PRESSURE TESTING OF INSTRUMENTS

GENERAL

1. The efficient sealing of instruments is an important function in the overhaul of optical instruments, to prevent the ingress of dirt, dust, and moisture, and to control the development of fogging, filming, and fungus. Consequently, it is essential after optical instruments have been cleaned, assembled, and sealed according to the approved technique, to apply a test to determine the efficiency of the sealing. This is done by measuring the rate of leak of air from the instrument when its internal pressure is 2 1/2 psi above the external atmospheric pressure.

2. The above test can be performed by either of the following methods:-

(a) By applying an initial pressure of 2 1/2 psi and observing, by means of a manometer, the time taken for the pressure to fall to 2 1/4 psi.

(b) By applying an initial pressure of 2 1/2 psi and then measuring, with a suitable apparatus, the rate at which air must continue to be supplied to maintain that pressure and make good the losses caused by leakage.

3. The degree of sealing which can be achieved will vary with the type of instrument. In instruments especially designed for efficient sealing, or those which are particularly suited to this operation, it should be possible to obtain a seal which will not have a rate of leak greater than 0.5 cu cm per min; this is the ultimate aim. In other instruments, however, particularly where there are moving parts communicating between the internal air spaces and the external atmosphere, it will not be possible to obtain this degree of perfection and it may therefore be necessary to accept leakage rates of 20 cu cm per min, or more, depending upon the number and type of such joints. Careful attention should be given to sealing instruments with the aim of getting the lowest possible rate of leak.

PRINCIPLES OF TESTING

4. In the most simple case, shown in Fig 1, a piston-type hand pump supplies air to the sealed instrument under test through a filtered air reservoir and desiccating chamber. A simple U-tube mercury manometer, having a scale adjacent to one limb, is used to indicate the air pressure in the instrument. Since a difference of 2-in in the relative levels of the mercury in the limbs indicate a pressure of 1 psi, the scale will be in inches and read in psi. During use the pressure inside the instrument is raised to 2 1/2 lb as indicated by the manometer; the stopcock is then closed. The time taken for the air pressure to fall to 2 1/4 lb will be the measure of the rate of leak when the cubic capacity of the instrument

is known where:

$$\text{rate of leak [redacted]} = \frac{\text{volume of instrument (cc)} \times 0.015}{\text{time (mins)}} \quad \text{or} \quad R = \frac{0.015V}{t}$$

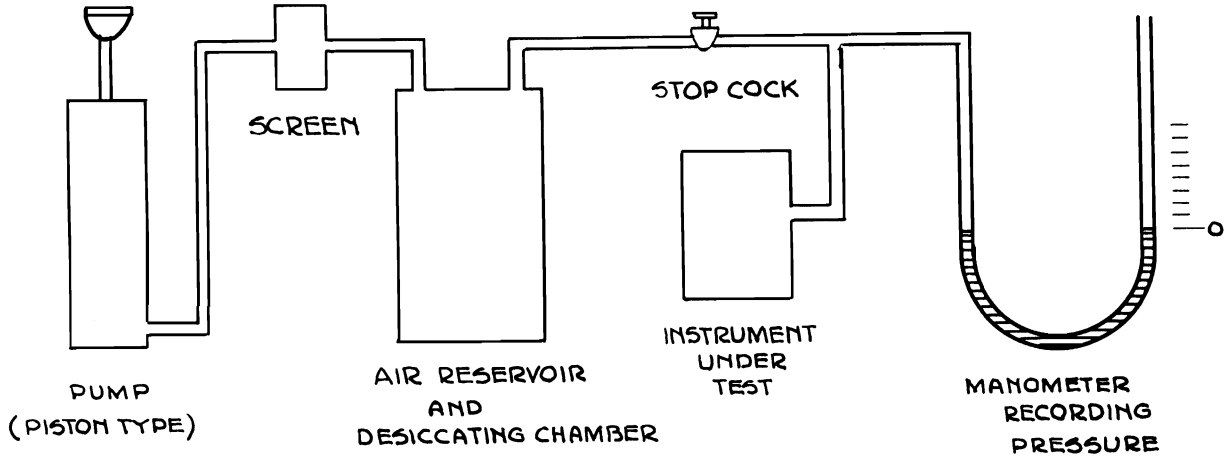

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Fig 1 - Diagram of apparatus for measuring pressure in an instrument

5. In the alternative case, Fig 2, a rotary-type pump supplies a steady delivery of air to the sealed instrument through a filtered air reservoir and desiccating chamber. A manometer indicates pressure of the air supply, while a second manometer indicates any difference of air pressure between the ends of a capillary tube fitted in the supply pipe. If the instrument is perfectly sealed, there will be no movement of air through this capillary tube and equal air pressure will be built up throughout the system. If there is leakage it will cause a movement of air through the capillary tube, resulting in a difference of pressure between the ends of the capillary. This difference of air pressure will be indicated on the connected manometer. Two capillary tubes may be used to provide for coarse and fine leakage rate values. During use the air pressure inside the connected instrument is raised to 2 1/2 psi as indicated by the pressure manometer. A release valve connected in the system will operate to maintain the pressure accurately at the 2 1/2 psi value. The second manometer will then indicate a movement of air through the capillary tube to the instrument to maintain pressure and replace any air which is lost by leakage, thereby indicating the rate of leakage from the instrument under test.

APPARATUS

6. The types of apparatus which may be used in workshops for pressure testing and measuring the leakage rate of instruments are:

(a) manometer and hand pump,

(b) apparatus, measuring leakage rate.

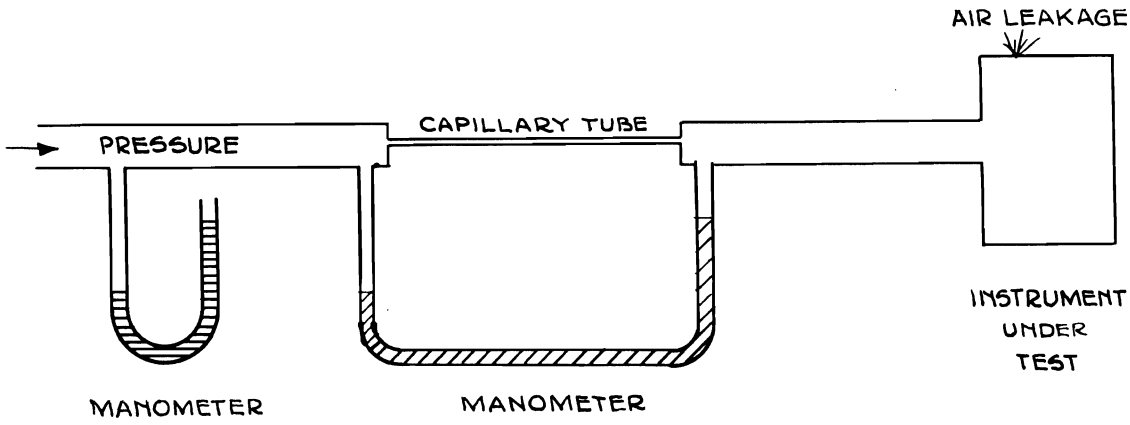

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Fig 2 - Diagram of apparatus for measuring the rate of leakage of an instrument

Manometer for Pressure Testing

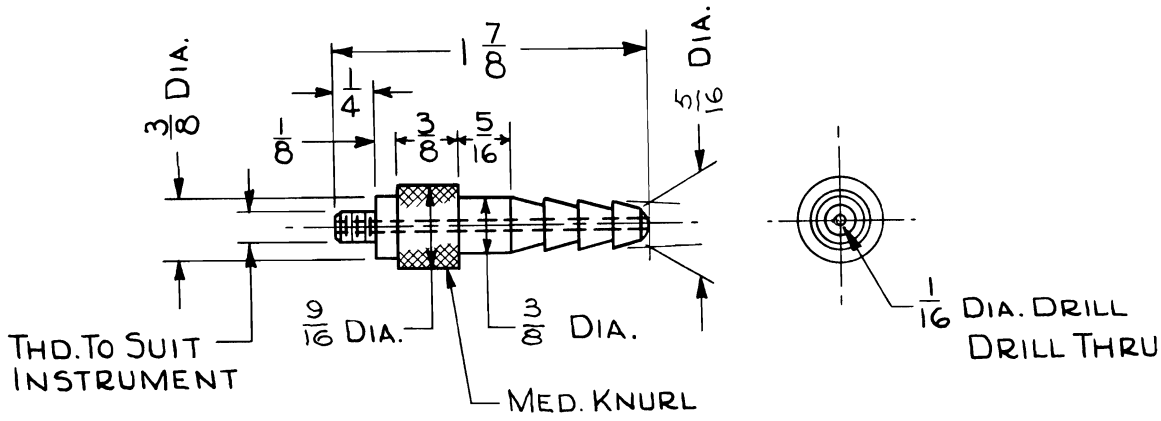
7. This type of apparatus is suggested for use in workshops where a number of personnel are engaged at the same time in sealing and testing the sealing of instruments. It can be used for detecting whether an instrument is perfectly sealed or not and by using suitable adapter plates, separate parts or assemblies of instruments may be tested for leaks. The design of the apparatus enables a number of tradesmen to do preliminary pressure testing at the same time without interfering with the leakage rate measuring apparatus which should be used for final testing. The pressure testing apparatus will need to be made up locally by workshops in accordance with the details shown in Fig 4.

8. The apparatus consists of a glass manometer U-tube partly filled with mercury, one end being connected to the instrument under test, the other end being open to the atmosphere. A scale, graduated in inches, is fixed alongside the limb of the U-tube open to the atmosphere. The zero point on the scale is coincident with the level of the mercury when the height of the mercury in both tubes is the same. An increase of pressure on the mercury in the limb connected to the instrument under test will cause a difference in level of the mercury in the two limbs of the manometer. This difference in level is a measure of the air pressure in inches of mercury. The scale, adjacent to the open limb, is graduated in inches and therefore measures the increase in level of that limb only, which will be one half of the difference between the level of the two limbs. Since inches of mercury divided by two equal pounds per square inch, the scale may be read directly in pounds per square inch.

9. The apparatus, a general layout of which is shown in Fig 4, consists of two manometers or pressure gauges, connected through two needle valve stopcocks D to the one pressure pump by means of connecting tube H. The manometers may therefore be used separately or both together. The number of manometers connected to the pump may be increased or decreased as found necessary. The open

limb of the manometers is connected by means of rubber and glass tubing to a glass overflow trap J which is open to the atmosphere. This trap conserves any mercury which may overflow from the open limb of the U-tube due to a sudden and large increase of pressure from the pump to the instrument and manometer.

10. The most convenient type of pump for use with this apparatus is a piston type hand or foot operated pump similar to that used for automobile tires. The pump must be connected to a metal container which acts as a compressed air reservoir. The connection between air reservoir and connecting tube H on the apparatus should go through a container filled with silica gel, and an air filter, to ensure dry dust-free air being passed to the instrument under test. Air leaks in the connections on the pressure side of the manometer can be checked by sealing the end of tube E and applying a pressure of 2 1/2 psi; with stopcock D closed the manometer reading should not fall over a period of 1 or 2 hours. If leaks are detected at the rubber joints, they should be coated with shellac, varnish, or other suitable material.



NOTE:
REMOVE ALL SHARP EDGES

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Fig 3 - Adapter nozzle for instruments

Operation

11. The instrument or component under test is connected by a suitable adapter nozzle and length of rubber tubing to one of the tubes E at connection L. The adapter nozzle for connecting the rubber tubing to the instrument will need to be made up locally as detailed in Fig 3. A stopcock D in the manometer inlet pipe is then closed and the air in the reservoir compressed slightly by operating the pump. The stopcock of the manometer in use can now be opened very slightly and carefully until a pressure of 2 1/2 psi is read on the scale, indicating that this pressure has been attained in the instrument or component under test. The stopcock should then be closed to prevent further increase in pressure.

NOTE: It is important that the stopcock be opened very slightly and carefully in order to prevent a sudden rush of air from the compressed air reservoir which will cause the mercury to be blown out of the tube into the glass overflow trap. Care should be taken to avoid building up excessive pressure in the compressed air reservoir.

12. If the instrument is sealed perfectly, the level of the mercury in the U-tube will remain constant. If the instrument is not sealed perfectly, the mercury level will drop slowly or rapidly, depending on the rate of leak and the volume of the instrument. The rate of leak may be determined by timing the fall of the mercury column from 2 1/2 to 2 1/4 psi and substituting this time (in min) in the following equation:

$$\text{rate of leak (in cu cm per min)} = \frac{0.015 \times \text{vol of instrument (in cc)}}{\text{time (in min)}}$$

NOTE: (a) The constant 0.015 in the above equation can be used only in conjunction with a pressure drop from 2 1/2 to 2 1/4 psi. For any other pressure drop a different constant would be needed.

(b) A list of internal volumes of a number of instruments is given in para 16.

13. When the internal volume of the instrument is small, for example, less than 1000 cc, the time taken for the pressure to fall from 2 1/2 to 2 1/4 psi will be so small, a matter of a few seconds, that it will be difficult to obtain a sufficiently accurate reading. To overcome this difficulty a reservoir of about 5000 cc or more should be connected between the manometer and the instrument to be tested, thereby increasing the total volume of air and the time taken for the drop in pressure. The reservoir must be fitted with two adapter nozzles for connecting rubber tubing, but otherwise perfectly sealed. The volume of the reservoir can be measured accurately by filling with water and then pouring off into a measuring jar. When using the reservoir the test is carried out exactly as before and the equation then becomes:

$$\text{rate of leak} = \frac{0.015 \times \text{total volume}}{\text{time}}$$

14. If the rate of leak is excessive, the instrument is imperfectly sealed and it is necessary to locate the leak. Two methods can be adopted to locate leaks, while at the same time maintaining pressure inside the instrument by operating the pump and opening the stopcock very carefully:

(a) By applying a suitable soapy solution by means of a small brush to suspected leaks, air bubbles will be observed at the point of leakage.

(b) By immersing the instrument or component under water, the leak will be detected by escaping air bubbles. Because of the difficulty in drying out the instrument after immersion the method at (a) is to be preferred.

Apparatus, Measuring Leakage Rate

15. This apparatus consists of a portable self-contained unit designed to give a direct measurement of the rate of leakage from an instrument when the internal air is maintained at a constant pressure of 2 1/2 psi. The supply of air at constant pressure is provided by means of an electric motor-driven pump and this air is filtered and dried before being delivered to the instrument under test. The rate of leak is registered directly on a manometer in cu cm per min. There are two scales provided; the coarse scale reading 0 to 1,000 cu cm per min and the fine scale reading 0 to 100 cu cm per min.

INTERNAL VOLUME OF INSTRUMENTS

16. The internal air volume of various instruments is given below:

Instrument	Volume
Binocular, periscopic, AFV, Mk 1	360 cc (each half)
Binocular, prismatic, No 2	100 cc (each half)
Binocular, prismatic, No 5	300 cc (each half)
Director, No 7	30 cc
Rangefinder, No 2	2400 cc
Rangefinder, No 12	1700 cc
Sight, dial, No 9	130 cc
Sight, periscopic, AFV, No 1, Mk 4	1660 cc
Telescope, battery commander, M65	750 cc (each half)
Telescope, elbow, M16	70 cc
Telescope, panoramic, CDN, No 1, Mks 1 and 2	165 cc
Telescope, sighting, No 22C	110 cc
Telescope, sighting, No 39	380 cc

Telescope, sighting, No 43 x 3, ML	430 cc	
Telescope, stereoscopic, No 1B	460 cc	(each half)
Telescope, bearing and elevation, No. 8	400 cc	
Telescope, tank, M51 and M70	390 cc	