

CHAPTER 11

JET CALIBRATING MACHINES

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General

1. Jet calibrating machines are employed for the calibration of carburettor jets to the standard set up by the National Physical Laboratory. The machines enable a comparison to be made quickly of the flow rate of the jet to be calibrated, with the flow rate of certain master jets, on the principle that the ratio of flow between one jet and another of the same design is always the same. The types of machine in use in the Service are described in the following paragraphs.

JET CALIBRATING MACHINE, MK. XB

2. A front view of this instrument is given in fig. 1, Sketch I, which shows that two gauges glasses, each with its own standard orifice, and two cocks and jet adaptors are employed. This is done in order to increase the range of jets that can be calibrated, the standard orifices being suitable for use with jets having a flow between 100 c.c. and 500 c.c., in the one case, and between 500 c.c. and 2,000 c.c. in the other. The above two sets of components, together with upper and lower tanks, hand air pump and tray, are all mounted on a vertical backboard. The instrument should be firmly fixed in a vertical attitude where it will be free from vibration, shock, direct sunlight and extreme variations of temperature, and at such a height that the scales may be read without errors due to parallax. The tray receives the fuel either as discharged from the jet under test or when filling the system, the filling being carried out by first filling the lower tank through the tray and then transferring the fuel from lower to upper tank by creating sufficient air pressure in the lower tank to lift the fuel to the upper tank. The fuel is drained through a filter in the tray comprising a disc of fine mesh gauze and then passes via a cock and pipe to a closed cylindrical tank having additional connections to the delivery side of the hand operated air-pump and to the return pipe which leads to the upper tank.

3. The air-pump is single acting and is furnished with the usual cup-type leather washer on the plunger. The upper tank is closed similarly to the lower tank except for a central cylindrical filter which screws into and seats on the adaptor for the cock (A) in the base of the tank. A dust cap, with a small air-vent hole covers the protruding top of the filter. The fuel supplied from the lower tank is thus filtered before passing through the cock (A) and its appended pipe to the float chamber. This chamber houses a float and a needle valve which acts upwards against a seating in the chamber cover and thus controls the fuel level. Fuel is drawn from the bottom of the float chamber by the supply pipe which delivers it to the body of the instrument (see fig. 1, Sketch III). The body is divided into two branches so as to form two distinct instruments from this point. At the root of each branch the passage is tapped to receive the orifice. This is a screwed plug provided with a flange seat (an intervening washer is fitted) and bored to form a venturi-shaped orifice. Each branch is divided at the front end into four passages leading in a downward direction to the special cock (B), inwards to the socket for the gauge glass, upwards to the air-release cock and forwards to receive a screwed plug

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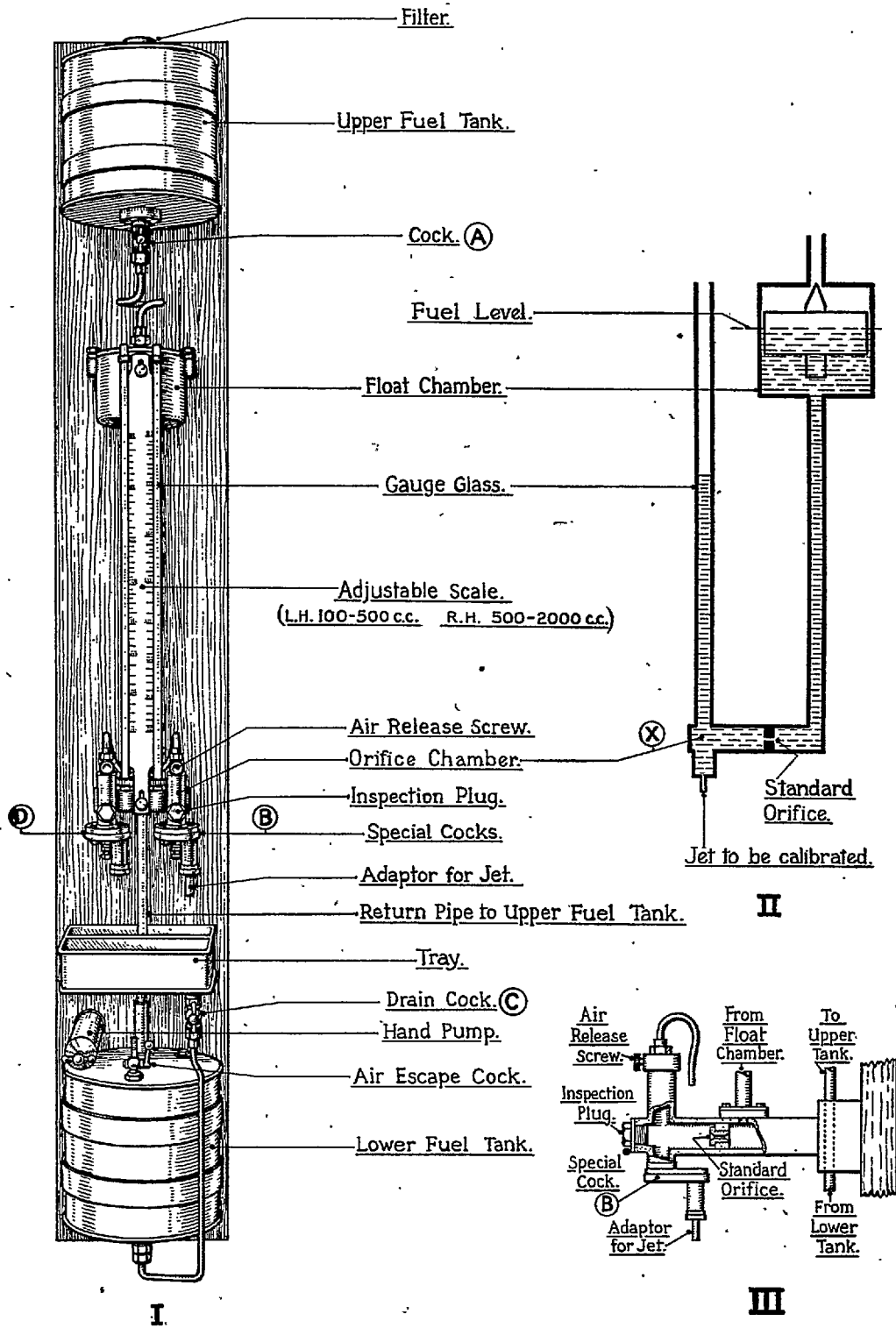


Fig. 1.—Jet calibrating machine, Mk. XB

which, when removed, provides access to the orifice to permit removal of the standard orifice by means of a hexagonal tube spanner. The downward branch terminates in an eccentric flange which is faced with cork to form the seat of the jet-adaptor cock. The jet-adaptor holder has a corresponding eccentric flange which pivots concentrically with that of the branch. Rotation of the jet-adaptor flange brings the adaptor holder in line with the downward branch of the orifice chamber and thus allows fuel to flow into the adaptor. The jet to be tested is mounted in its appropriate adaptor, which is then screwed upwards into the holder. The gauge glasses are open at their upper ends and are held in their sockets by a gland fitting. Two scales on the one scale plate are provided which are graduated during the manufacture of the instrument from the levels obtained when using the standard reference jets previously mentioned. Three reference jets are supplied with each instrument, their nominal sizes being 70 c.c., 300 c.c. and 1,250 c.c. respectively, whilst the actual individual rate of flow is marked on each jet. The left-hand portion of the instrument covers jets between 100 c.c. and 500 c.c. per minute, whilst the right-hand portion is intended for the calibration of jets between 500 c.c. and 2,000 c.c. per minute.

### **Principle of operation**

4. In fig. 1, Sketch II, which illustrates the principle of operation, it will be seen that the fuel supply is maintained at a constant head by the float chamber, whence it flows through the standard orifice to the chamber (X) from which the gauge tube leads upwards and the jet to be calibrated leads downwards. With the jet open and the instrument working for a sufficient length of time for the conditions to become stabilised, it will be found that the fuel in the gauge will remain at a certain height, depending upon the ratio between the sizes of the standard orifice and the jet to be calibrated. This is because the pressure provided by the head of fuel falls to zero in two steps, the first in proportion to the size of the standard orifice and the remaining drop to zero in proportion to the size of the jet. It will be evident that a scale, calibrated directly in c.c. per minute, can be placed on the gauge glass, but this scale, if fixed in one position, will not be correct for all conditions of temperature, specific gravity of fuel used, and so on. This difficulty is surmounted by making the scale plate adjustable as to its position relative to the level in the gauge glass, and its location for any given set of conditions is determined by first using a reference jet—which must be of the same type as the jet under test—the calibration of which is accurately known. The reference jets are calibrated on a master jet-calibrating instrument at the National Physical Laboratory and are marked with the actual rate of flow in c.c. per minute.

### **Operation**

5. The instrument is operated as follows:—

- (i) Fill the tray with fuel and open the air-escape cock and drain cock (C) on the lower tank. Continue to replenish the tray until the lower tank is nearly full, then shut the air escape and drain cock (C).
- (ii) Operate the hand pump to transfer fuel from the lower tank to the upper tank until the latter is at least half-full. The cock (A) on the upper fuel tank should remain open whenever the calibrator is in use.
- (iii) Screw the 300 c.c. reference jet for the L.H. scale into the L.H. cock (D), making sure that a fuel-tight joint is obtained, otherwise it will not be possible to obtain a correct reading. For this purpose the adaptor must be fitted with a serviceable joint washer not greater than  $\frac{1}{16}$  in. thick.
- (iv) Open the cock by rotating from left to right, when fuel will flow into the tray.
- (v) Release all air from the orifice chamber. The air above the jet is released by opening the air escape cock until fuel issues forth. Air in the vicinity of the jet is removed by placing a finger over the hole in the reference jet, when air bubbles will rise in the gauge glass. When the bubbles cease it can be accepted that there is no more air in the orifice chamber. Remove the finger from the reference jet and the fuel level in the glass will gradually fall until it remains constant. It is important that fuel shall flow for at least one minute to allow the level to become stabilised.
- (vi) Adjust the scale plate so that the graduation on the L.H. scale which corresponds exactly with the marking on the 300 c.c. (nominal) reference jet is opposite the fuel level as indicated by the meniscus in the L.H. gauge glass. If, for example, the 300 c.c. reference jet is stamped 299, the graduation 299 will be placed opposite the fuel level.
- (vii) Shut the L.H. cock (D) and remove the adaptor.

6. The instrument can now be used for calibrating any jets with a flow between 100 c.c. and 500 c.c. per minute. To use the R.H. portion of the calibrator, the same routine should be followed, the reference jet in this case being one of 1,250 c.c. flow per minute. It is essential that the setting of the scales is always checked against the marked figure on the proper reference jet before commencing work, if the instrument has been standing idle, and also after every hour if the instrument is in continuous use.

7. A complete set of jet adaptors is available, and when issued for use, the box contains an illustration of the adaptors and the method of inserting a jet in its appropriate adaptor (see fig. 2). Before making a calibration test, however, it is essential that reference is made to the particular aero-engine handbook, to verify that this method is in accordance with the latest modification to the carburettor. Adaptors should not be made up by Units locally.

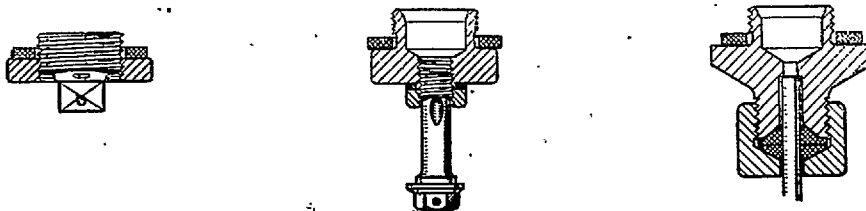


Fig. 2.—Types of adaptors used in calibrating machines

8. All carburettor jets are stamped with their nominal flow in c.c. per minute. If the actual flow recorded on test does not differ from the normal flow by more than  $\pm 2$  per cent. (up to 200 c.c.) or  $\pm 1$  per cent. (over 200 c.c.) the jets should be regarded as satisfactory. If the reading obtained is outside this tolerance, the jet should be rejected. On no account should any carburettor jet be altered or modified, and any jet rejected should be returned to Stores Depot as unserviceable.

9. After the completion of the tests, all fuel except that which is left in the orifice chamber should be allowed to run into the bottom tank; this prevents any possibility of inaccuracy due to difference in temperature between fuel in the top and bottom tanks.

#### Servicing

10. The following notes indicate the chief points in relation to the servicing of this calibrating machine:—

- (i) It is advisable that the orifice chamber should only be emptied at the times of periodic cleaning and that a depth of 6 or 7 inches of fuel is always left in the gauge glasses. This will avoid the formation of air locks and will prevent the collection of deposit on the surface of the calibrated orifices.
- (ii) The instrument should only require cleaning every 18 months or 2 years and on these occasions the calibrated orifices should be removed very carefully, and minutely cleaned in fuel, a piece of watchmaker's pegwood being perhaps the best material to remove any foreign matter in the orifice. Any such deposit would cause the instrument to indicate a higher reading, and would also show that the whole instrument required cleaning.
- (iii) On no account should a metal instrument or tool of any description be put into the calibrated orifices or into any reference jet. Very slight mechanical damage to the hole of either the calibrated orifice or the reference jet will render them useless. Reference jets must, therefore, be handled with the greatest care and when not in use are to be kept in their wooden container.
- (iv) Only clean, strained fuel of standard specification at a temperature in the neighbourhood of  $15^{\circ}$  C. ( $59^{\circ}$  F.) should be used. The fuel should be changed periodically, as the density tends to increase.
- (v) The packing around the gauge glass is made of cork and is held in position by a gland and nut. Leakage from the gland can generally be eliminated by tightening up the gland nut, but if this fails to remedy the defect, a new packing washer should be inserted. If occasion arises which necessitates fitting a new gauge glass, the orifice chamber and its adjacent connections should be thoroughly blown through to remove any trace of broken glass.
- (vi) To prevent foreign matter collecting in the tray, a locally made cover should be improvised; the cover may be made in sheet metal with wired edges and should always be in position when the instrument is not in use.

### JET CALIBRATING MACHINE, MK. XIII

11. The Mk. XIII jet-calibrating machine (see fig. 3) is the same in general principle as the Mk. XB already described. The Mk XIII machine is, however, mounted on its own base and is fitted with an electric motor driven fuel-circulating pump. It is intended for calibrating jets up to 15,000 c.c. which is three times the size of the maximum that can be checked on the Mk. XB machine.

#### Construction

12. The machine is an independent unit, 6 ft. 6 in. in height, mounted on a heavy cast-iron stand, the base of which can be bolted down to the floor. An electric motor and centrifugal fuel-circulating pump are mounted on the base whilst a fuel tank and the calibrating mechanism surmounted by the header tank are attached to the upright of the stand.

13. The machine is provided with a central scale plate on which there are two scales, viz.—Left-hand, 750 to 4,000 c.c. per minute, right-hand, 3,000 to 15,000 c.c. per minute. On each side of the scale plate there is a glass tube and a metal tube behind which there are three larger metal tubes. Of the latter the right-hand tube is the supply pipe for the header tank and the left-hand tube carries the overflow back to the fuel tank from the header tank, a sight glass being fitted to the L.H. tube in order that the overflow can be observed; both these tubes serve also as supports for the header tank. The larger tube, positioned between the support tubes, forms the main fuel feed to the jet adaptors and the four tubes at the sides of the scale plate.

14. At the base of each metal tube adjacent the glass tubes is an adjustable valve which can be closed when fitting a jet in the adaptor and opened when the jet is ready for calibration. The valves are cork-faced and close down on to a flat brass seat. Underneath the two valve operating knobs are two hexagonal caps, covering the entrances to the venturi chambers and these caps should be removed only when it is required to examine and clean the venturis. In between the caps are two milled-headed screws, the purpose of which is to permit the level of fuel in the glass tubes to be lowered quickly when calibrating a jet, the scale reading for which is in the lower range of the scale.

15. The fuel tank is provided with an integral funnel and anti-splash cups in which flame traps are incorporated. The tank has a working capacity of from four to five gallons and this latter amount must not be exceeded. A drain plug is fitted at the base of the tank for draining and cleaning purposes.

16. Below the tank is an adjustable valve for regulating the main flow of fuel from the pump, to suit the size of jet which is being calibrated. The pump-motor switch is attached to the left-hand support tube.

#### Operation

17. In order to operate the calibrating machine, from four to five gallons of clean, filtered fuel having a specific gravity of from 0.7 to 0.75 should first be poured into the tank.

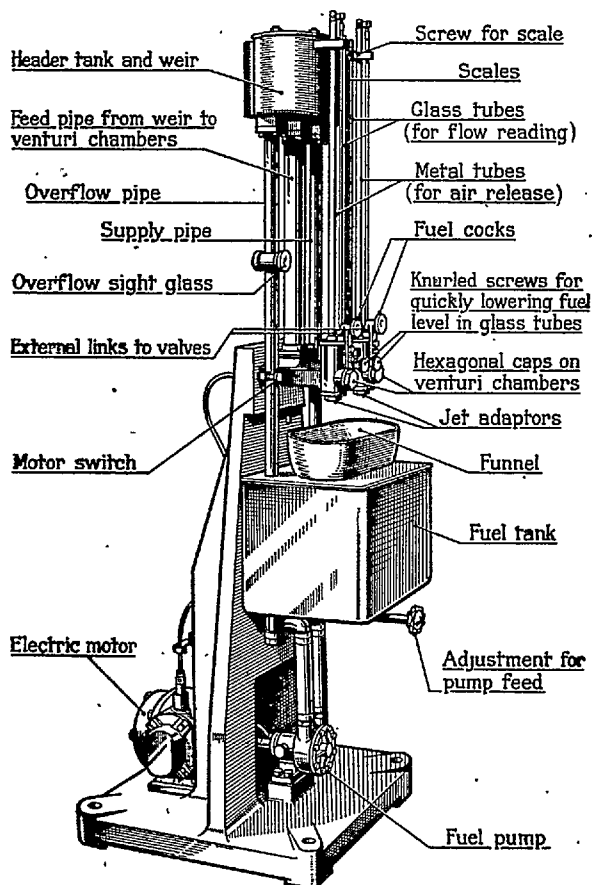


Fig. 3.—Jet calibrating machine, Mk. XIII

18. The electric motor should then be switched on and the header tank allowed to fill and overflow, the two valves meanwhile remaining closed. When it is seen at the sight glass that the header tank weir is flooding, one of the two master jets provided should be fitted to the appropriate adaptor. The jet selected should be that which suits the scale to be used and which will give a reading approximately midway on the scale. The associated valve should then be opened and fuel allowed to pass through the master jet until all signs of air bubbles have disappeared from the fuel in the glass tube after which the pump fuel flow should be regulated by means of the valve until the weir just overflows.

19. When these conditions are stabilised the scale should be adjusted so that the level of the fuel in the glass tube in use is opposite the number of the scale which is equivalent to the size of the master jet. The valve should be closed and the master jet removed, the jet to be calibrated being screwed into the adaptor in its stead.

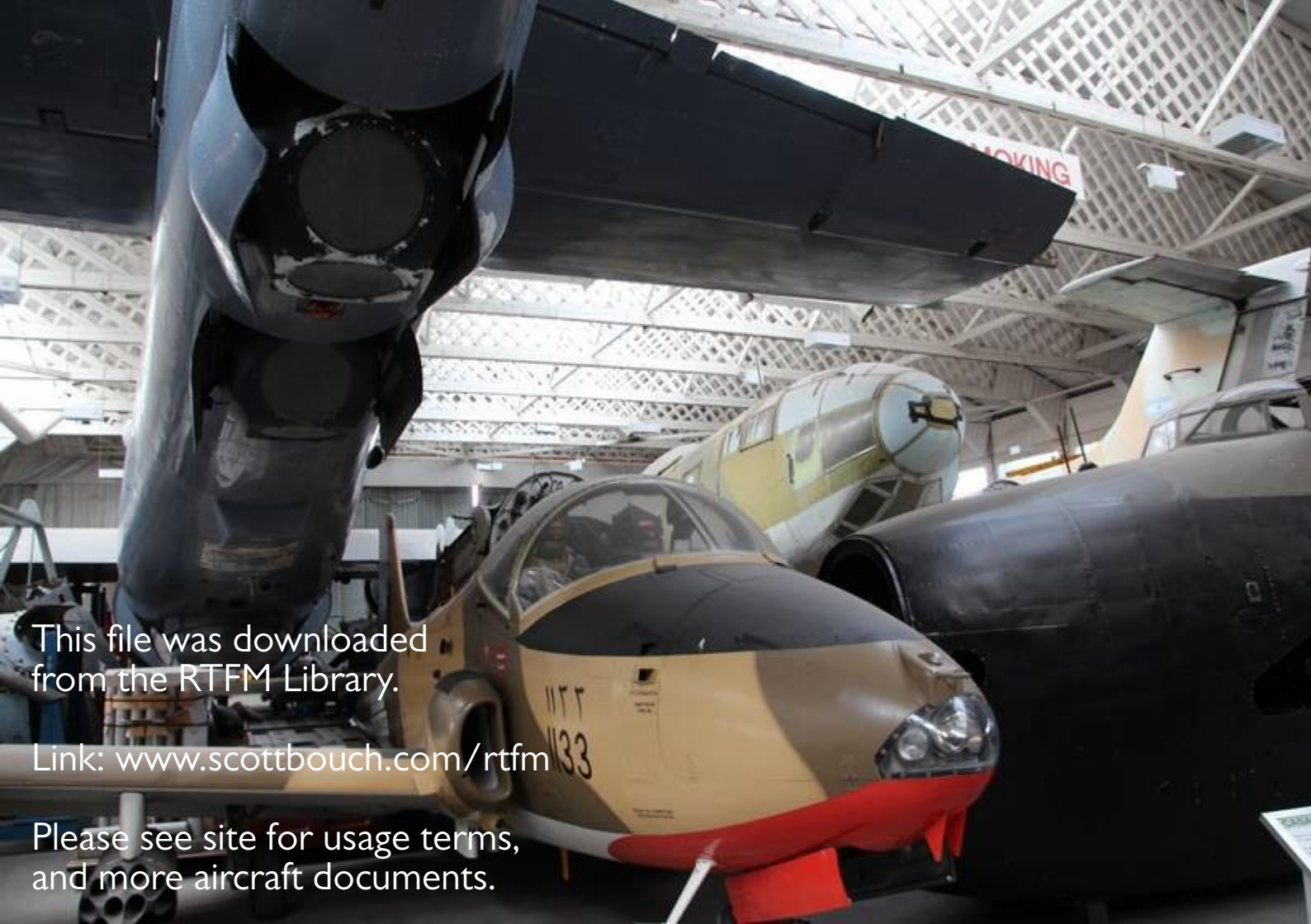
20. The valve should now be opened fully upon which the level of the fuel in the glass tube will begin to fall to a point where it remains steady. This point indicates on the appropriate scale the flow reading in c.c./min. of the jet under test.

21. Compensation should be made for slight variations in the temperature and specific gravity of the fuel feed by re-adjusting the scale to the master jet, hourly. After the fuel has been in use for some time evaporation of the lighter elements takes place and causes the specific gravity to become higher, therefore the fuel should be changed periodically.

### **Servicing**

22. The calibrating machine should be kept clean and in a serviceable condition. Provided that clean fuel only is used, the machine should not require cleaning internally for at least two years. The pump gland should be lubricated periodically by means of the screw-cap lubricator provided; grease, petrol resisting, Stores Ref. 34A/62 should be used. The pump gland should be carefully tightened in the event of a leak at that point. The pump hose-connections should be kept tight and free from fuel leaks, new petrol-resisting hose being fitted when any signs of deterioration are seen in the old ones. If the gauge glass tubes leak at the ends, the gland nut should be gently tightened; if the leakage continues, a new cork gland packing should be fitted. In the event of a gauge glass being broken great care should be taken to remove all traces of broken glass and the new replacement tube should be cleaned, before it is fitted, by means of a pull-through.

23. Foreign matter should not be allowed to collect in the tank filler and a suitable lid made up locally from three-ply wood should be fitted. No metal instrument or wire should be used for cleaning the reference jets, which should be kept safely in the wooden container when not in use.



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