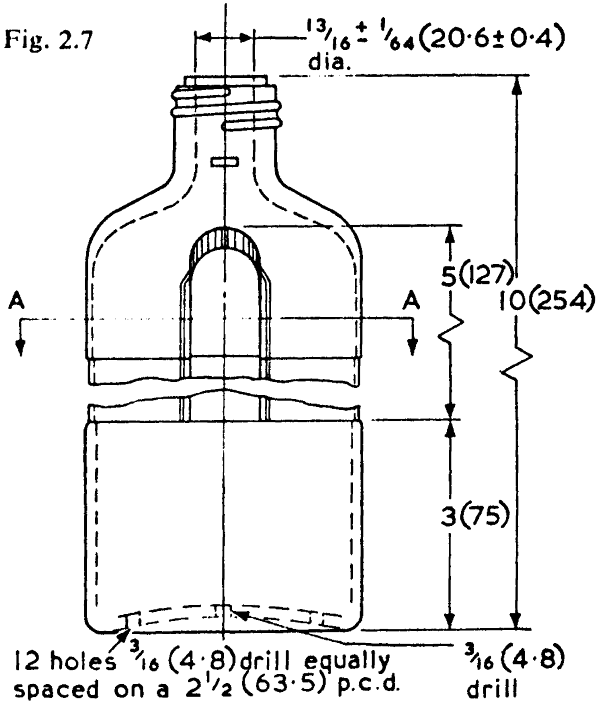


Fig. 2.6. Bottle (modified)

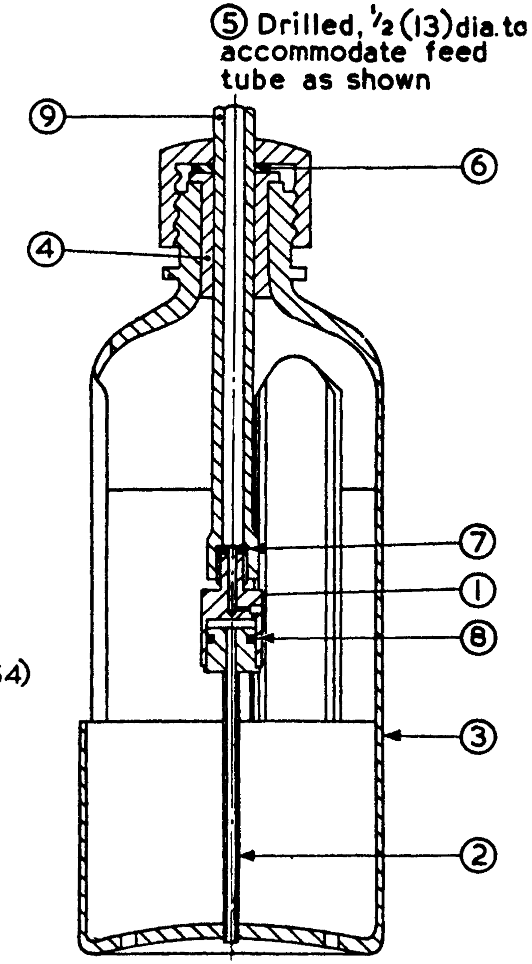


Fig. 2. Assembly of atomizer
All dimensions are in inches (mm in brackets)

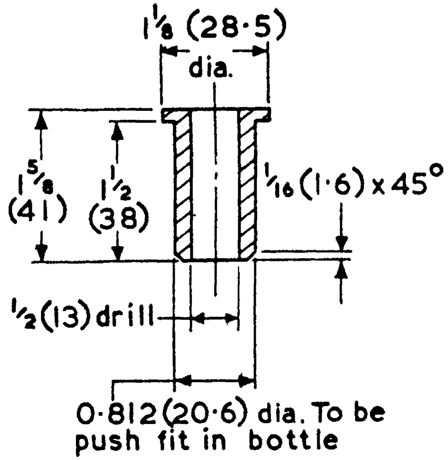
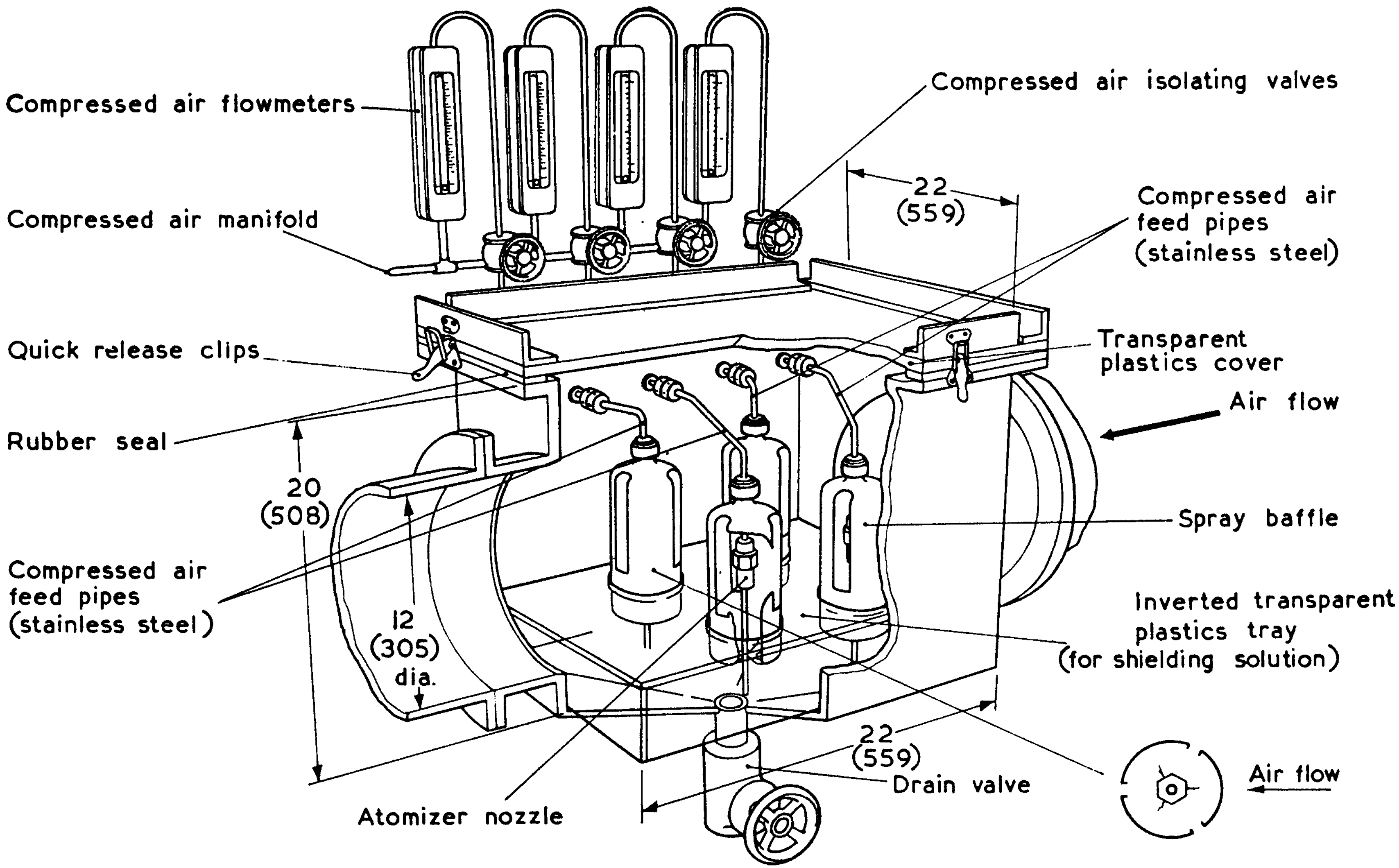


Fig. 2.8 Sleeve.

ITEM LIST FOR FIG. 2

Item	Fig. No.	Name	No. off	Remarks
—	2	Assembly of atomizer	1	
1	2.1–2.4	Nozzle	1	
2	2.5	Feed tube, salt solution	1	
3	2.6–2.7	Bottle, polythene	1	Modified
4	2.8	Sleeve	1	
5	N.D.	Screw cap for bottle	1	Modified
6	N.D.	Washer 1 × ½ × ⅛ (25 × 13 × 3·2)	1	Hard rubber
7	N.D.	Washer ⅜ × 3/16 × 3/32 (9·5 × 4·8 × 2·4)	1	Hard rubber
8	N.D.	'O' seal O.S.9	1	To BS 1806
9	N.D.	Air tube ½ (13) o.d., ¼ (6·5) i.d.	As reqd.	Stainless steel

Figure 2 — Assembly of atomizer (items 3 and 4) *(continued)*



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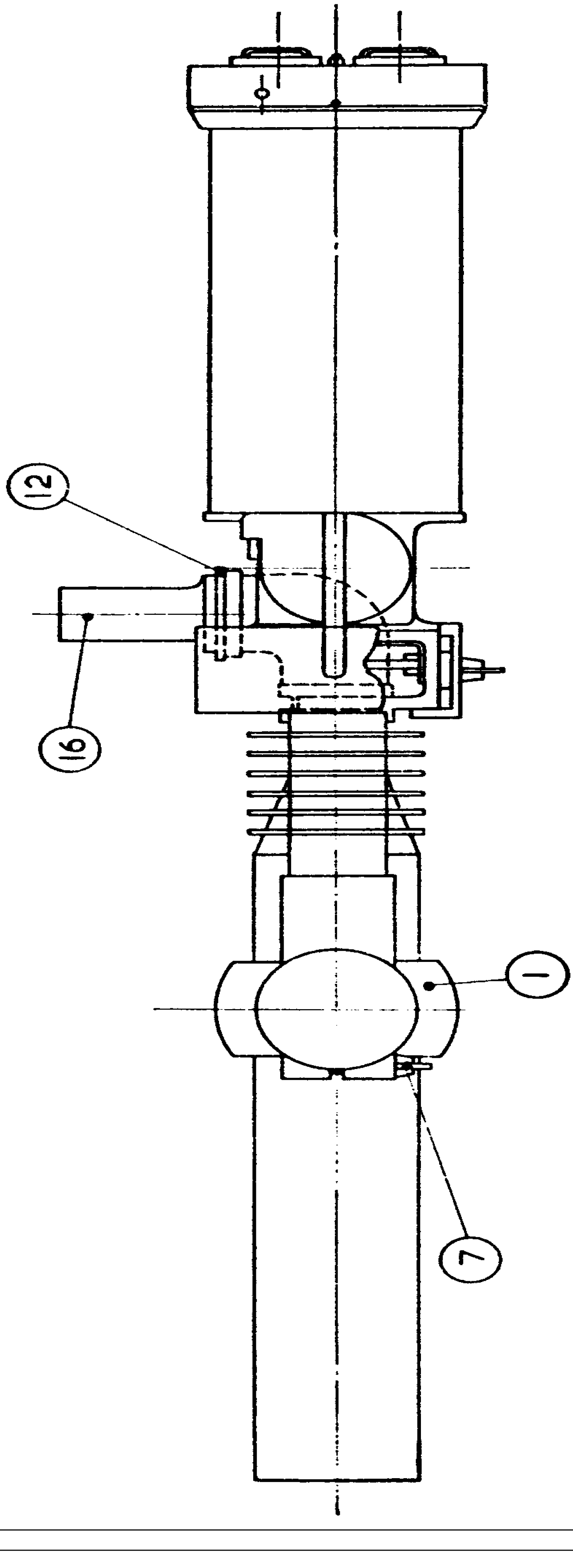
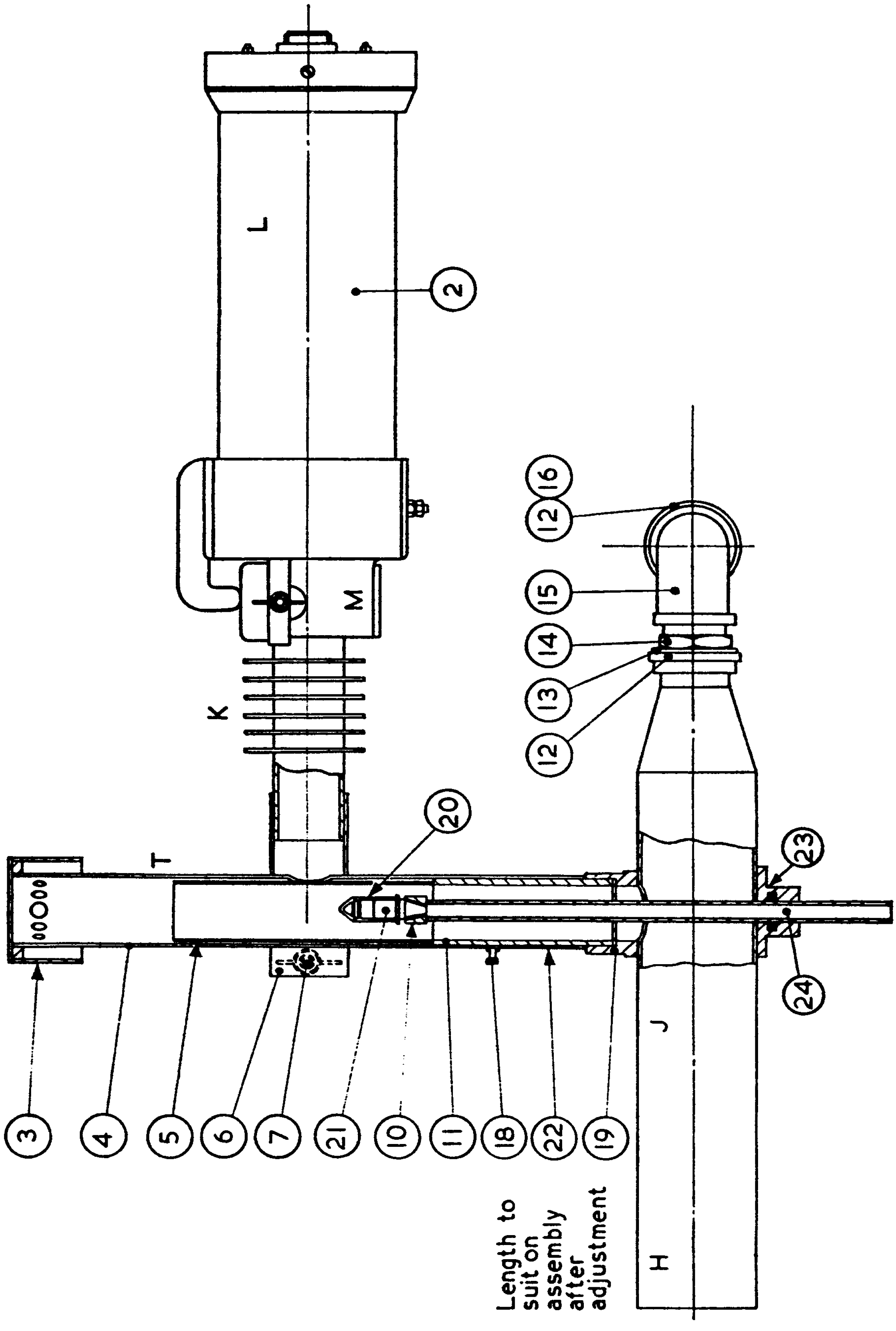
All dimensions are in inches (mm in brackets)

Figure 3 — Spray box



For item list see page 20

Figure 4 — Photomultiplier, test tube and flame tube assembly



For item list see page 20

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*

ITEM LIST FOR FIG. 4

Item	Fig. No.	Name	No. off	Remarks
1	4.1	Bearer assembly	1	
2	4.2	Housing assembly	1	Photo-multiplier
3	4.3	Cap	1	
4	4.4	Flame tube	1	
5	4.5	Glass chimney	1	
6	4.6	Bracket	1	
7	N.D.	Screw, special ¼ BSF	1	' Wing head '
8	—	—	—	
9	—	—	—	
10	4.8	Feed pipe	1	
11	4.9	Tube	1	
12	N.D.	Washer	2	Leather
13	N.D.	Washer	1	Metal
14	N.D.	Lock-nut ¾ BSP	1	
15	N.D.	Connection to elbow assembly	1	
16	N.D.	Connection to elbow	1	For rubber hose
17	—	—	—	
18	N.D.	Screw, 6 mm × M4 × 0·7–6 g brass cheese head	1	Brass nickel plated
19	4.10	Baffle	1	
20	N.D.	Copper burner	1	
21	N.D.	Flow restricter	1	
22	N.D.	Collar	1	
23	N.D.	' O ' Seal, 110	1	
24	N.D.	Screw, 6 mm × M4 × 0·7–6 g brass cheese head	1	Brass nickel plated

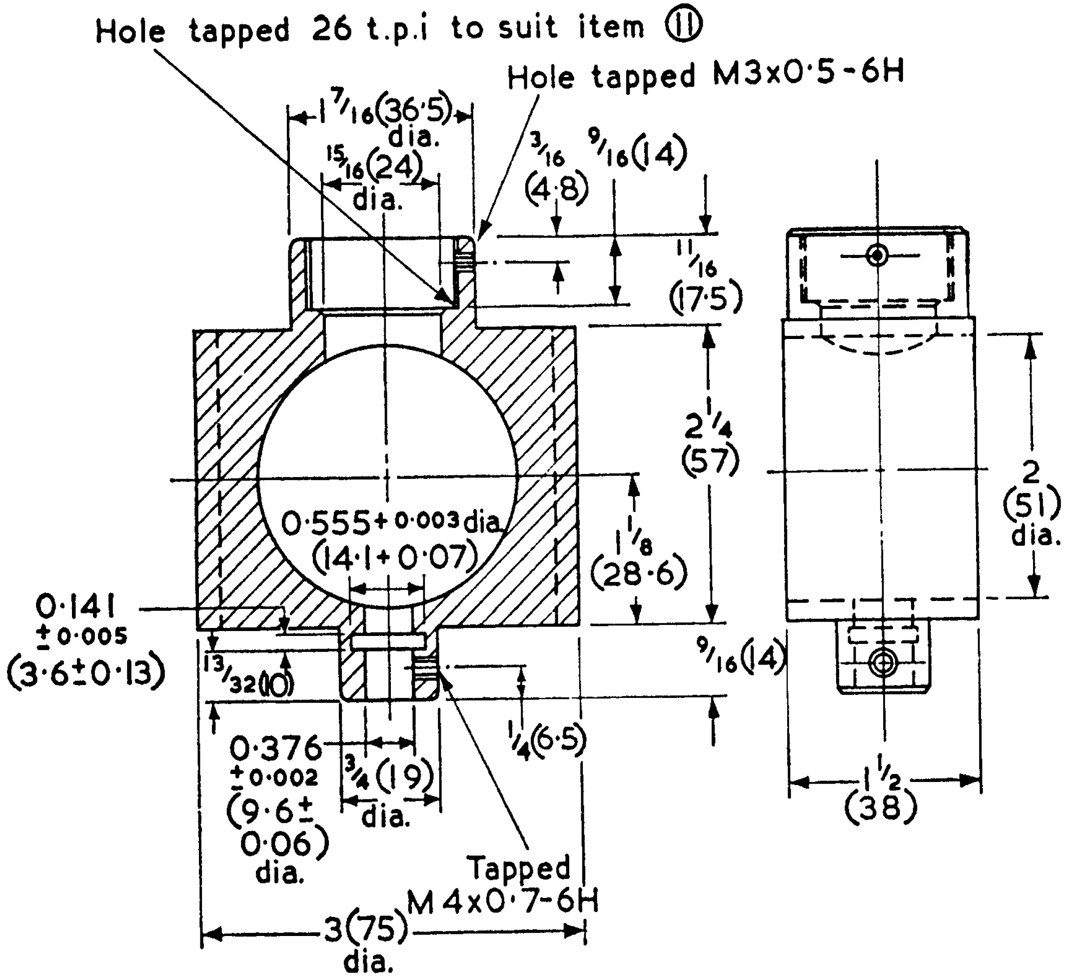


Fig. 4.1. Bearer assembly

All dimensions are in inches (mm in brackets)

Material brass to BS 249
Protective finish: nickel plated

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*

ITEM LIST FOR FIG. 4.2

Item	Fig. No.	Name	No. off	Remarks
1	N.D.	Eccentric to open lid	1	
2	4.2(1)	Lid	1	
3	4.2(2)	Shutter assembly	1	
4	4.2(3)	Housing assembly	1	
5	N.D.	Stop	1	
6	4.2(4)	Pad	1	
7	4.2(5)	Cover	1	
8	4.2(6)	Housing and wiring details	1	
9	N.D.	‘O’ sealing ring, O.S.40	1	BS 1806
10	N.D.	M2 countersunk screws ¼ (6) long	3	Matt black finish
11	N.D.	Screw, 6 mm × M3 × 0·5 – 6 g brass c’sk head	3	Matt black finish
12	N.D.	Screw, 10 mm × M3 × 0·5 – 6 g brass countersunk head	1	
13	N.D.	‘O’ sealing ring, O.S.1	1	BS 1806
14	N.D.	Nut, M4 × 0·7 –6H brass	2	Matt black finish
15	—	—	—	
16	N.D.	Hinge pin No. 14 SWG (·081) 1½ (38) long	1	Matt black finish
17	N.D.	Black flock paper, Type D.910	As reqd.	
18	4.2(7)	Rear ring	1	
19	4.2(8)	Pin connection	30	
20	4.2(9)	Front ring	1	
21	4.2(10)	Spring	3	
22	4.2(11)	Spacer	3	
23	4.2(12)	Distance piece	3	
24	4.2(13)	Rod	3	
25	N.D.	Socket, fixed, single pole small, concentric Mk.4	2	
26	N.D.	1⁄32 (0·8) dia. split pin ¼ (6·5) long	3	
27	N.D.	Nut, M3 × 0·5 –6H brass	6	Brass
28	N.D.	Photomultiplier, Type 9524.A	1	
29	N.D.	Valve holder No. B14B	1	
30	N.D.	Screw, 5 mm × M4 × 0·7 – 6 g steel pan head	2	
31	N.D.	Resistor, high-stability	12	1 MΩ ±5 %
32	N.D.	Polythene insulated tinned copper conductor 14/·0076 024 (0·6) radial thickness of polythene	As reqd.	
33	4.2(14)	Filter support	1	
34	N.D.	Neutral tint filter	As reqd.	
35	N.D.	Sodium interference filter, 2 in (51) dia. 90Å bandwidth for sodium light 5890Å	1	

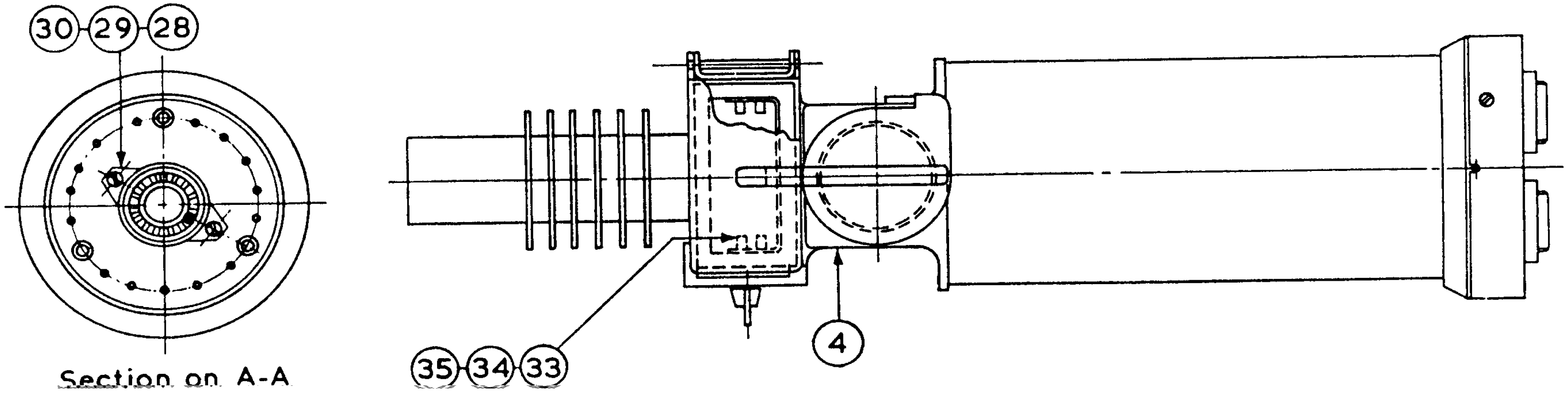
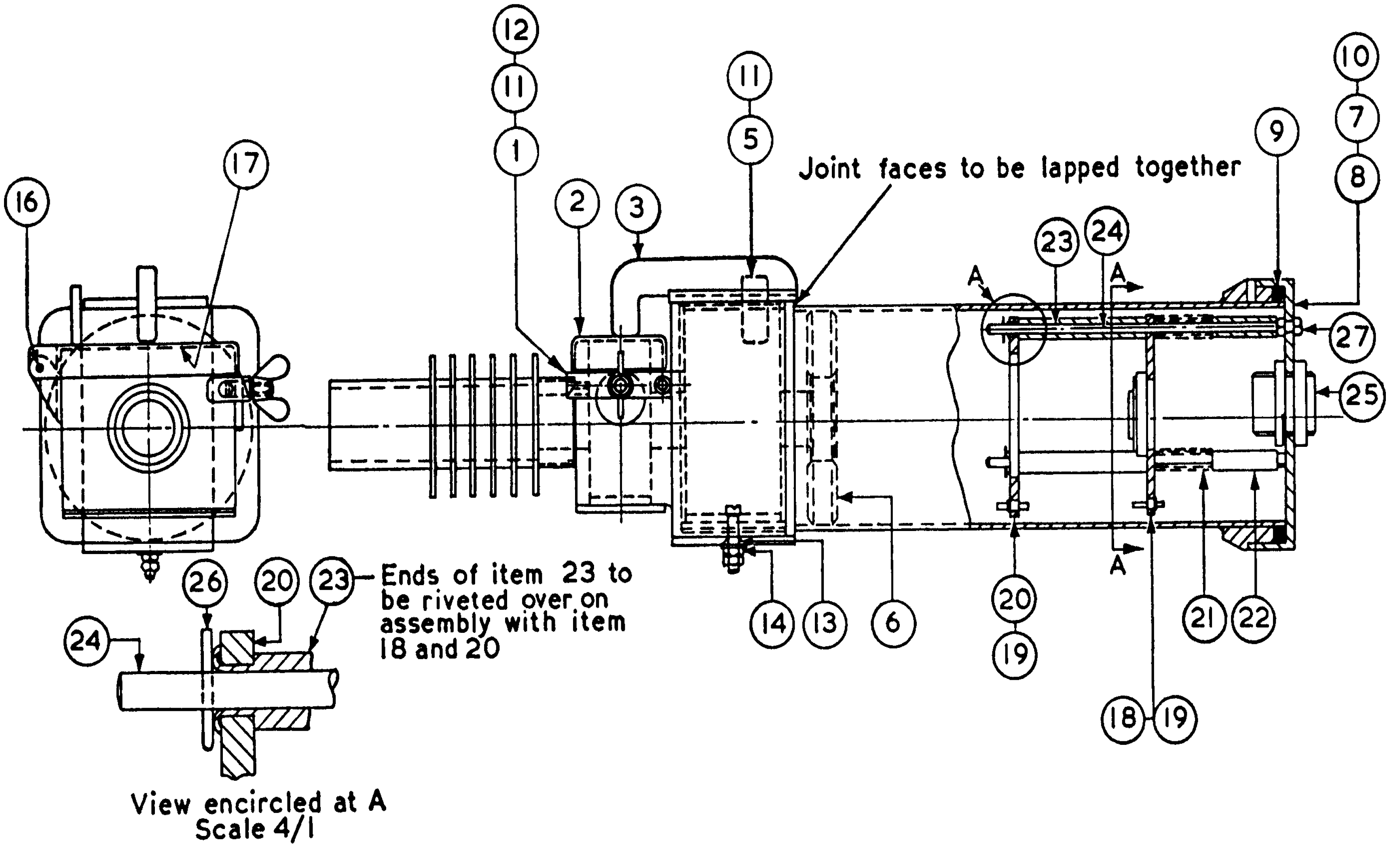


Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*

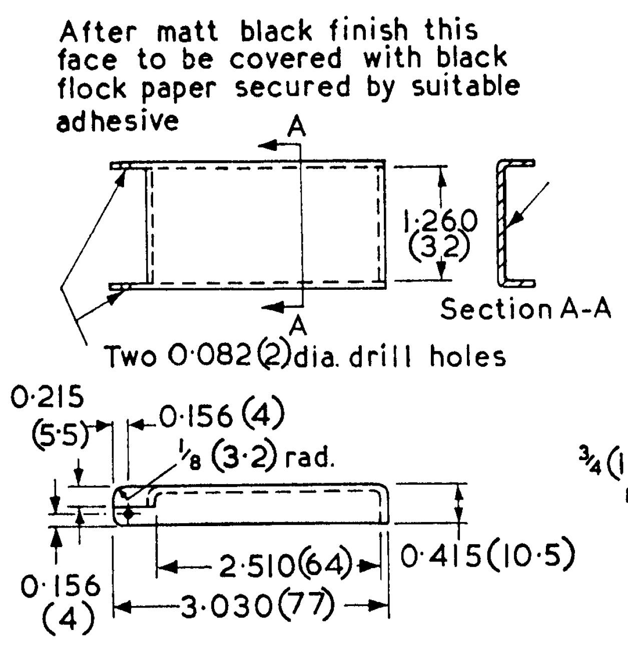


NOTE. Care must be taken when assembling items 2, 3 and 8 that all joints are perfectly light tight

Fig. 4.2. Housing assembly

For item list see page 21

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*

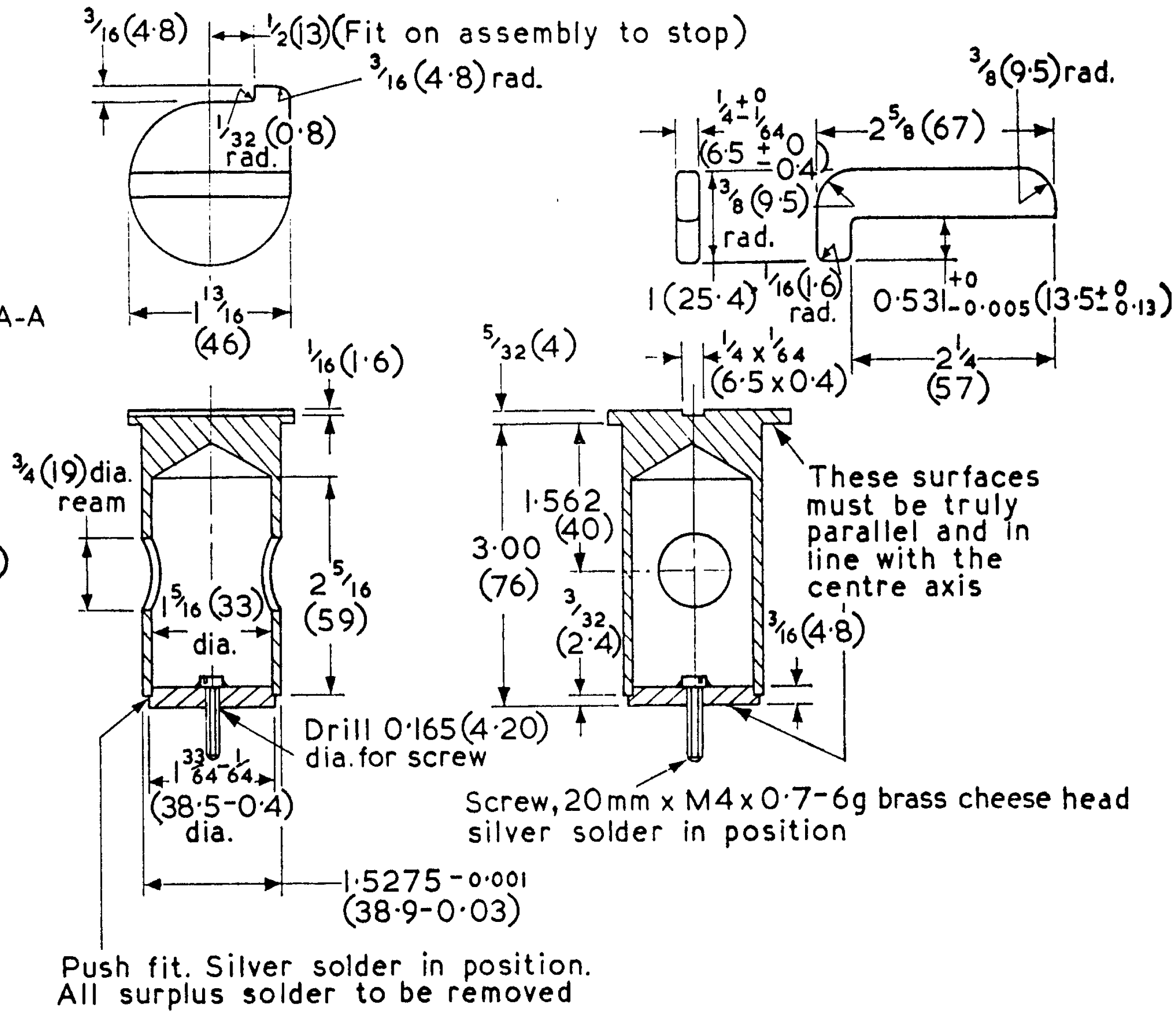


Material: Brass No. 16 SWG to BS 409

Protective finish: Matt black inside and out

NOTE. All joints to be silver soldered to BS 1845

Fig. 4.2(1). Lid



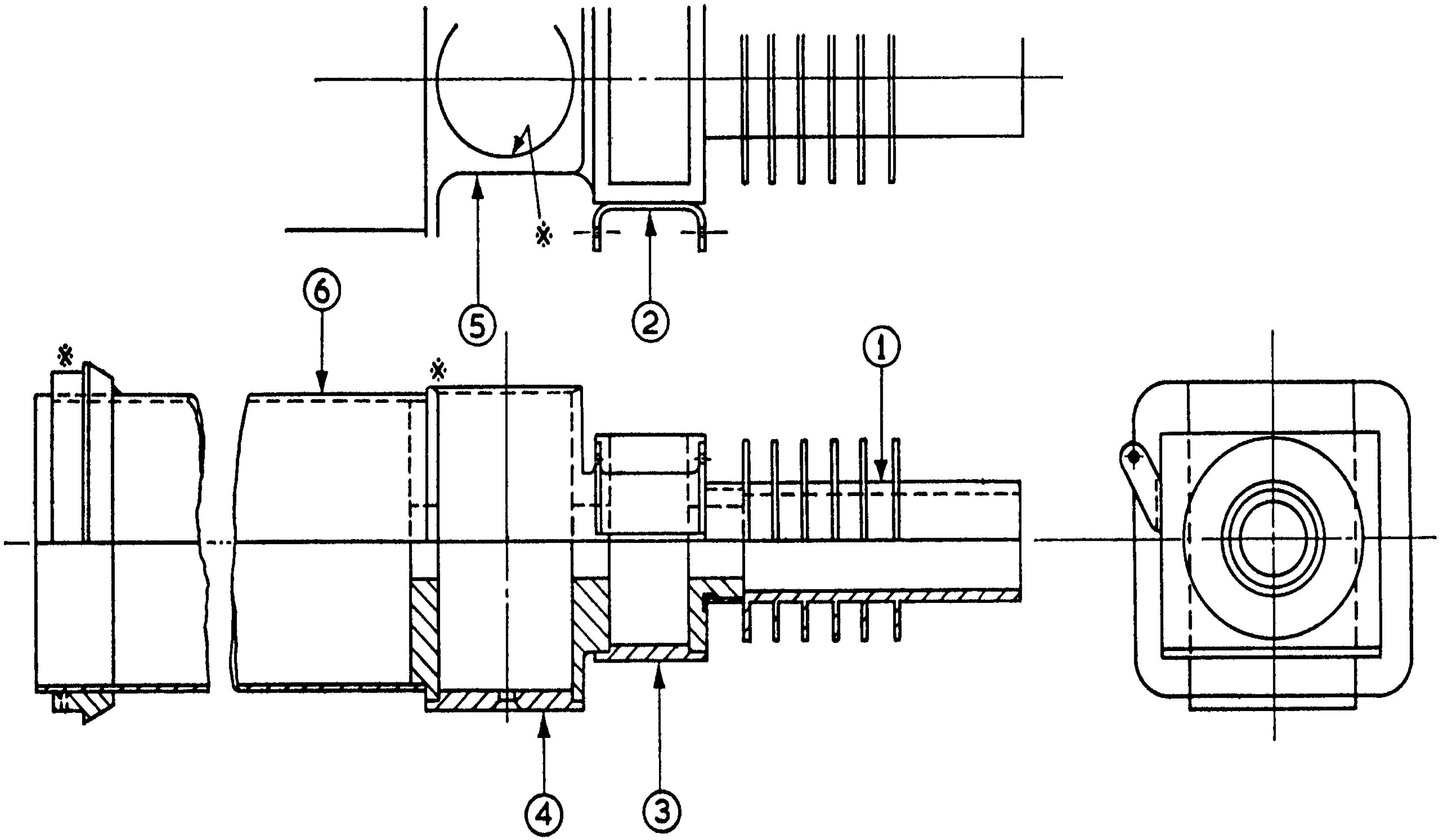
Mater Brasals to BS 249

NOTE. All joints to be silver soldered to BS 1845

Fig. 4 2(2). Shutter assembly

All dimension are in inches (mm in brackets)

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*



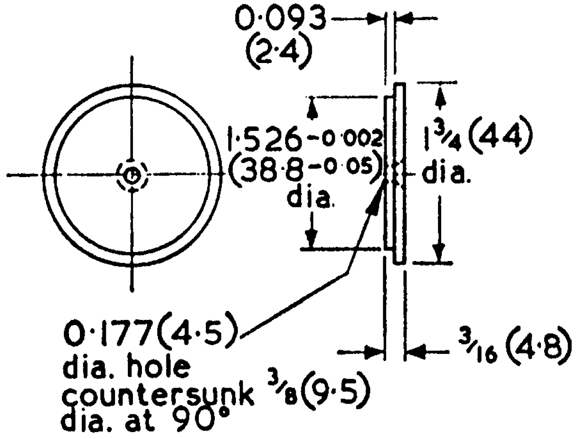
Protective finish: Matt black inside and out (except surface shown*)

NOTE. All joints to be silver soldered to BS 1845

Fig. 4.2(3). Housing assembly

For item list see page 25

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*



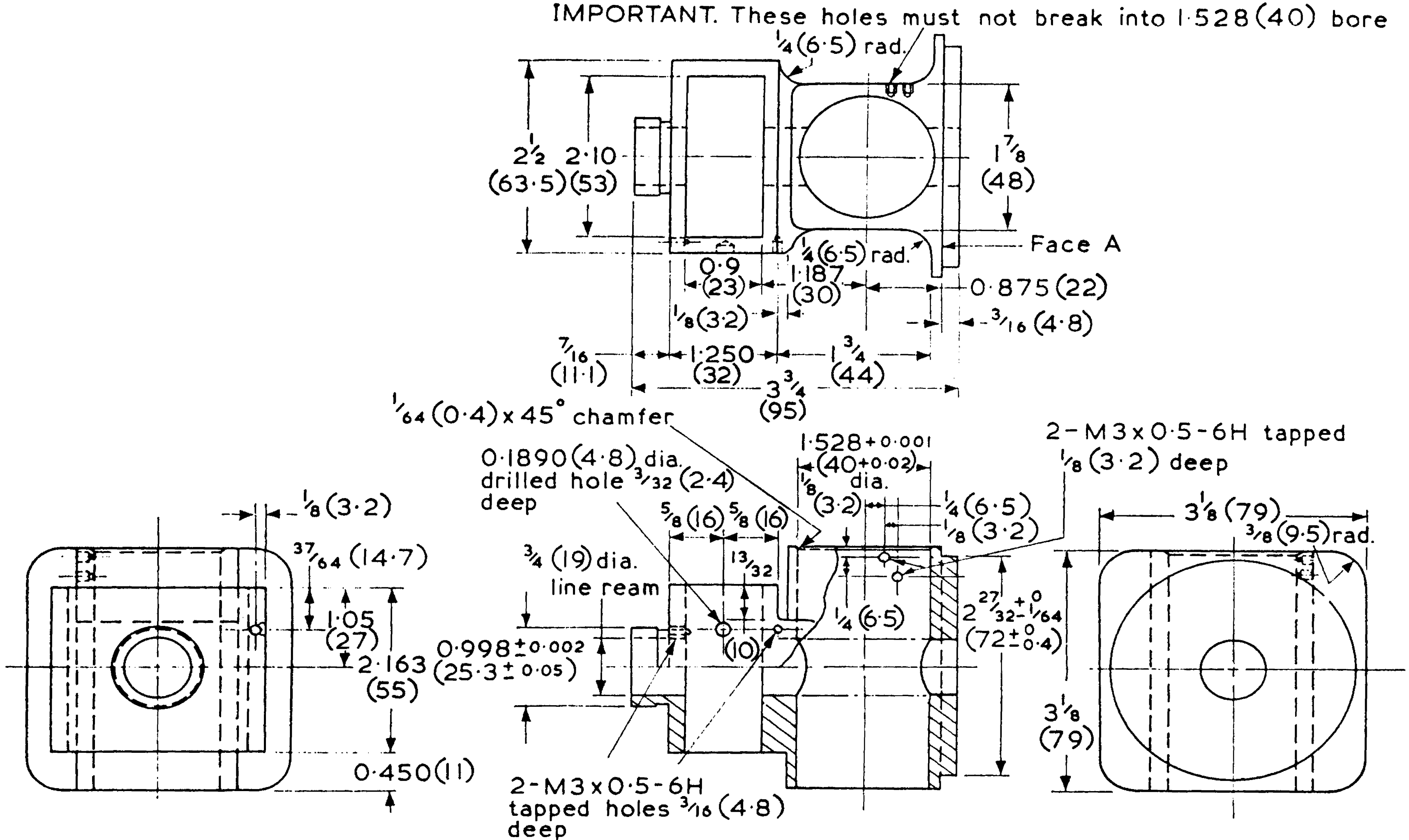
All dimensions are in inches (mm in brackets)

Fig. 4.2(3)*a*. Cylinder base

ITEM LIST FOR FIG. 4.2(3)

Item	Fig. No.	Name	No. off	Remarks
1	N.D.	Tube	1	
2	N.D.	Hinge	1	
3	N.D.	Box base	1	
4	4.2(3)*a*	Cylinder base	1	
5	4.2(3)*b*	Housing and filter box	1	
6	N.D.	Tube assembly	1	
7	N.D.	Tube ring	1	
8	N.D.	$3/32$ (2·4) pin, $9/32$ (7) long	3	

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*



Remove sharp corners

NOTE. Ensure that barrel diameter and box form are parallel with face marked ‘A’.
Also axis of 3/4 (19) dia. hole is at 90° to face marked ‘A’.

Material: Brass to BS 249

All dimensions are in inches (mm in brackets)

Fig. 4.2(3)*b*. Housing and filter box

For item list see page 25

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*

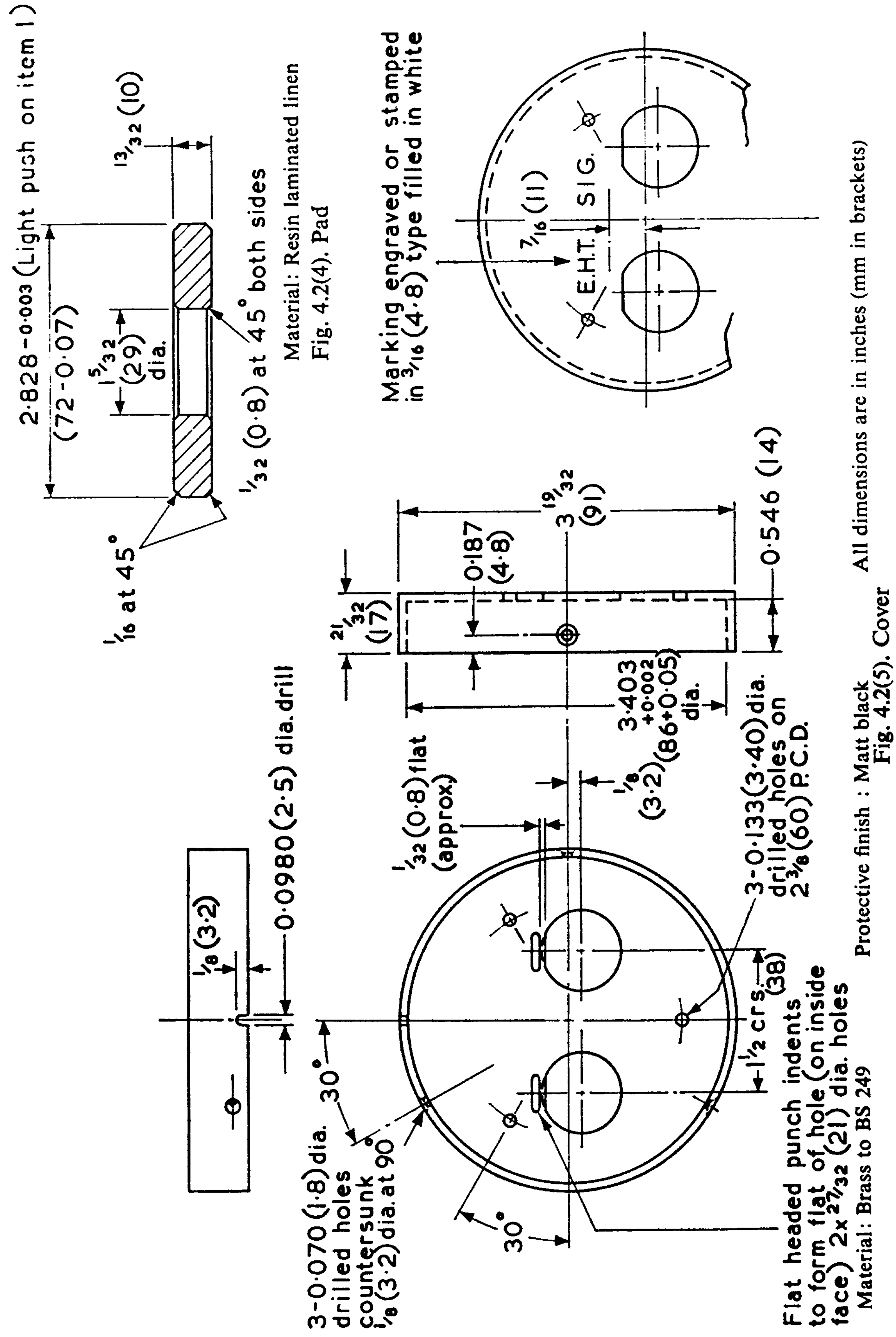
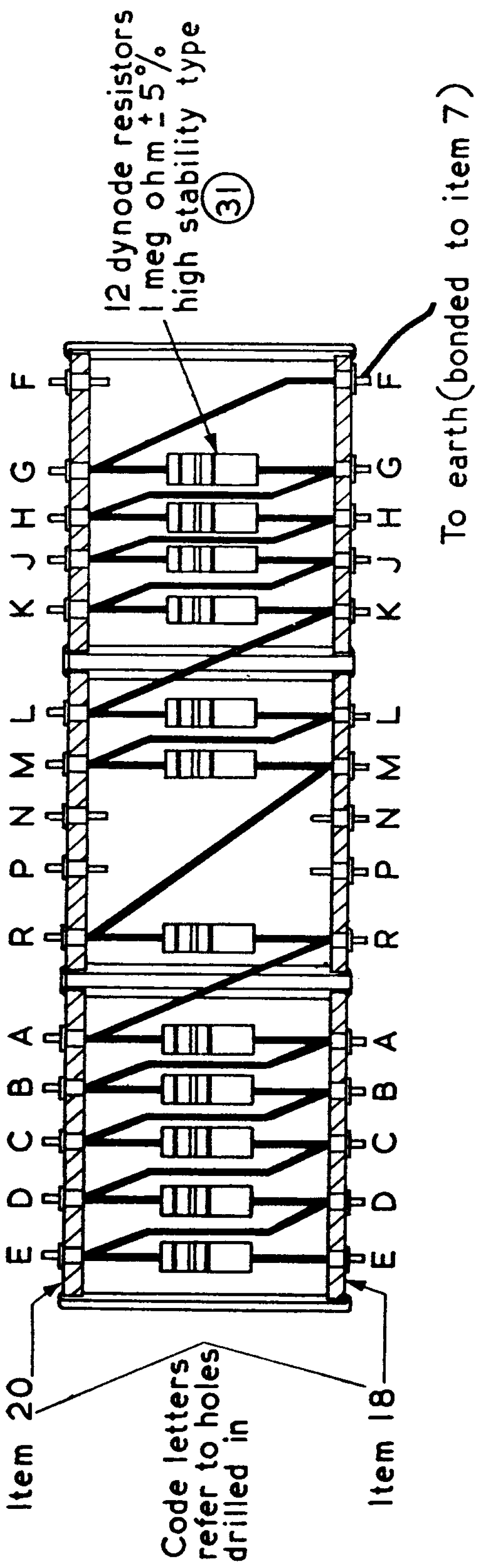


Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*

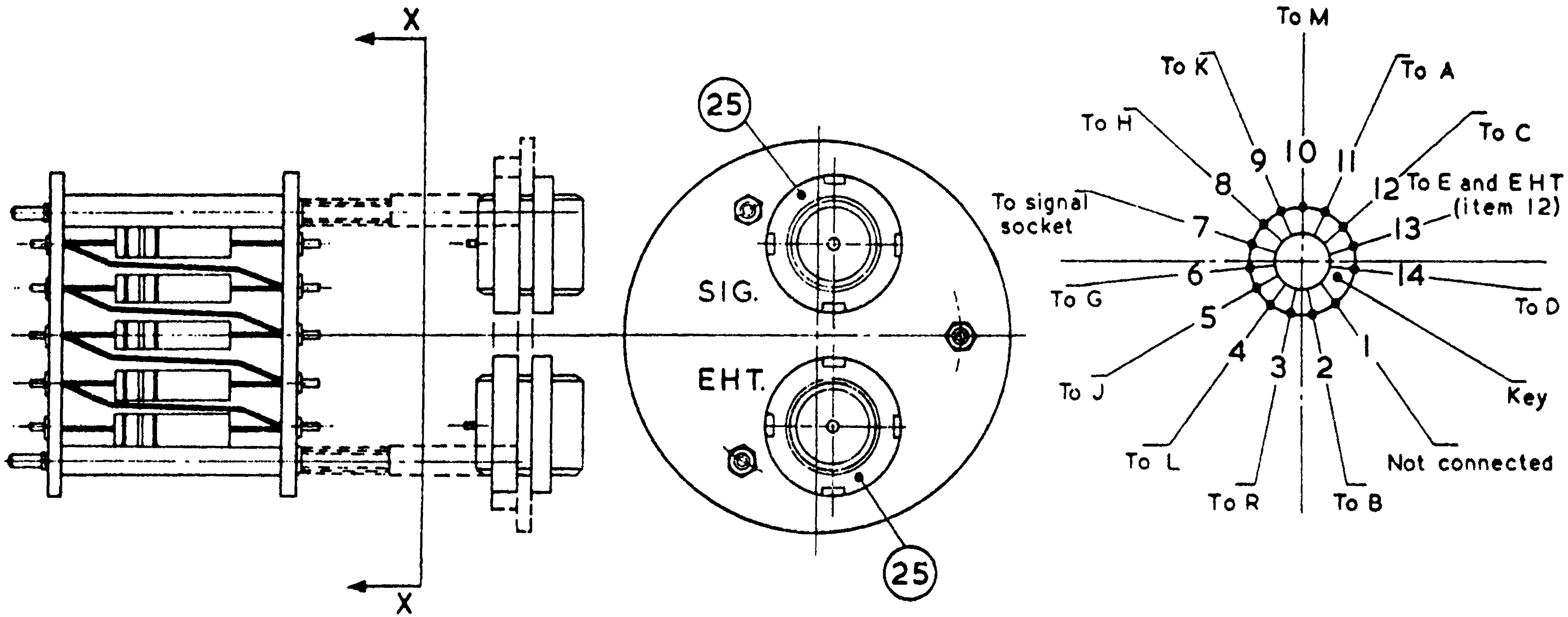


NOTE. Valve base connections from underside clockwise from key.
Diagrammatic development of resistor housing

Fig. 4.2(6). Housing wiring details

For item list see page 31

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*

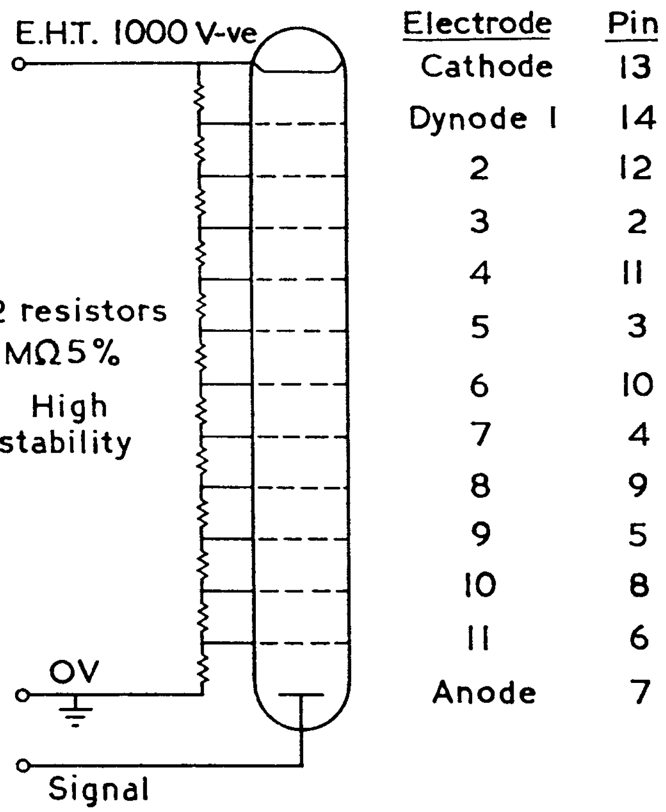


Diagrammatic layout from underside of valvcholder
Code letters in diagram refer to item 18.

Fig. 4.2(6). Housing wiring details (*continued*)

For item list see page 21

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*



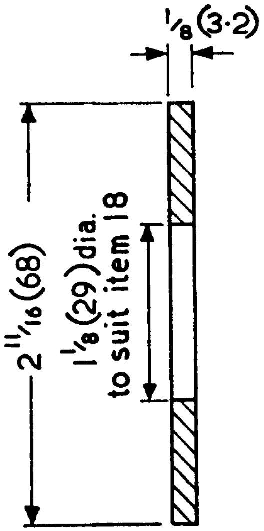
For connections use polythene[a] insulated wire 14/.0076 tinned copper (0.024 in) (0.6 mm) radial thickness of polythene. Type 4.
Connections made with high conductivity resin core solder.

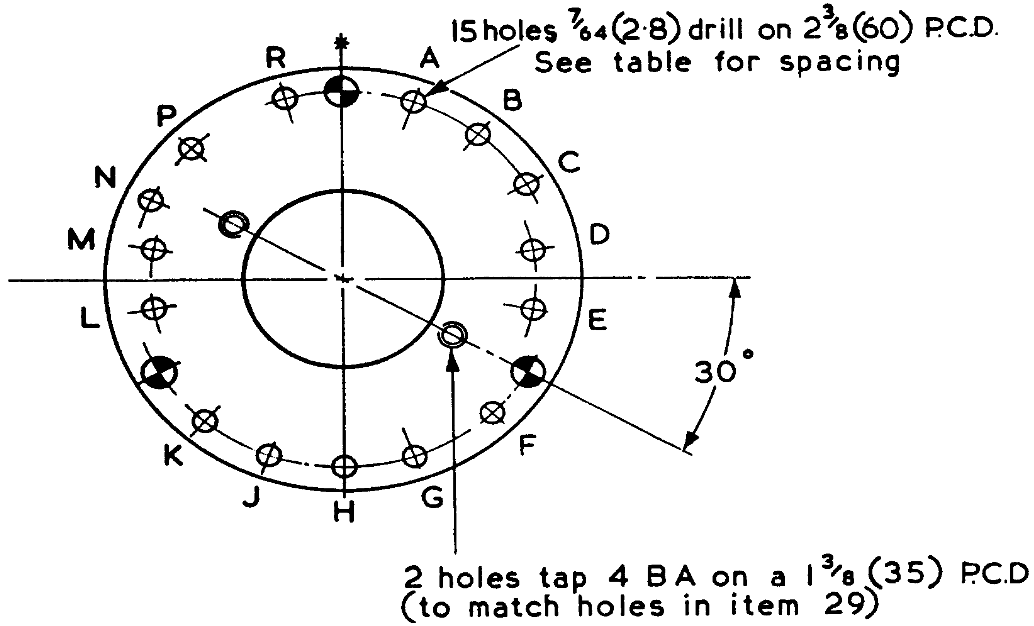
Figure 4.2(6). Housing wiring details *(continued)*

[a] It should be noted that the name polythene is equivalent to the name polyethylene.

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*

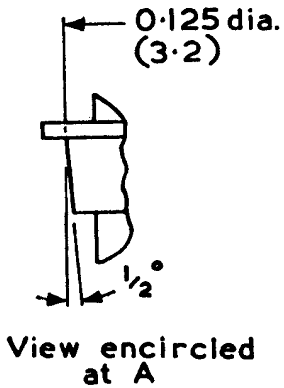
Material:
Resin laminated linen

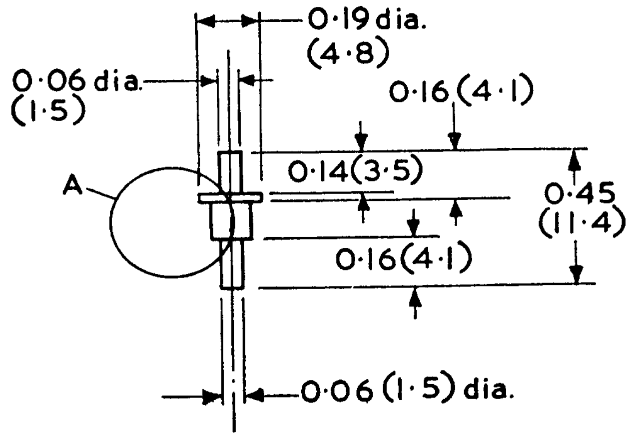




Hole positions from zero* clockwise		Hole positions from zero* clockwise	
A	20°	J	200°
B	40°	K	220°
C	60°	L	260°
D	80°	M	280°
E	100°	N	295°
F	135°	P	315°
G	160°	R	345°
H	180°		

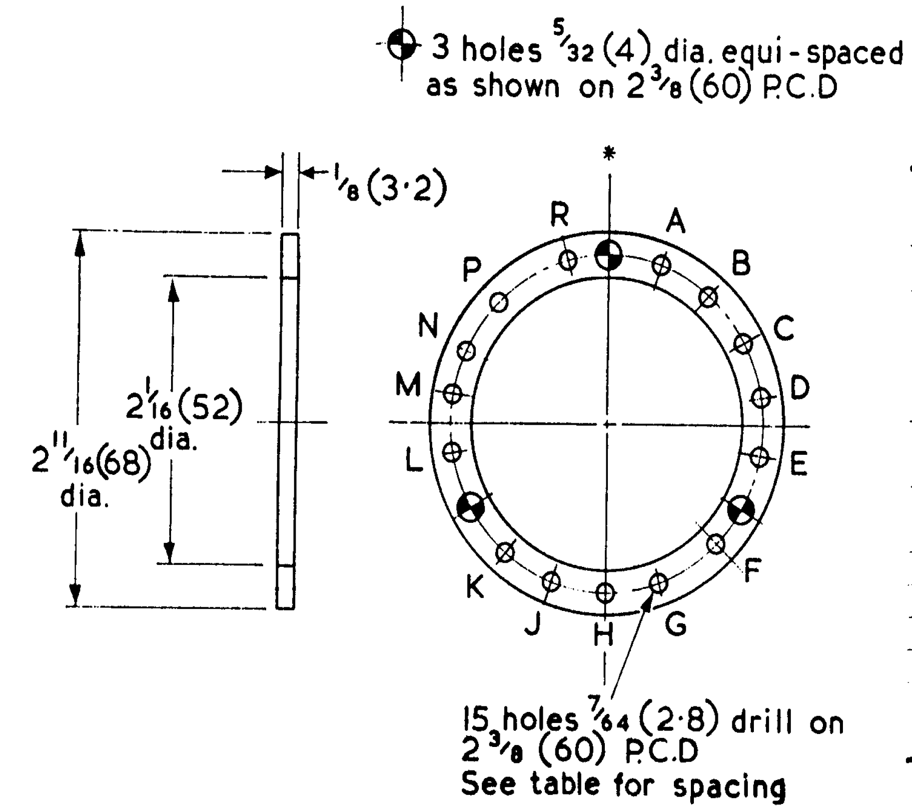
All dimensions are in inches (mm in brackets)





Material: Brass to BS 249
Fig. 4.2(8) Pin

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*

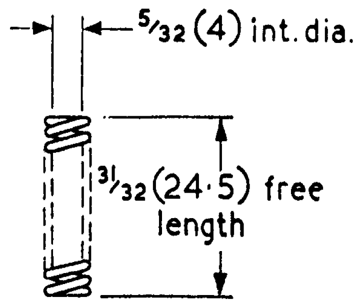


Hole position from zero* clockwise	
A	20°
B	40°
C	60°
D	80°
E	100°
F	135°
G	160°
H	180°
J	200°
K	220°
L	260°
M	280°
N	295°
P	315°
R	345°

Material: Resin laminated linen

Fig. 4.2(9). Front ring

All dimensions are in inches (mm in brackets)



Material: Steel piano wire, tinned to BS 1408

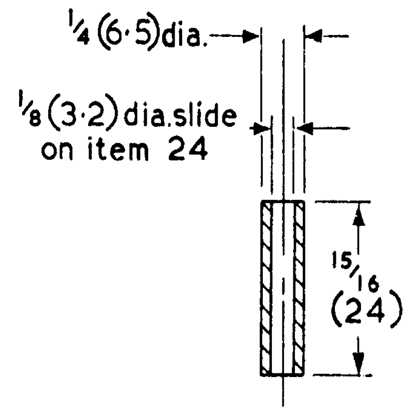
Fig. 4.2(10). Spring

Spring data

Dia. of wire (0·028 (0·7) 22 SWG

No. of coils: 14

Ends ground flat



Material: Resin laminated linen

Fig. 4.2(11). Spacer

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*

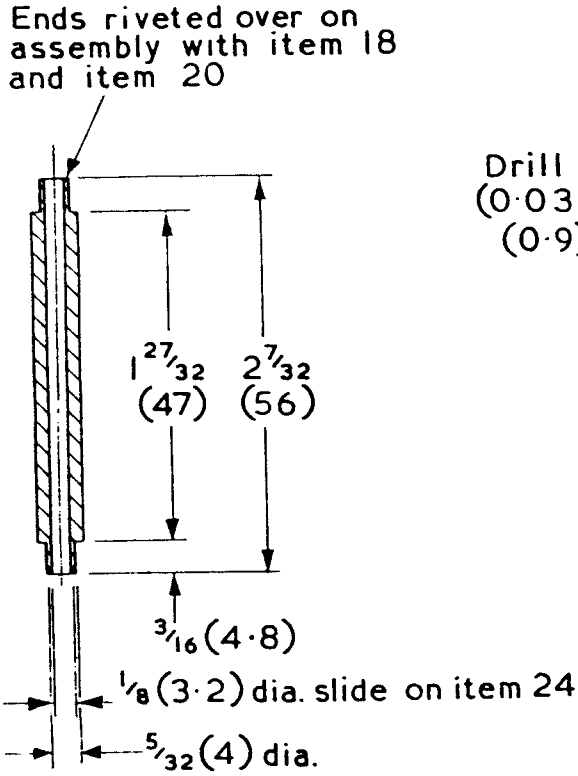
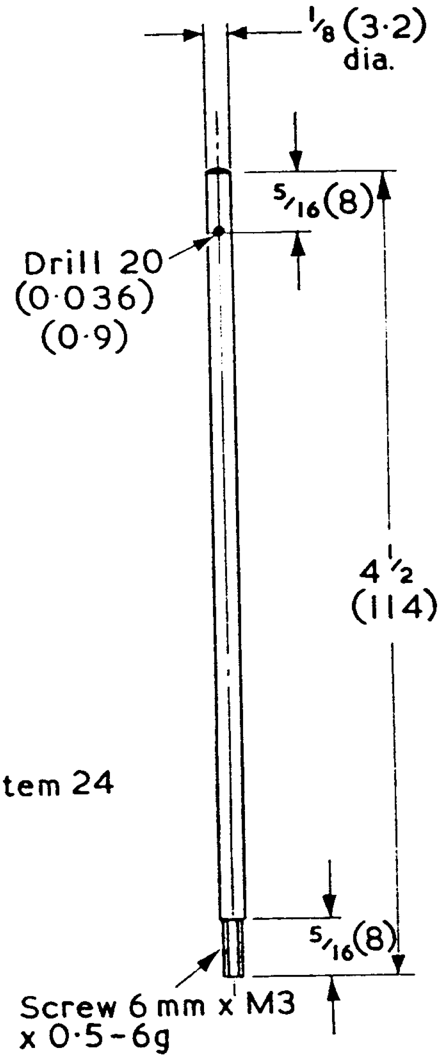


Fig. 4.2(12). Distance piece

Material: Silver steel to BS 1407

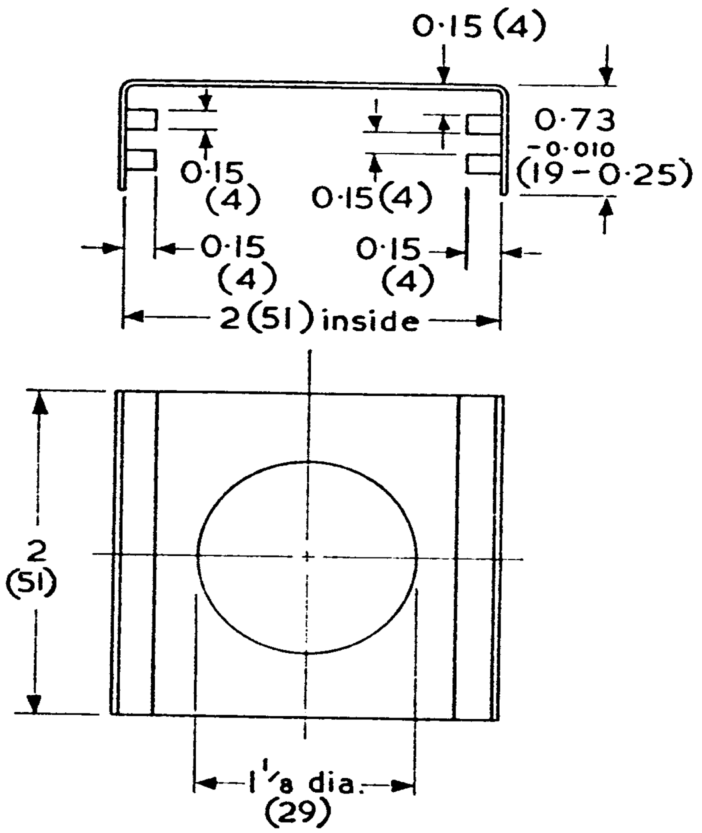
All dimensions are in inches (mm in brackets)



Material: Brass to BS 249

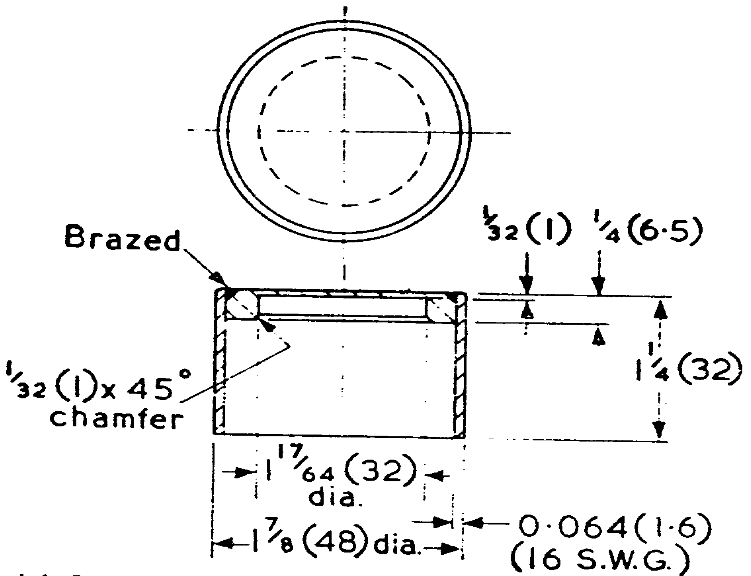
Fig. 4.2(13). Rod

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*



Material: Brass to BS 267 0·036 (0·9) 20 SWG
Protective finish: Matt finish all over
NOTE. All joints to be silver soldered to BS 1845

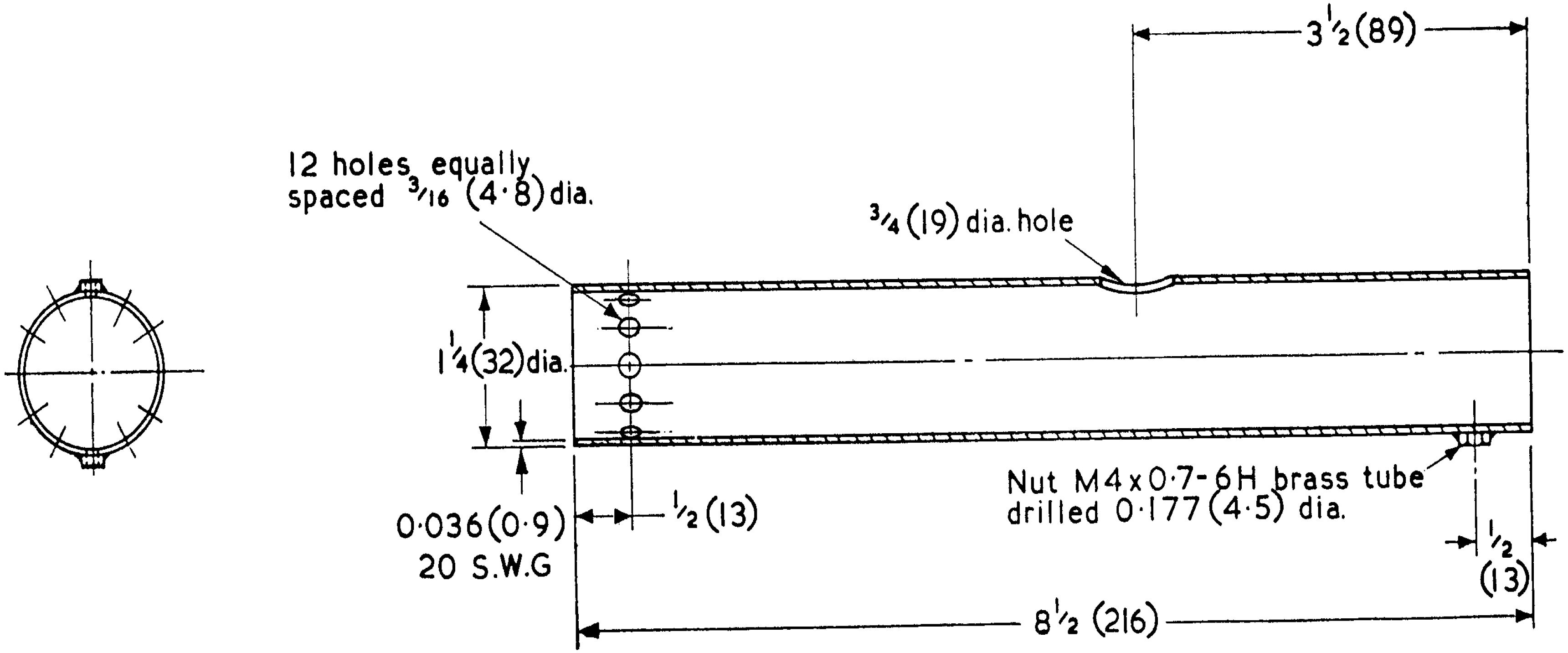
Fig. 4.2(14). Filter support



Material: Brass to BS 885
Protective finish: Nickel plated

Fig. 4.3. Cap

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*



Material: Brass to BS 885
Protective finish: Nickel plated and matt black finish all over
All dimensions are in inches (mm in brackets)

Fig. 4.4. Flame tube

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*

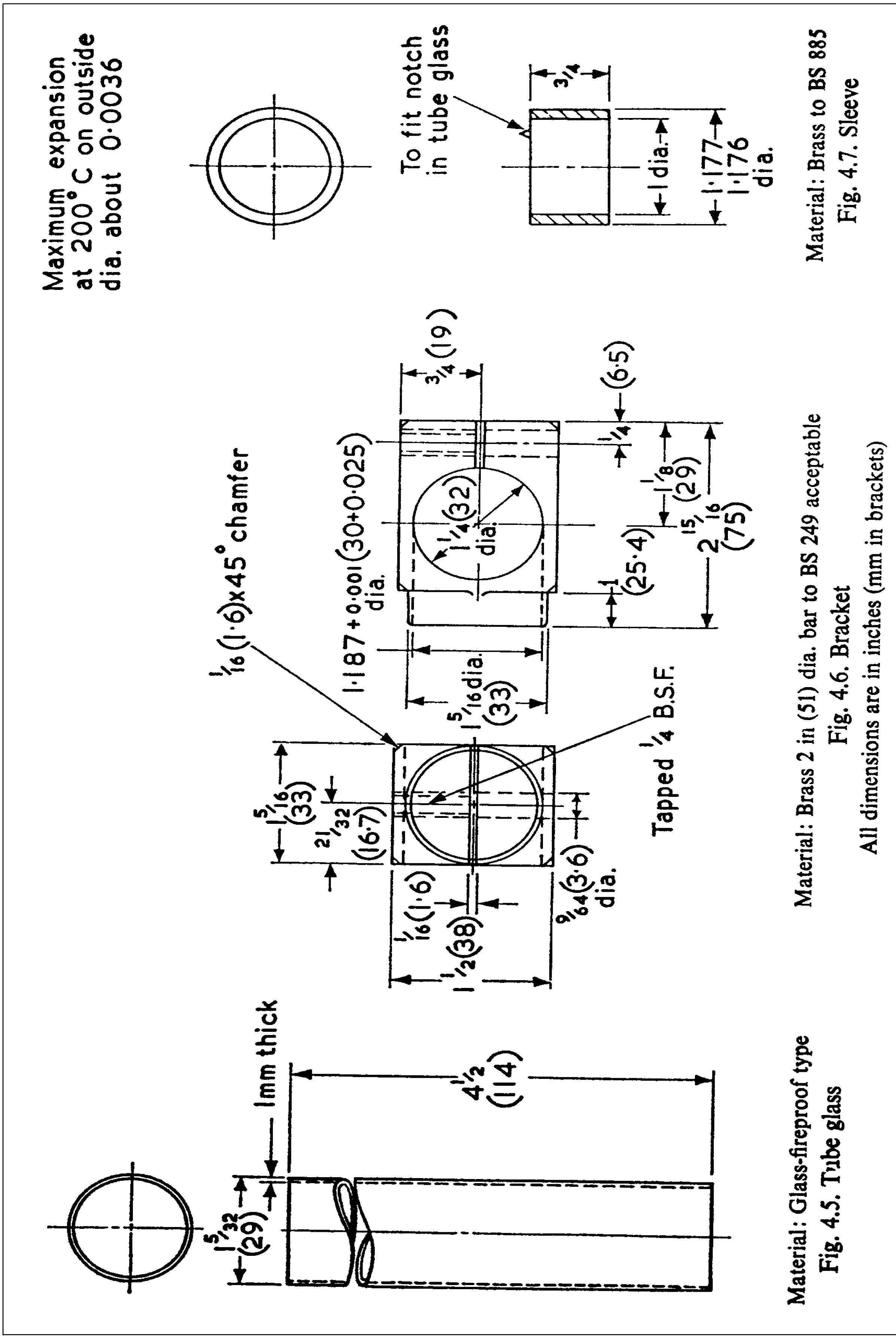
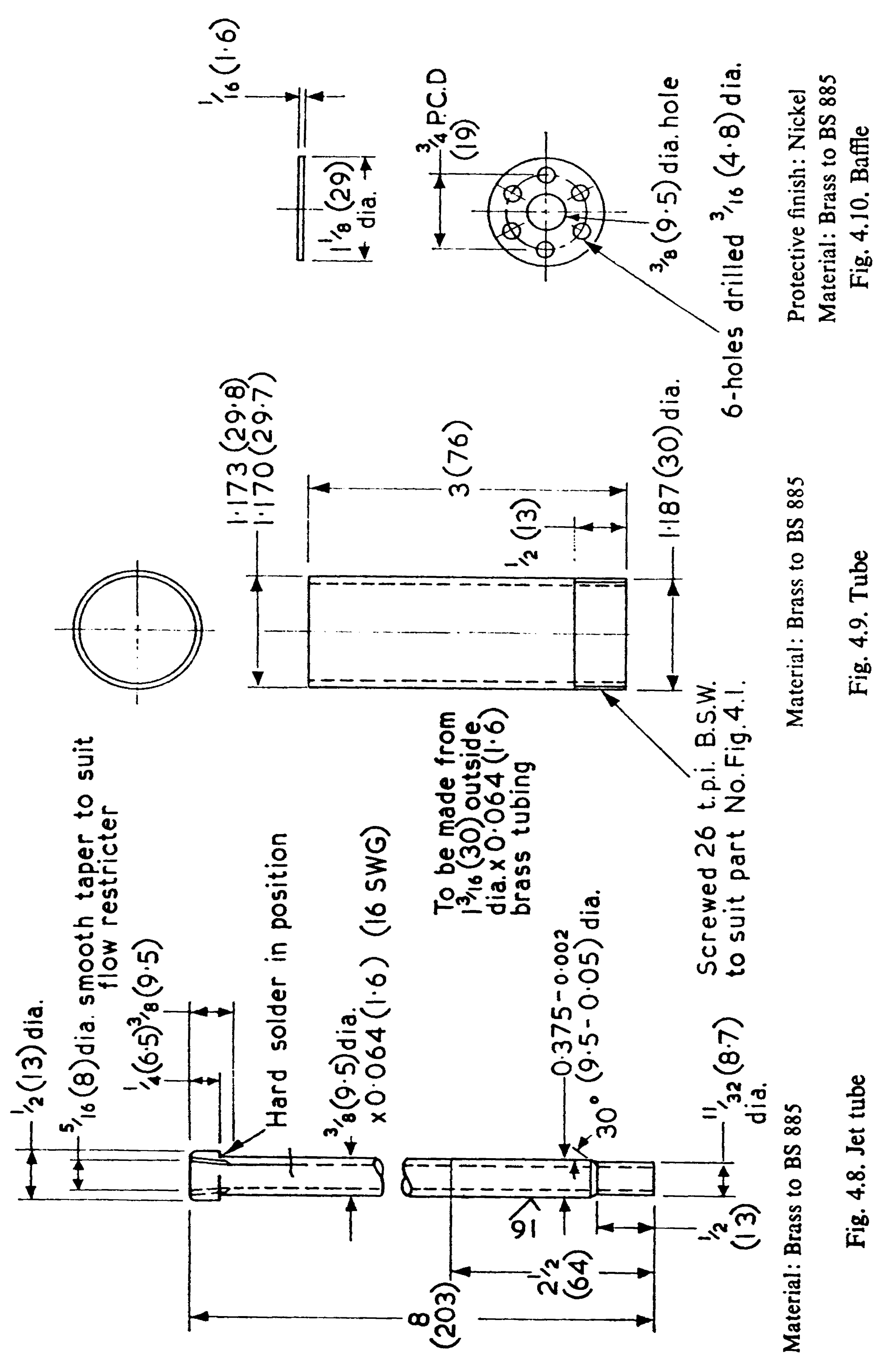


Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*



All dimensions are in inches (mm in brackets)

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*

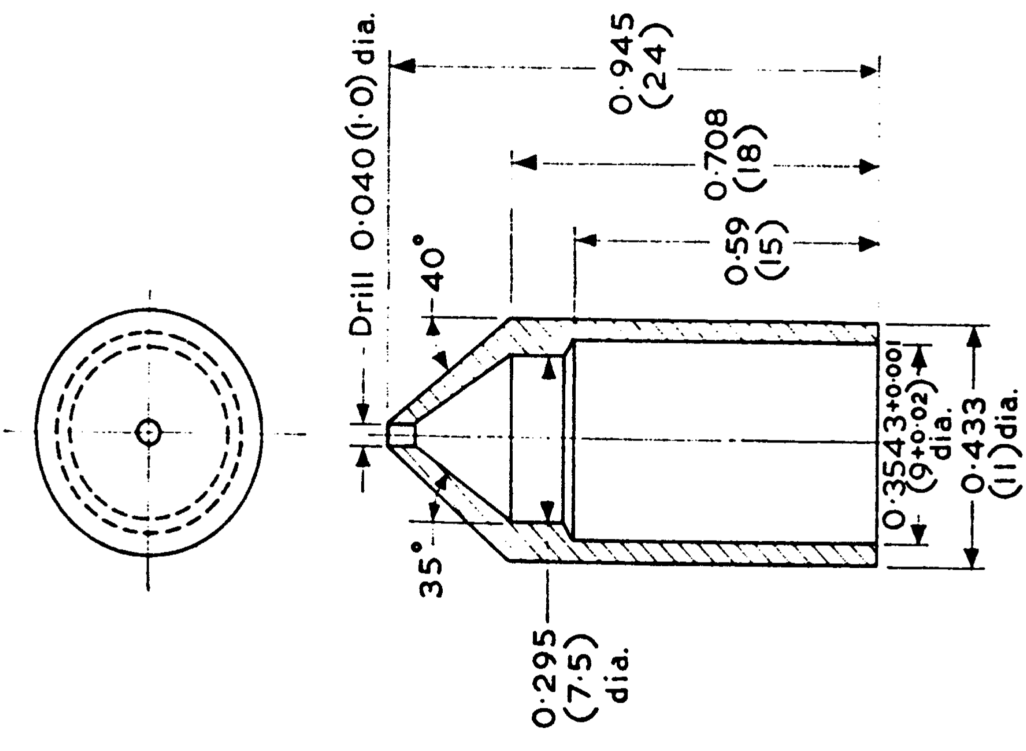


Fig. 4.11. Copper burner

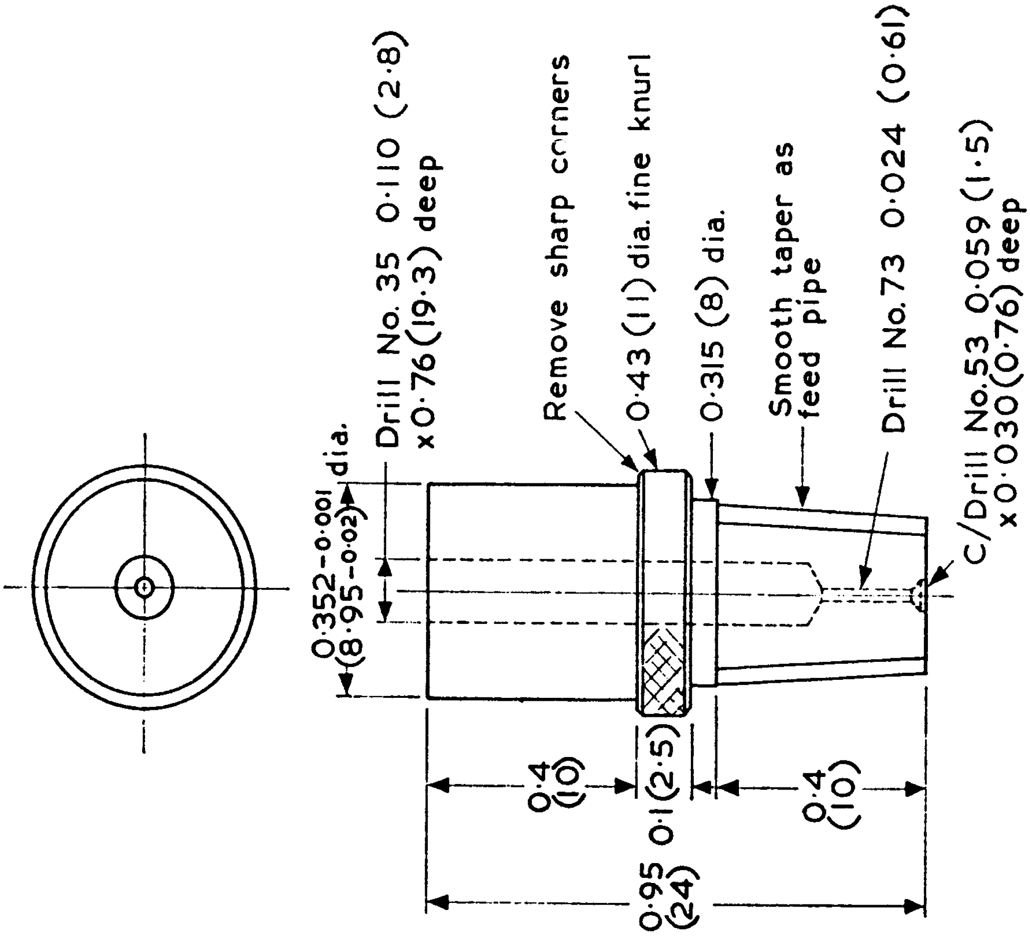


Fig. 4.12. Flow restrictor

All dimensions are in inches (mm in brackets)

Figure 4 — Photomultiplier, test tube and flame tube assembly *(continued)*

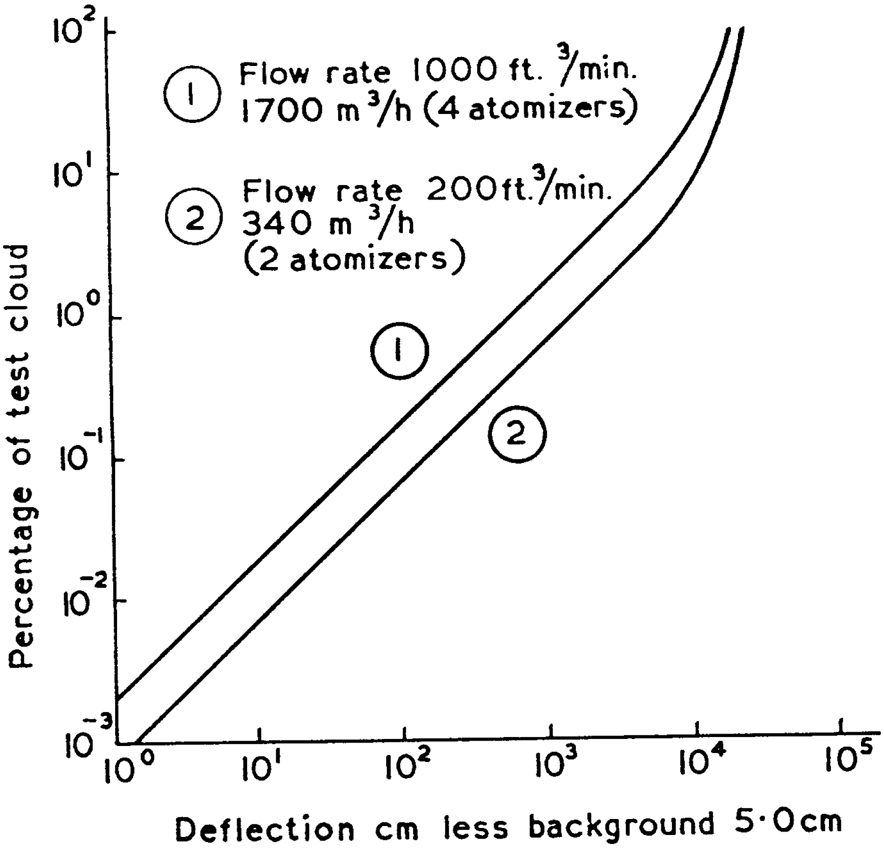
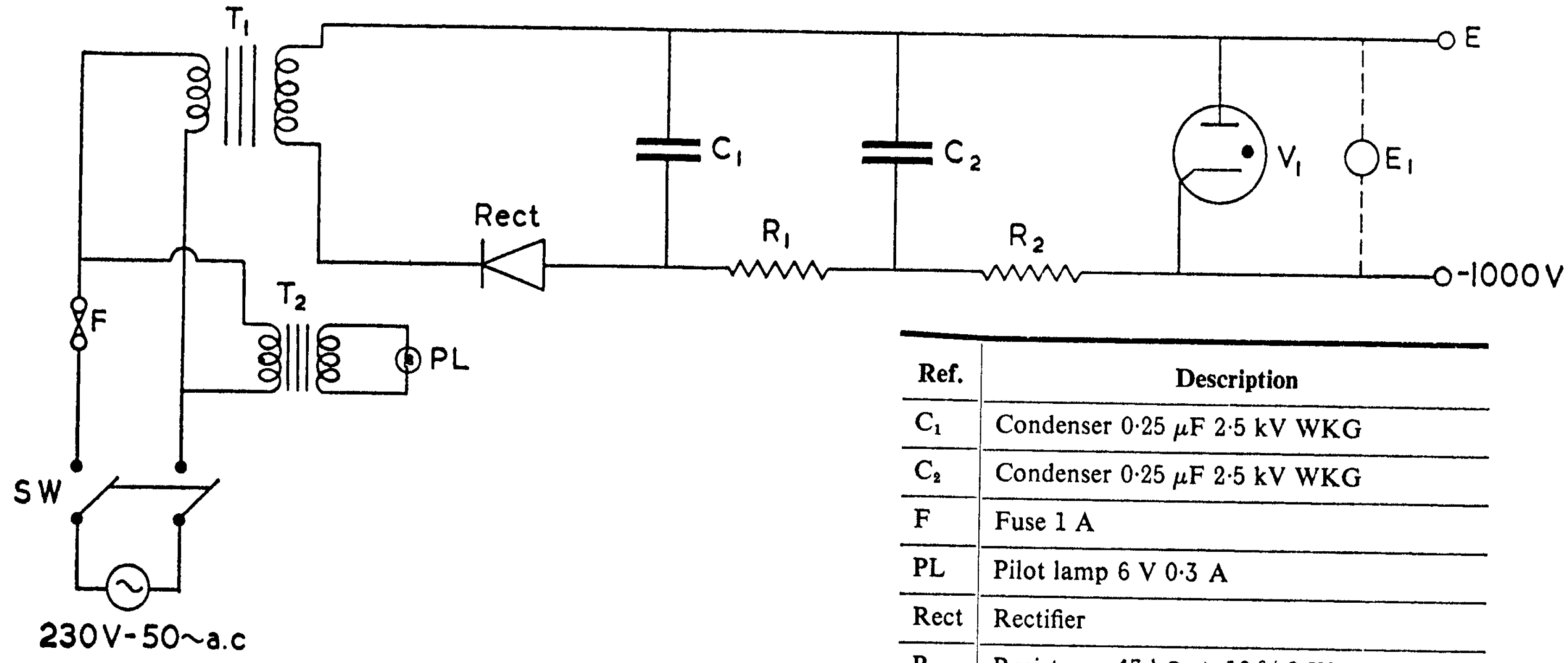
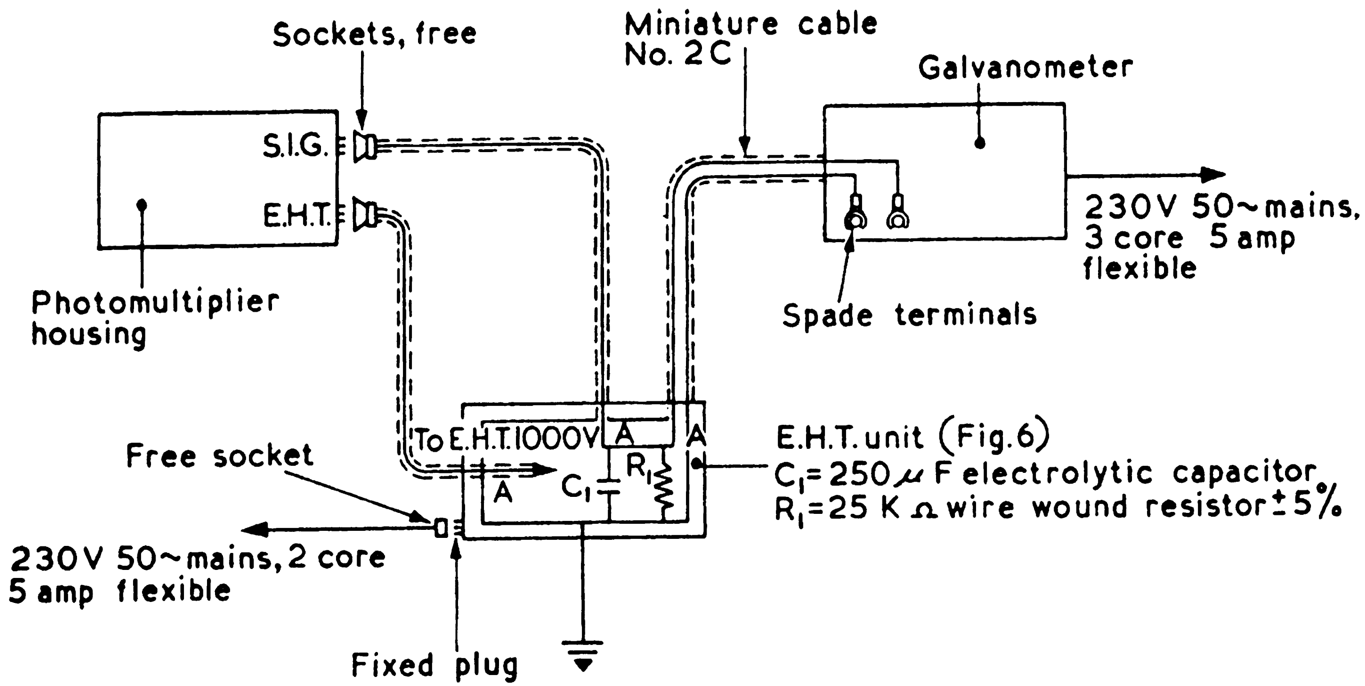


Figure 5 — Concentration versus deflection



Ref.	Description
C_1	Condenser 0·25 μF 2·5 kV WKG
C_2	Condenser 0·25 μF 2·5 kV WKG
F	Fuse 1 A
PL	Pilot lamp 6 V 0·3 A
Rect	Rectifier
R_1	Resistance 47 kΩ ± 10 % 2 W
R_2	Resistance 4·7 MΩ ± 10 % 2 W
SW	Mains switch D.P.S.T.
T_1	Mains transformer, primary 230 V secondary 1600 V
T_2	Mains transformer, primary 230 V secondary 6·3 V
V_1	Corona stabilizer
E_1	Electrostatic voltmeter

Figure 6 — Circuit diagram for E.H.T. unit



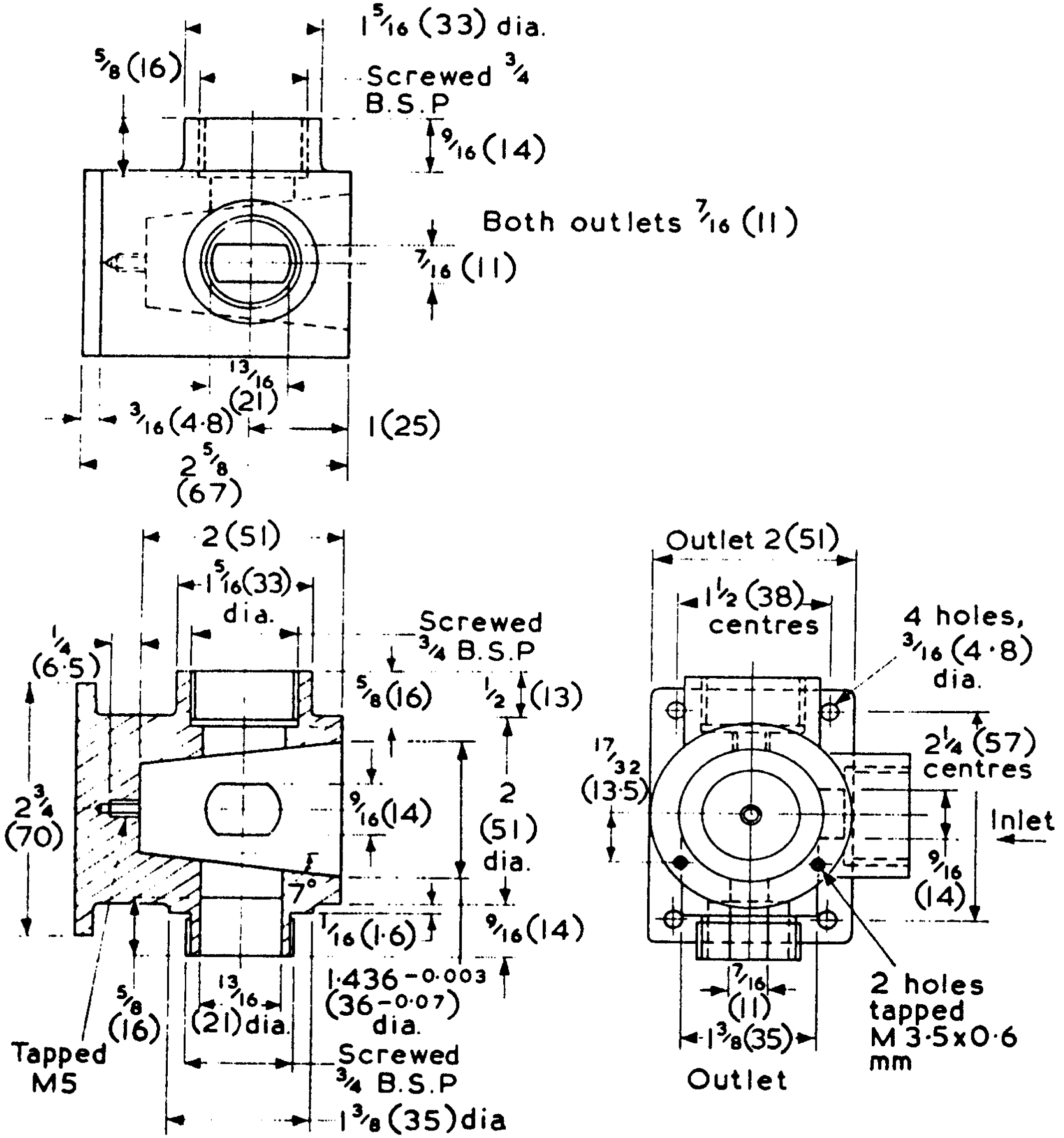
NOTE 1. Braiding at cable termination end A to be combed out, twisted to a lead and soldered directly to the earth point on the E.H.T. chassis.

NOTE 2. It is recommended that C_1 and R_1 are normally mounted on the E.H.T. unit chassis and that the cable connections to these components are permanently soldered in place.

NOTE 3. The earth connection for the system should then be made only at the E.H.T. unit.

Fig. 6.1

Figure 6 — Circuit diagram for E.H.T. unit



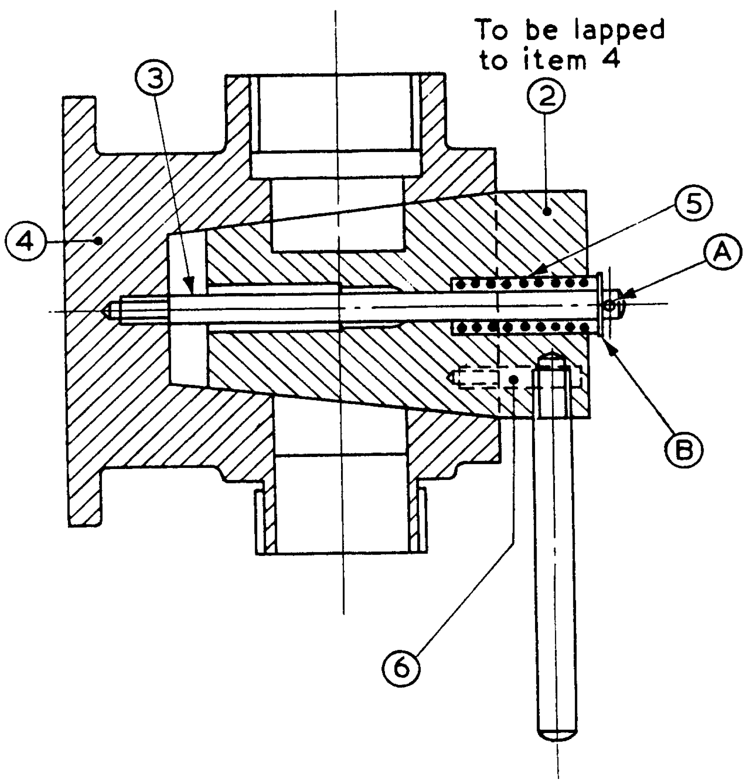
SUMMARY OF ITEMS

Item No.	No. Off	Description
1		Assembly
2	1	Plug
3	1	Spindle
4	1	Body
5	1	Spring
6	2	Stop pin
7	1	Pin

All dimensions are in inches (mm in brackets)

Material: Brass casting to BS 1400 BI-C

Figure 7 — Control cock

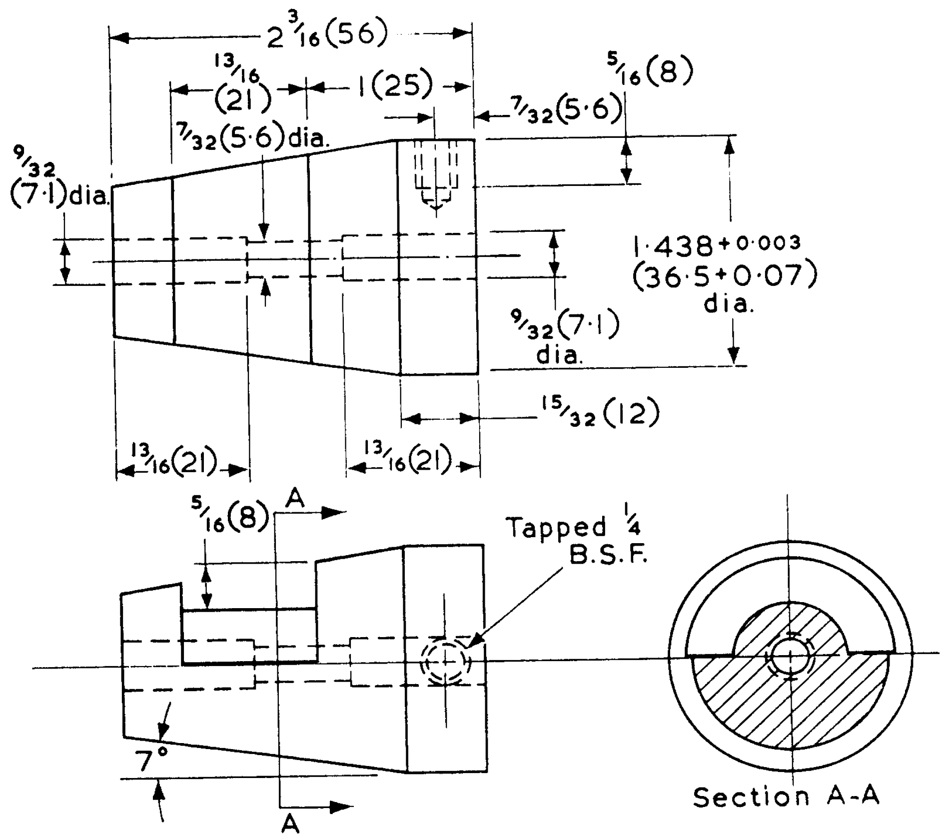


Item 1. Assembly

Material: Brass to BS 249

STOCK PARTS REQUIRED PER ITEM 1

Item No.	Description	No. off	Material
A	1/16 (1·6) dia. split pin 1/2 (13) long	1	Mild steel
B	3/16 (4·8) standard washer	1	Mild steel



Third angle projection

All dimensions are in inches (mm in brackets)

Item 2. Plug

For item list see page 42

Figure 7 — Control cock *(continued)*

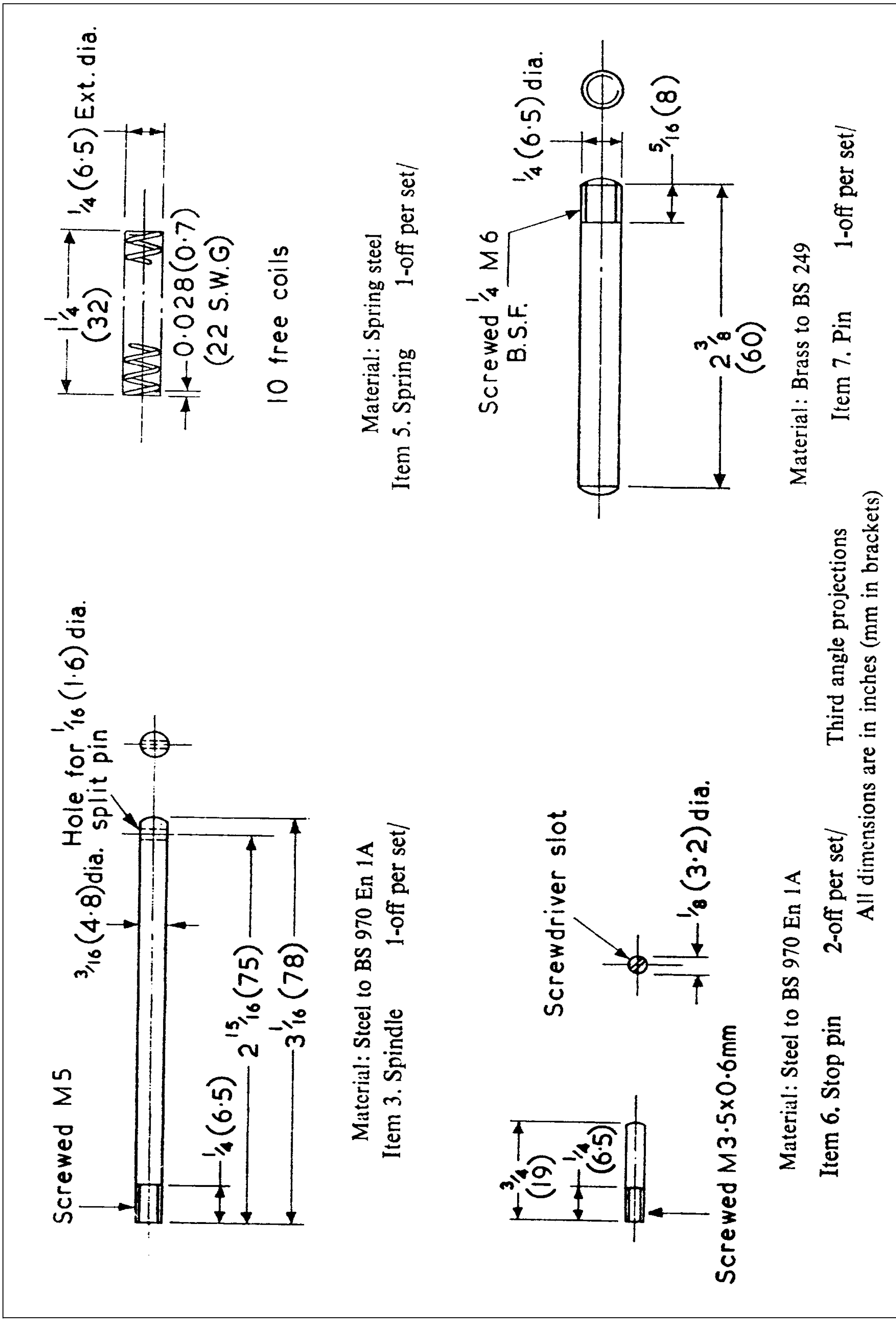


Figure 7 — Control cock *(continued)*

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